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ABSTRACT
DOCTORAL THESIS

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Risk Management for the aerodynamic characteristics of an asymmetric profile

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TABEL OF CONTENTS

INTRODUCTION

In the field of Aerospace Engineering, Safety Management is the state in which the probability of personal injury or property damage is decreased to an acceptable level by analyzing accidents and avoiding potential risks.

Due to the necessity to validate numerical results or obtain information about the aerodynamic properties of the models, the experimental analysis for testing models / models in wind tunnels, specially designed for measuring parameters relevant to the model's aerodynamics, is considered. Even at low speeds, detachment of the flow is a significant obstacle in the analysis of the impediment caused by reattachment to raise the lift. At low subsonic speeds, the flow is characterized by a turbulent boundary layer. [1]

Numerous studies on profile surface modification have been performed to improve the aerodynamic efficiency of the profile by delaying flow separation. Various methods of delaying flow separation have been proposed by various researchers, for example, the use of vortex generators to induce turbulence and delay the separation of the boundary layer [2].

The major purpose of the paper is to adjust the surface flow characteristics of a NACA 1410 profile in order to improve the performance of an asymmetric profile aircraft, which places the paper within the scope of this Doctoral program's Engineering and Management focus.

Another objective is the analysis of the protrusions on the aerodynamic profile and the investigation of the differences between several configurations of the NACA 1410 profile (conventional profile, profile with outward protrusion, and profile with inward protrusion).

The paper's **second objective** is to solve the influence of air humidity during wind tunnel tests by implementing the decision analysis module of the WINQSB program, which offers a new approach that enables decision making and selecting an optimal risk strategy.

To avoid running a large number of tests simultaneously, dangerous circumstances should be categorized by conducting risk assessments and selecting those whose negative impacts do not outweigh the expense to management. Consequently, the examination of the NACA 1410 profile **highlights** a risk factor, the increase in fuel consumption, when the profile of a protrusion raises the drag coefficient.

In this context, **the study presents** actual Risk Management solutions by optimizing the decision-making process through the use of algorithms.

Applying the moment method generates optimally transparent outcomes for the upgraded of the air fleet.

The implementation of studies conducted in the field of Engineering and Management was carried out in an appropriate manner by analyzing all existing risk concepts in a consultancy company. This means that the delivery of services must combine the classic concepts of Risk Management with the implementation and development of services with an innovative character, using the FRAM analysis - Accident Resonance Model.

This thesis's **research methodology** includes the use of the following methods and instruments of analysis:

- Adequate study of a selected bibliography with maximum attention to detailed comparative analyses;
- 2D - Numerical simulation, numerous tests performed using ANSYS Fluent software;

- Development tools: Matlab, Xfoil;
- WINQSB Software.

Chapter 1

1. General Fundamentals of Risk Management in Aerospace Engineering

This chapter illustrates the concept of Risk Management, and it is important to note that aviation regulations and applicable policy at the national and international level often influence the acceptability of safety performance. To maintain a balance between productivity and protection, the appropriate level of risk management is required. Thus, hazard identification is the initial stage in Risk Management, as its causes and effects change based on the aerodynamic characteristics' performance. It may involve any scenario or condition with the potential to result in an injury, event, or accident. Risks exist in every aspect of a organization, thus a method for recognizing and reporting risks is necessary. The human factors involved in the business process should be responsible for continuously identifying and analyzing this circumstance. This chapter introduces Bayesian analysis as an approach that allows argument based on straightforward calculation assumptions.

1.1 Limitations applied in Risk Management

1.1.1 The concept of Aviation Risk

In the topic of Risk Management, the human factor is exposed to a variety of risks, regardless of whether we are examining its work environment, lifestyle, or social environment. As these risks are detected, they are evaluated simultaneously with their possible advantages, and if it is determined that the risks outweigh the benefits, the algorithm is discontinued; if the benefits exceed the risks, the algorithm is continued.Similarly, the level of safety in all of its practical components will be assessed. [3]

According to the ISO 31000: 2018 [4] documentation, risk is described as "impact of uncertainty on objectives." The outcome deviates from what was anticipated to occur. The risk can be positive, negative, or both, and it can be mitigated, created, or result in a number of opportunities and threats. The objectives of Risk Management can be classified and have multiple aspects that can be applied at different levels.

1.1.2 Types of errors and how to perform the burglary process

The concept of error is an action or inaction performed by a human factor that will lead to deviations from the intentions or expectations of individuals or organizations.

1.1.3 The concepts of danger and hazard

Document 9859 (ICAO Safety Management Manual - SMM) defines hazard as "a condition or object with the potential to cause injury to personnel, damage to equipment or structures, loss of material or reduced ability to perform a prescribed function". According to the updated edition, it is defined as "a condition that could cause or contribute to a plane crash or accident".

1.1.4 Methods for identifying aviation dangers

Identifying potential sources of failure is a complex process, as a large variety of potential failure factors must be addressed. When assessing dangers, several elements must be taken into account, depending on the nature and size of the organization, the operational area, and the surrounding environment.

1.1.5 Methods of identifying aerospace hazards

The SMS (Safety Management Systems) team of ECAST (European Commercial Aviation Safety Team) has developed the guidance document for air operators on hazard identification. The resulting data serve as the foundation for a variety of tools and approaches for identifying hazards and outlining their benefits and disadvantages. In actual aviation circumstances, both reactive and proactive strategies for hazard identification are useful. The investigation of aircraft events is an efficient method for identifying potential dangers. In properly implemented Safety Management systems, the proactive approach to hazard identification is utilized extensively, so that the hazard is identified and eliminated before it may cause an accident.

1.2 Management of risks and their assessment

The ICAO Handbook defines Risk Management as "the identification, analysis, and elimination (and/or reduction to an acceptable or tolerable level) of hazards and consequent risks that seriously affect an organization's sustainability."Risk Management maintains a balance between assessed risk and its mitigation. Therefore, a rigorous and detailed analysis is required, as well as the implementation of their processes and research methodologies in a reasonable order.

Once a hazard has been identified, a thorough investigation of the situation is required to determine its potential for causing damage. Probability, severity, and exposure rate are taken into account during this procedure.

1.3 Probabilistic Risk Assessment

Existing risk analysis methodologies are generally complementary. Methods such as PRA - Probabilistic Risk Assessment or GRA - Global Risk Assessment - Global Risk Assessment [5] allow the identification of potentially hazardous aviation safety scenarios and the application of associated safety management measures that the aviation system may encounter. This initial study can be supplemented by a more extensive analysis, using linear, nonlinear, or more basic methods, such as well before risk assessment or pre-flight risk assessment.

1.3.1 The study of conditional probabilities in the Bayesian analysis

Conditional probabilities can be considered as extremely valuable tools in the study of stochastic events, since it allow us to take into account external interactions that not only determine the occurrence of a new event, but also its variation over time all the factors that will determine the event under study. If the numerous values of a random variable in an entire process that is studied over a period of time are tracked, it is evident that the occurrence of a specific value for the variable considered at a given time does not represent an independent phenomenon, but rather an evaluation of the previous activity of the entire process.

The event cannot be investigated using classical algebraic probabilities, as these are derived from mathematical calculations that disregard the manner in which the random variable under consideration was deduced. [6]

1.3.2 Bayesian methodology

Bayesian methods are characterized by concepts and procedures as follows:

- The use of random variables, or, more generally, indeterminate values, to model all sources of uncertainty using statistical models, including the determination of uncertainty due to lack of information.

- The need to determine the distribution of the previous probability, taking into account the available information, previously existing.
- Sequential use of Bayes's formula: when more data are available, the subsequent distribution is calculated using the previous mathematical formula.
- While, for the calculation of probabilities based on frequency, a hypothesis is a statement, which can be true or false, therefore the probability can be 0 or 1. In Bayesian statistics the probability that can be attributed to a hypothesis is included in -an interval ranging from 0 to 1 if the truth value is uncertain. [7]

1.3.3 Case study on Bayesian methodology

During a flight from Rio de Janeiro to Paris in June 2009, an Air France 447 aircraft vanished from radar.[8] Components of the aircraft were discovered floating on the surface of the Atlantic five days later, but the cause of the disaster was determined using data from the black box and the cockpit voice recorder. After identifying a few aircraft components, it would seem straightforward to locate the rest of the aircraft, but this is not the situation, after a couple of days, the components will degrade with the ocean currents. There is specialized software that can replicate the movement of an aircraft's components at the moment of initial impact. The U.S. Coast Guard frequently uses this program. In this situation, though, it was of no service because the area near the equator is notorious for erratic currents, especially at that time of year. American, Brazilian, and French ships, aircraft, and submarines conducted a search for the aircraft but were unsuccessful. At the time, the French aviation accident investigation authority, BEA, reached out to a group of American statisticians with expertise in locating missing objects at sea. In their technique, they implemented Bayesian interference, which takes into consideration all previously known information about the crash location and search activities. The outcome is a probability distribution for the wreck's location.

In this case, the end result was the finding of the aircraft's wreckage, flight data recorder, and cockpit voice recorder, which revealed crucial evidence regarding the aircraft's final moments.

1.4 Conclusions

Despite the fact that, from a practical standpoint, the ultimate objective is the elimination of all occurrences and accidents with particularly severe consequences, it is unavoidable that this field has inherent dangers and risks. Investigations cannot guarantee the absence of operational errors and their effects due to the human variables involved. Consequently, safety is a dynamic aspect of aviation systems, and safety hazards must be decreased continuously. Importantly, the study of safety performance is frequently influenced by national and international legislation and processes. The open and dynamic system, such as the aviation industry, may nevertheless retain the ideal balance between production and protection, so long as risks are kept under adequate control.

The use of the Bayesian methodology produces a comparable Bayesian interpretation of probability, which has been viewed as an extension of the logic of sentences that permits simplified reasoning of the hypotheses considered, i.e. statements whose truths are false or uncertain. In the case of Air France 447, the fundamental distribution was the probability of analyzing the wreckage at a particular position. The Bayesian model was used to determine the interpretation and subsequent embedding of the data.

Chapter 2

2. Optimization methods applied in the aviation accident investigation study

2.1 Aviation accident modeling

This chapter provides a comprehensive comparison of four types of fighter aircraft for the development of the air fleet, based on the following criteria: maximum speed, flight altitude, maximum load, and military equipment.A presumption has been made regarding these parameters, and the optimal variant is the Mig 21 Lancer, resulting in the Mig 21 Lancer being the best fighter jet in the Romanian fleet.

The analysis was conducted to maximize the manner in which decisions are made under conditions of certainty characterized by types of decision situations in which the influencing factors are known and a single, controllable condition determines the outcomes of the known decision.The primary purpose is to discover and characterize a common area between the decision and selection processes.In this case study, the four varieties of fighter aircraft (decision maker) must acquire the appropriate technical knowledge, aerodynamic data, and information.

In the specialized literature, three mathematical calculation models for the investigation of accidents are established in direct association with recent advancements in Aerospace Engineering. Sequential and systematic approaches are considered linear, whereas systemic calculation methods are nonlinear. [9]

Sequential models

Sequential models assume that the accident is the result of a set of events or situations that interact sequentially and linearly with one another. Thus, accidents can be avoided by ignoring the components of the linear sequence.

These clearly depicted models were ideal for research in the first half of the twentieth century, but they cannot be used to illustrate the accidents of today's more complicated systems.

Epidemiological models

Models of epidemiology are motivated by the transmission of a contagious disease. The International Civil Aviation Organization (ICAO) also adopted this approach in order to comprehend the occurrence of accidents. According to this theory, an accident is the outcome of a combination of unfavorable variables, which creates an unsafe environment.

In 1987, Professor James Reason devised the Scweitzer Model, often known as the Swiss-Cheese Model, which is representative of this category.

Systemic models

The new perspective on accident modeling has established that these models are not need to be linear. Accidents can be considered as the consequence of a number of interacting variables.Perrow, Leveson, and Holnagel are the primary investigators of the systematic models. [10]

These authors describe the system in its whole and do not rely on its decomposition. Systematic approaches establish links between human elements, hence revealing the possibility of more unpredictability. Considered to be composed of interdependent components that maintain equilibrium through information loops. A system is not viewed as a static entity, but rather as a dynamic process that is constantly adjusting to fulfill its objectives and quickly respond to changes from the outside in. Accidents are viewed as the outcome of faulty interactions between human variables, social and organizational structures, engineering efforts, and hardware and software system components (Leveson 2004).[11]

FRAM - Accident Functional Resonance Model - is predicated on the notion that performance variability, internal variability, and external variability are normal, in the sense that performance is never steady in a sociotechnical system as complex as aviation.

2.2 Human Factor

Human error has been identified as a factor in over 70 percent of commercial aviation accidents.Human error, which is typically connected with flight operations, has recently emerged as a key concern in air traffic maintenance and management techniques.

2.3 Fault Tree Analysis

Fault Tree Analysis (FTA) was the first method designed to do a systematic assessment of industrial risks. Developed by the Bell Telephone Company in the early 1960s, the approach was utilized to assess the safety of missile launch systems. It seeks to establish the causal chain and event combinations that can result in an undesirable occurrence, and is a prevalent technique in the aviation sector. This method employs graphical analysis and permits the inclusion of errors.

2.4 The moments method for upgraded the Romanian air fleet with fighter aircraft

All choices are made in relation to several criteria, even in the most common personal decisions, which leads to the consideration of the following type-problem: either V = {v1, v2, ..., vm}a lot of objects (variants of decision) and C = {c1, c2,..., cn}, a set of criteria for assessing objects in V. The criteria in C are of equal importance. In order to solve the problem of the fleet endowment, the algorithm developed by S.B. Deutch and J.J. Martin [12] will be applied, which is suitable for solving group decision-making and multidimensional problems. This method is also known as the "moment method".

The algorithm thus developed can be structured as follows:

1. It is made an arbitrary arrangement of the lines corresponding to the *m* variants;
2. The utilities are calculated according to the maximum formula;
3. The line-moments are calculated and the lines (variants) are rearranged in the ascending order of the line-moments;
4. The column-moments are calculated and the columns (criteria) are ordered in ascending order of the column-moments;
5. Resume the algorithm from Step 3 and continue until no more rearrangements of the columns are needed.

2.5 Decision making under certainty

We assume that it is wanted to equip the Romanian Air Force fleet with fighter aircraft. We have four models available and, in the end, we will choose the best option using the method of moments (Deutch Martin).[13]

A comparison will be made between the four models according to the following criteria:

- C1- maximum speed;
- C2- maximum operating altitude;
- C3- maximum load ;
- C4- military equipment.

The four types of military aircraft are: Mirage 2000, F – 16 Block 15 Fighting Falcon, F – 18C Hornet and Mig 21 Lancer C.

The consequences of each variant that are considered based on the decision criteria are shown in Table 2.4:

Table 2. 4 The matrix of consequences

	C1	C2	C3	C4
V1	2.2	16460	6300	6
V2	2	18000	5000	15
V3	1.8	15240	8165	5
V4	2.4	18200	2000	5

Table 2. 9 The normalized matrix columns

	C1	C4	C2	C3
V4	1	0	1	0
V2	0.33	1	0.93	0.48
V1	0.66	0.1	0.41	0.69
V3	0	0	0	1

Table 2.10The normalized matrix lines

	C1	C4	C2	C3
V4	1	0	1	0
V2	0.33	1	0.93	0.48
V1	0.66	0.1	0.41	0.69
V3	0	0	0	1

It is noticed that the last table is identical to the previous one, so it is no longer possible to reorder the rows and/or the columns of the matrix.

This last ordering of the lines represents the best hierarchy of decisional variants. Therefore, the version V4 is optimal.

2.6 Conclusions

For analysis, four types of fighter aircraft were compared for the development of the air fleet, based on the following criteria: maximum speed, maximum operating altitude, maximum load and military equipment. The assumption was made about these criteria and the optimal version is MiG 21 Lancer, which leads to a best choice from the Romanian fleet of fighter aircraft.

The decision maker, (in that case, the four types of fighter aircraft) has to hold up knowledge, data and information relevant to the analysed situation.

In this study case, the calculations show the following aspects (i.e. the selection):

- The maximum speed (C1) subserves to a constantly development because is one of the most important criterion in different military missions. During the modernization we have as advantage the optimal flight time.
- The armament (C4) is a maximum criterion and its advantage is that help to support high-end combat operations and sustain homeland defense. Also, the other criteria provides a unique asymmetric advantage for the fleet through its ability to secure and maintain theater-wide air superiority.

These attributes are vital to decisive strategies against highly capable adversaries.

Chapter 3

3. Risk Management with applications in wind tunnels

This chapter summarizes how to identify the multitude of hazards that need to be properly managed, which means that risks and threats must be eliminated, and threat control methods must be planned and nominated leaders and executors who are responsible for wind experiments. In order to avoid carrying out a large number of tests in the wind tunnel, which should be performed simultaneously, hazardous situations that may occur accidentally should be classified by conducting risk assessments, and the selection of situations with adverse effects should not exceed manufacturing costs initially assessed.

The major key in investigating aviation incidents and accidents is to determine the facts, conditions and circumstances of the event, to determine the root cause and subsequently to take suitable actions to prevent the repetition of the event and the causes leading to the accident. The objective of Safety Management is to detect risks and manage safety risk factors and to increase the effective area of activity to effectively integrate human factors as well as their activities.[14]

3.1 Wind tunnels - Brief history and evolution over time

A wind tunnel is the main tool used in experimental aerodynamics. In order to use the experimental data obtained in wind tunnels correctly, it is necessary to apply aerodynamic theory and calculation methods for data interpretation, experimental planning and control of installations. All existing information on aerodynamic research for development programs is a solid basis for both aerodynamic theory and applied experimental methods. Previous calculation results and experiments are of great importance in wind tunnel testing.

Once the digital computer was invented, fluid dynamics simulations became an important part of the development of the aerospace vehicle. The calculation methods underwent a rapid development and it was supposed to be necessary to replace the classic wind tunnels. However, the complexity of the actual flows could not be fully reiterated by computer simulations. [15]

3.2 Wind tunnel experiments

The design of the experiments has been extensively studied and can provide valuable information about the experiments performed in the wind tunnel. A block diagram representation of an aerodynamic tunnel experiment is shown in Figure 3.1 The inputs are represented by variables as follows: model angle of attack, yaw or roll, and total pressure. The controllable elements are: the size of the model and the tunnel, the model materials, the construction process, the duration of the experiment and the configuration.

Some variables may appear in either the input data or the controllable factors, depending on their function. Components of forces and moments measured with the internal balance, pressure data from the transducers, and recorded images of the various methods for visualizing the flows represent the output elements. Uncontrollable variables include wind tunnel turbulence, temperature, humidity, and model deformation.

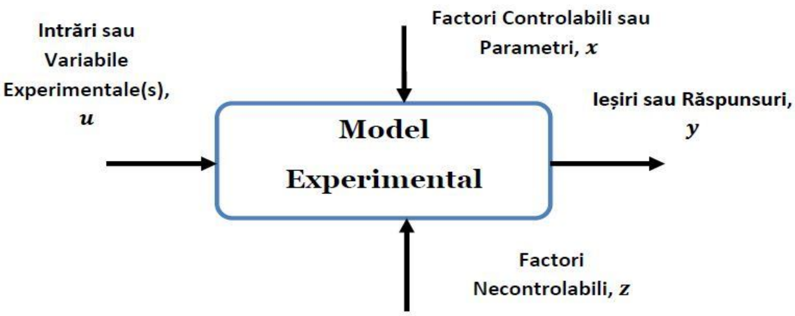


Fig. 3. 1 Conceptual model of an experimental setup

3.3 Considerations for risk assessment and safety assessment in wind tunnels

Tests performed in the wind tunnel include inherent risks that could affect personnel, equipment or the progress of experiments. Controlling these risks is essential to ensure that testing personnel, equipment and operations are safe and that the facilities are operating to their full potential. As a result, safety principles must be taken into account when designing a model and associated equipment for an operation.

The risk associated with conducting a test is proportional to the severity of the hazard and the uncertainty or probability that it will occur.

3.4 The characteristics of the Trisonic Wind Tunnel from INCAS

Based on existing data over time (LOG Trisonic Wind Tunnel) we derived some statistics to demonstrate the need to improve the accuracy and quality of the tests. Trisonic Wind Tunnel is a project started in 1970, and the main parameters of accuracy were at the level required then. The continuous adaptation to the evolution of technology and customer requirements makes it necessary to adopt new methods and updated measurement techniques, which requires substantial refurbishment.

Over time, the blower has had a multitude of improvements that can determine the parameters needed for use in international projects.

The three aerodynamic configurations that can be performed in aerodynamic experiments are (Fig. 3.2):

- SWEEP mode: during aerodynamic tests, the model can cover a range of angles between minimum -15° and maximum +25°;
- FIX mode: the model is positioned at a single angle of incidence;
- STEP mode: in this case the model can be positioned at at least 2 preset angles.

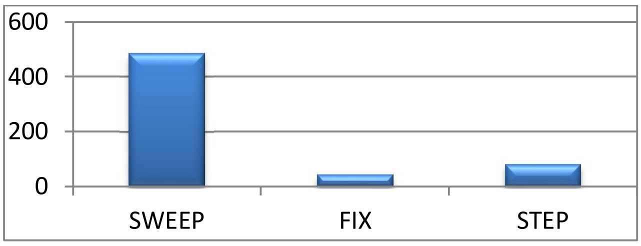


Fig. 3. 5 The three aerodynamic configurations

Figure 3.5 shows a ratio of the number of aerodynamic experiments desired for the three modes of the incidence mechanism in a large-scale experimental program. It is noted the importance given by the customer for bursts with variable incidence (sweep mode).

3.5 The risk of an experiment being missed if the air is humid

For a given freestream Mach number, the humidity influence is only local to the supersonic regime around the shock wave. The profile of the Mach number in the separation region has not changed significantly. When an oversaturation was reached, two types of condensation were observed:

(i) condensation upstream of and in the working section at the requesting regime (Schlieren visualizations);

(ii) condensation near the model from local supersonic regions, such as near the surfaces of aerodynamic profiles.[16]

Working section conditions and test measurements are affected in both situations.

For Safety Management, it is necessary to assess the risk factors for the safety of tests and experiments performed in the wind tunnel, associated with the safety consequences, by assigning each specific risk in the safety manual. Each safety issue may have one or more consequences and each consequence may be assessed as a single or multiple risk test procedure.

3.6 Case study on Decisional Analysis for air humidity using WINQSB software

The decision process encompasses all of the stages involved in preparing, adopting, implementing, and evaluating the decision. To make efficient decisions, decision makers must adapt faster in order to deal with difficult situations and requirements arising from changes in the wind tunnel environment. Decision-making situations arise as a result of environmental conditions, and they can be certain, risky, uncertain, or fuzzy.[17]

The effect of air humidity has three decisional alternatives, D1, D2, and D3, as well as three natural states, S1, S2, and S3. The Mach number can vary due to humidity in most cases. The following variables were identified when analyzing the decision as natural states: dew point temperature (S1), desired Mach number (S2), and Reynolds number (S3). Presuming that the probability of occurrence of each state is P(S1) = 40%, P(S2) = 30% and P(S3) =30 %,maximin criterion, maximax criterion, minimax regret criterion, and optimal decision building the tree decisional of the problem were determined. Each decision's variables were used for different flow regimes: supersonic (M = 2, M = 1.8) and transonic (M = 0.95).[18]

A decision tree is a logical sequence that includes all combinations of supported decision alternatives and state of nature (Table 3.1).

Table 3. 1 Decision Analysis for air humidity

Alternative Decizionale	**Stări naturale**		
	S_1	**S_2**	**S_3**
D_1	-40	2	8
D_2	-20	1.8	8
D_3	-10	0.95	4.15

The air humidity problem will be solved using the Decision Analysis module from the WINQSB program.[19]

In the "Problem Specification" window, the type of problem (Rewards Table Analysis), title, number of environmental states, and number of decision alternatives will be selected, as shown in Figure 3.12.

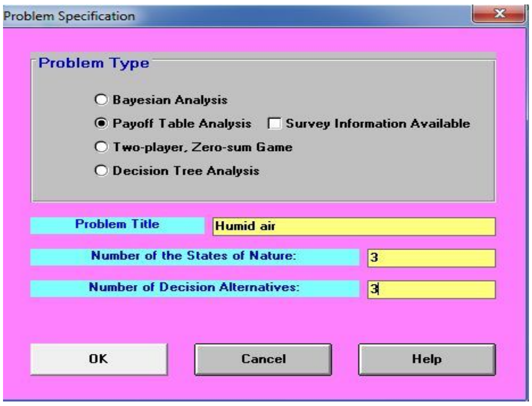


Fig. 3. 12 Interface for data input

Figure 3.13 illustrates how to enter data:

Decision \ State	State1	State2	State3
Prior Probability	0.4	0.3	0.3
Alternative1	-40	2	8
Alternative2	-20	1.8	8
Alternative3	-10	0.95	4.15

Fig. 3. 13 Data entry

It will be selected Solve the problem from the Solve and Analyze menu. A window similar to the one shown in Figure 3.14 will appear on the screen, stating the decision criteria and prompting the user to enter the optimism coefficient for the Hurwicz criterion.

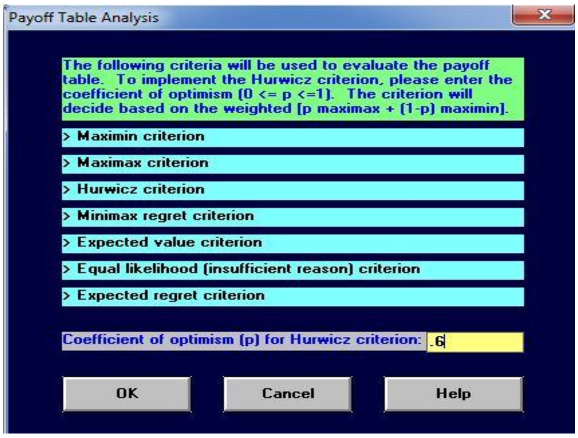


Fig. 3. 14 Analysis result based on Hurwicz criterion

The decision tree is developed in Figure 3.16.

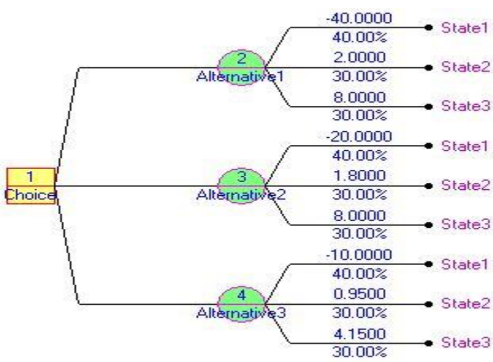


Fig. 3. 12 Decision tree for humid air

The best value is determined by the maximum value, which in this case is node 4, but the dew point temperature in the wind tunnel is negative, so the maximum value is node 2, implying that decision D1 is the best option.

3.7 Conclusions

Therefore, all hazards must be properly managed, which means that risks and threats must be identified, threat control methods must be planned and the leaders and executors responsible for the experiments must be nominated. In order to avoid carrying out a large number of tests in the wind tunnel, which should be performed simultaneously, hazardous situations that may occur accidentally should be classified by conducting risk assessments, and the selection of situations with adverse effects should not exceed manufacturing costs initially assessed. The Hurwicz criterion (optimistic criterion) applied in the experiments performed in the windmill, allows the selection of the variant that maximizes the determined profit if the most favorable state of the environment is taken into account, using the values of the parameter $\alpha \in [0,1]$.

Solving the case study with the decision analysis module using WINQSB software provides a new perspective on assisting in decision making and selecting the best risk strategy for studying the effect of humidity in wind tunnel experiments. Since the value of the dew point temperature in the wind tunnel is negative, therefore the maximum allowable value is at node 2, which implies that the decision taken D1 is the best option considered.

Chapter 4

4. Original contributions on the effect of semicircular protrusion on the aerodynamic characteristics of the NACA 1410 profile

This chapter includes the various methods of delaying flow separation that have been proposed by many researchers, who have included in their studies the use of vortex generators to create turbulence and delay the detachment of the boundary layer.

The study of the protrusions on an aerodynamic profile can optimize the performance of an aircraft by modifying the surface flow characteristics. An existing protrusion on a NACA 1410 aerodynamic profile proved to be more necessary in adjusting the lift, drag, and pitch forces than the use of a conventional profile. The results obtained as a result of the inclusion in the case study of this fact were structured as follows: in the first case, the protrusions on the NACA 1410 profile are oriented outwards, thus improving the pitch coefficient, and the protrusion curve has, of also the additional effect of accelerating the separation of the boundary layer, thus lowering the pressure coefficient, when used together with the model k- ω, the shear force limiter thus helping to prevent excessive accumulation of turbulent energy at stagnation points. In the second case, when the angle of attack (AoA) of the protruding profile increases rapidly and the absence of a protrusion creates a slight fluctuation of the profile, the pressure coefficient decreases, eventually resulting in the formation of a small vortex in the profile. An inner protrusion will be formed over the surface of the profile, allowing the observation of the separation of the boundary layer, which will be arranged for the lowest drag and maximum lift. It also improves the aerodynamic efficiency of the aircraft, which in turn improves overall performance.

4.1 Numerical modeling of the NACA 1410 aerodynamic profile

In this study, the aerodynamic flow parameters were numerically simulated in CFD in a 2D model of an aerodynamic profile, using the dynamic discretization function of the ANSYS Fluent solver. The numerical model is a CFD simulation of a 2D NACA 1410 model with the appropriate range and discretization grid for all angles of attack from -2 ° to 18 °.

To obtain the numerical results, three calculation methods were used for the aerodynamic profile NACA 1410. [20] Thus we have the parameters obtained from the CFD simulation, those obtained from the Abbott & von Doenhoff diagram [21] and those calculated in Xfoil.

Table 4.1 shows the values of the lift coefficients, the drag and the pitch coefficients of the unmodified NACA 1410 profile.

Table 4. 1 The coefficients of the NACA 1410 profile result from the 3 calculation models

Alpha	C_L			C_d			C_m		
	Fluent	Abbott	Xfoil	Fluent	Abbott	Xfoil	Fluent	Abbott	Xfoil
-2	-0.11101	-0.13	-0.1024	0.008937	0.0064	0.00537	-0.02435	-0.09	-0.027
0	0.10818	0.09	0.1217	0.00883	0.0055	0.00482	-0.02377	-0.08	-0.0267
2	0.32645	0.3	0.3443	0.009175	0.0058	0.00478	-0.02306	-0.085	-0.0261
4	0.54255	0.55	0.5604	0.009965	0.0062	0.00613	-0.02211	-0.075	-0.0237
6	0.75412	0.75	0.802	0.01152	0.0082	0.00804	-0.02072	-0.07	-0.0276
8	0.95761	0.99	1.0089	0.013245	0.01	0.00991	-0.01843	-0.07	-0.0237
10	1.1495	1.18	1.2153	0.01622	0.013	0.01238	-0.01513	-0.03	-0.0202
12	1.3193	1.35	1.4054	0.02067	0.016	0.01603	-0.00991	-0.01	-0.0146
14	1.14535	1.5	1.6694	0.02758	0.0206	0.02053	-0.00279	-0.005	-0.0059
16	1.5151	1.4	1.6204	0.040441	0.0067	0.03103	0.003801	-0.15	0.0052
18	1.3976	1.11	1.5823	0.074938	0.02	0.05977	-0.00531	-0.45	0.005

Due to the fact that the NACA 1410 is a very thin airfoil, it stalls from the trailing edge. As a result, surface modification is supplied in the form of inner and outward protrusion, as well as an outer protrusion of diameter 30 mm, located at a distance of 750 mm from the leading edge. The following table represents the model's wing specifications:

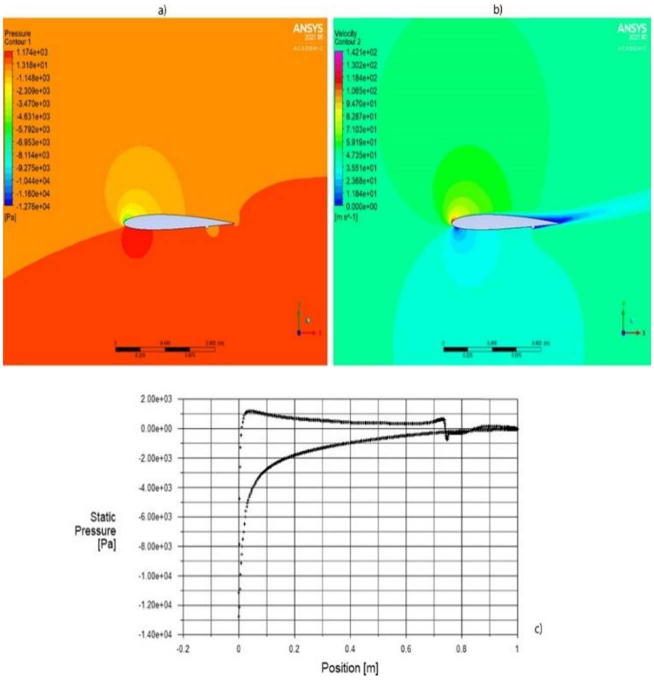
Table 4. 2 Model wing specification

Particularități	Caracteristici
Seria profilului	NACA 1410
Coarda	100 mm
Tipul proeminenței	Semi- circulară
Diametrul proeminenței	30 mm
Localizarea proeminenței	750 mm față de coardă (suprafața inferioară)

4.2 Numerical results obtained and their interpretation

The results of simulations of NACA 1410 airfoils with and without surface modifications were compared at various angles of attack ranging from -2° to 18°. Computational fluid dynamics simulations of NACA 1410 airfoils with and without surface modifications were also performed. To achieve the best possible aerodynamic performance, the coefficient of lift (CL), the coefficient of drag (Cd) and the coefficient of pitch (Cm) were determined and studied.

The outward protrusion has a significant impact on the flow, as can be seen in Figure 4.15c), which represents the pressure distribution along the chord. Even from the numerical simulation data, the lift coefficient and the pitch coefficient of the outward protrusion have a wide range of values, which determines them to have a considerable impact on the flow, due to the geometry of the NACA 1410 profile with outward protrusion where the value of the coefficient of pitching moment will increase. The inward prominence shown in Figure 4.16 has higher aerodynamic characteristics than the outer one. For this reason, it was decided that the inward protrusion is more suitable than the outward protrusion, as indicated by the findings of this study. The inward protrusion also offers greater aerodynamic efficiency. Due to the large curvature of the protrusion, the detachment of the boundary layer will take place faster, which will lead to a sudden decrease in the pressure coefficient.



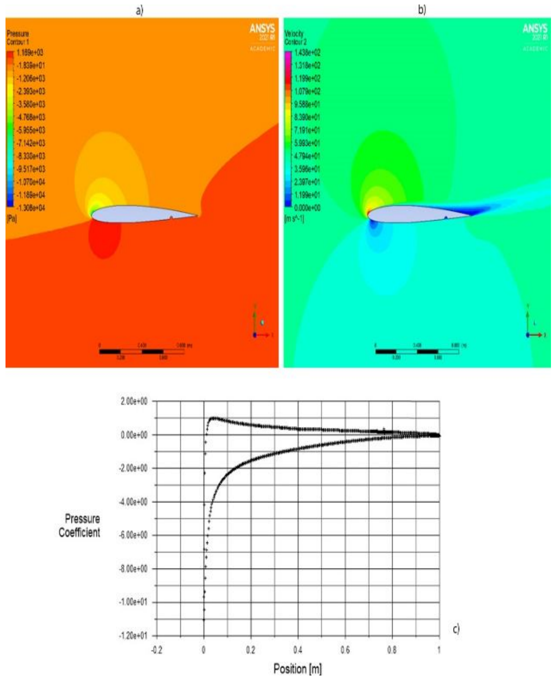


Fig. 4. 15 Analysis Results for 14° AoA of airfoil with outward protrusion
a) Pressure contour;b) Velocity contour c) Pressure distribution along the lenght of the chord
Fig 4. 16 Analysis Results for 14° AoA of airfoil with inward protrusion
a) Pressure contour;b) Velocity contour c) Pressure distribution along the lenght of the chord

4.3 Conclusions

Surface protrusions can improve an aircraft's performance by altering surface flow characteristics. A protrusion on a NACA 1410 aerodynamic profile proved to be more necessary in adjusting the lift, drag and pitch forces when using a conventional profile. The results were obtained by including this fact in the case study.

In the first case, the protrusions on the NACA1410 profile are oriented outwards, improving the coefficient of pitch. The protrusion curve also has the additional effect of accelerating the separation of the boundary layer by lowering the pressure coefficient, and when used in conjunction with the k- ω model, the shear force limiter helps prevent excessive accumulation of turbulent energy at stagnation points. In the second case, when the angle of attack (AoA) of the protruding profile increases rapidly and the absence of a protrusion creates a slight fluctuation of the profile, the pressure coefficient decreases, eventually resulting in the formation of a small vortex in the profile. The interior protrusion, unlike the other surface changes, offers the best aerodynamic characteristics, as previously stated. It was found that the internal protrusion exceeds the external protrusion in terms of aerodynamic efficiency and that the external protrusion produces a higher lift compared to a standard profile. An inner protrusion will be formed over the surface of the profile, allowing the observation of the separation of the boundary layer, which will be arranged for the lowest drag and maximum lift. It also improves the aerodynamic efficiency of the aircraft, which in turn improves overall performance.

Chapter 5

5. Risk of aeroelastic instability due to effects induced by semicircular protrusions on a NACA 1410 profile

In this chapter we study aircraft whose wings have as aerodynamic profile one that has a prominence that is in a dynamic motion with a higher speed than those whose wings have a basic profile, as long as the speed is lower than the one of divergence. The divergence phenomenon is a limiting phenomenon of aeroelastic stability, the equilibrium solution exists up to a critical value of the divergence pressure / velocity, and the interpretation of this critical value based on the definition of the stability condition indicates that the loss of stability will coincide with the cancellation. the denominator of a fraction (α_ech).

Because a decrease in lift performance is extremely difficult to manage, researchers have discovered new techniques to increase aerodynamic performance. The aim is to energize the flow sufficiently to combat the unfavorable pressure gradient and to push the separation point downstream. This will delay the detachment of the boundary layer and reduce the slip area, thus increasing aerodynamic performance.

The external protrusion produces a higher lift compared to the standard profile. The closer it is to the leading edge of the attack, the faster the detachment takes place and the lower the lift. Thus, it is recommended to position the outer protrusion closer to the trailing edge.

5.1 Modeling of the aerodynamic profile NACA 1410

In this study, the aerodynamic flow parameters were simulated in CFD in a 2D model of an aerodynamic profile, using the dynamic discretization function of the ANSYS Fluent solver. The numerical model is a CFD simulation of a 2D NACA 1410 model with the appropriate range and discretization grid for all angles of attack (0 ° to 16 °). [20]

As the NACA 1410 profile is a thin profile, the stall effect will appear from the leading edge, therefore the change of the surface in terms of the appearance of semicircular protrusions will be made for a diameter of 30 mm, at a distance of 250 mm from the leading edge, respectively 750 mm for the second protrusion.

5.2 Numerical results and their interpretation

The results of numerical simulations for the aerodynamic profile NACA 1410 with and without surface changes were compared at different angles of attack ranging from 0 ° to 16 °. CFD simulations of NACA 1410 profiles with and without surface modifications were also performed. In order to obtain the best possible aerodynamic performance, the coefficient of lift (CL), the coefficient of drag (Cd) and the aerodynamic efficiency (CL / Cd) were determined and studied.

Regarding the angle of attack, Figure 5.4 shows the relationship between the lift coefficient and different positions of prominence on the aerodynamic profile section. The cases considered include the study of aerodynamic profiles with and without protrusions, as well as those with external protrusions at 25% and 75% from the chord.

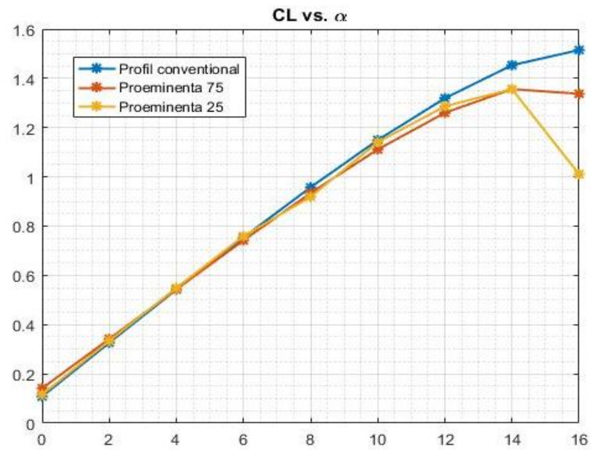
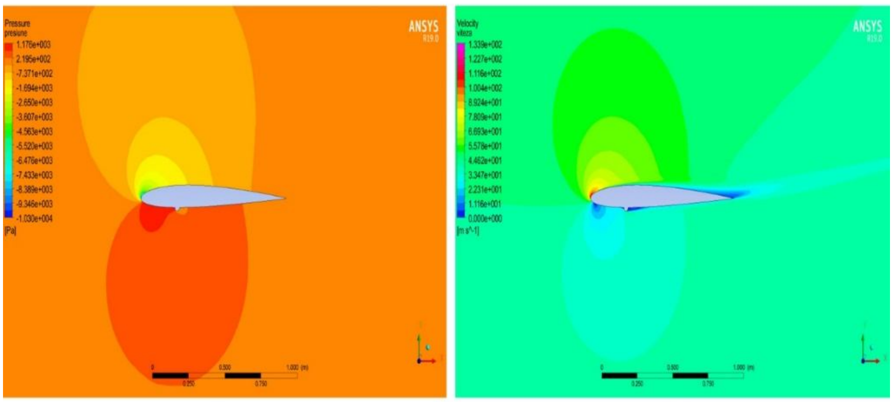


Fig. 5. 4 Analysis plot C_L vs. AoA

It has been observed that a profile without protrusion produces less lift. The protrusion determines the lift coefficient at a constant increase when it is introduced. As the angle of attack increases, so does the lift for both positions. Compared to a normal profile, the external protrusion offers a significant decrease in lift reduction. Therefore, it was found that the protrusion regardless of its position on the profile, which will lead to a decrease in lift. The closer the protrusion is positioned to the leading edge, the faster the detachment takes place and the significantly lower the lift. When the angle of attack is 16 degrees, the lift decreases considerably in the case of the external protrusion located near the leading edge.



a) b)

Fig. 5. 9 Analysis Results for 12° AoA of airfoil with outward protrusion positioned at 25% from the chord a) Pressure contour;b) Velocity contour

The outward protrusion has a significant impact on the flow, as can be seen in Figure 5.9a), which represents the pressure distribution along the aerodynamic chord. A fairly high pressure accumulates around the protrusion, and the flow will be affected and Figure 5.9b) shows that the speed decreases when there is an increase in the coefficient of drag.

From the pressure profile in Figure 5.10 a) it is observed how the pressure increases until the appearance of the outward protrusion. Being positioned close to the leading edge, the flow will not be greatly affected. The presence of this prominence changes the flow and will result in another detachment on its surface, which will lead to the formation of new vortices.

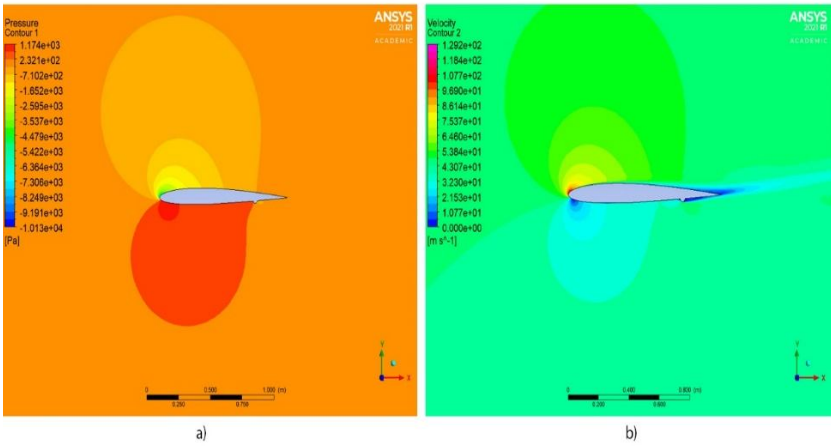


Fig. 5. 10 Analysis Results for 12° AoA of airfoil with outward protrusion positioned at 75% from the chord a) Pressure contour;b) Velocity contour

5.3 Risk of aeroelastic instability

Mathematical modeling of aeroelastic phenomena appeals to concepts taken from fields such as - mathematics, mechanics and aerodynamics. The degree of complexity of an aeroelastic model depends on the degree of complexity of the models.

A special case in the development of aeroelasticity is the concept of rigid wing supported elastically or of typical section.

Elastically supported rigid wing - typical section for the NACA 1410 profile

This concept was introduced in the years 1920-1930 when very careful observations showed that, for relatively straight wings in the classical construction (ailerons) the choice of a section located at about 75% of the wingspan determines the obtaining of calculation models that allow obtaining perfectly verified results from an experimental point of view.

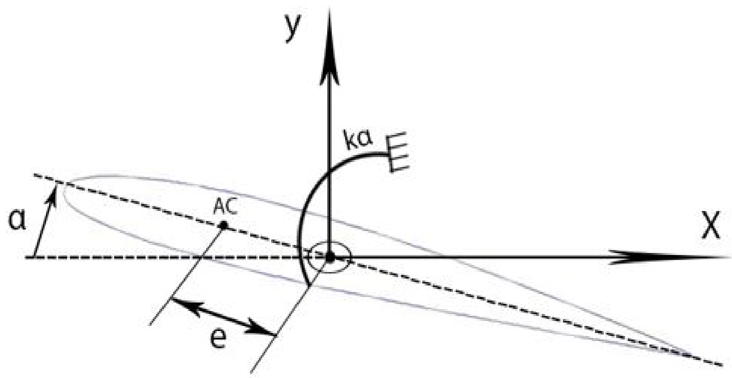


Fig. 5. 11 Elastically supported rigid wing - typical section for the NACA 1410 profile

Thus, from Figure 5.11 we distinguish two points on the chord:

- Focus (aerodynamic center marked with AC)
- Elastic center

k_α = constant of elasticity

e = the distance between the elastic center and the focus

α = elastic deformation angle

The bending stiffness of the finite wing allows the elastic center to move along the Z axis. The elastic center is the point on the chord where a force applied in the direction of the Z axis produces only one translation and a torque strictly produces a twist around that point (α). Considering that an elastic center can be defined for each section of the wing, a "Y" type elastic axis (AE) can be constructed.

As a first observation we have neglected the effect of weight, and the modeled phenomenon is a stationary one.

The elastic moment has the mathematical expression of the form:

$$M_{c_e} = -K_\alpha \cdot \alpha \tag{5.8}$$

K_α- constant of structural rigidity

The static equilibrium condition is as $(\Sigma M)_{c_e} = 0$ (sum of moments in the elastic center)

$$\Longrightarrow M_f + L \cdot e - K_\alpha \cdot \alpha \tag{5.9}$$

$$\left(K_\alpha - \frac{1}{2}\rho V^2 S_c C_m^\alpha - \frac{1}{2}\rho V^2 S C_L^\alpha \cdot e\right) \cdot \alpha \quad \text{- it is noted with } \Delta \tag{5.14}$$

$$\alpha_{echi} = \frac{1}{2}\left(\frac{1}{2}\rho V^2 S_c C_m^\alpha + \frac{1}{2}\rho V^2 S C_L^\alpha \cdot e\right)\alpha_\infty \tag{5.15}$$

$$\frac{1}{2}\rho V^2 \text{ – it is noted } q_\infty \text{(dynamic pressure)} \tag{5.16}$$

α_{echi}- equilibrium solution

$$\alpha_{echi} = \frac{1}{\Delta} q_\infty (S_c C_m^\alpha + S C_L^\alpha \cdot e)\alpha_\infty \tag{5.17}$$

As a first discussion, it was found that in the case of the profile equipped with C_L^α protrusion decreases, compared to the study of the simple profile. If C_L^α decreases$\Longrightarrow$ q_{∞_D} increases.

If q_{∞_D}it turns out that the divergence rate will also increase.

5.4 Conclusions

Surface protrusions can improve an aircraft's performance by altering surface flow characteristics. Prominence on a NACA 1410 aerodynamic profile has proven to be more successful in adjusting lift and drag than using a conventional profile. First of all, the protrusions on the NACA1410 profile are facing outwards, improving the lift coefficient. The protrusion curve also has the additional effect of accelerating the separation of the boundary layer by lowering the pressure coefficient and, when used in conjunction with the k- ω model, the shear force limiter helps to prevent excessive accumulation of turbulent energy at stagnation points. Second, when the angle of attack (AoA) of the protruding profile increases rapidly and the absence of a protrusion creates a slight fluctuation of the profile, the pressure coefficient decreases, eventually resulting in the formation of a small vortex in the profile. The external protrusion produces a higher lift compared to the standard profile. The closer it is to the leading edge of the attack, the faster the detachment takes place and the lower the lift. Thus, it is recommended to position the outer protrusion closer to the trailing edge.

Therefore, aircraft whose wings have a protruding profile can move at a higher speed than those whose wings have a basic profile, as long as the speed is lower than the divergence.

The divergence phenomenon is a limit type of aeroslastic stability phenomenon.
The equilibrium solution exists up to a critical value of the pressure / divergence rate, and the interpretation of this critical value based on the definition of the stability condition, indicates that the loss of stability will coincide with the cancellation of the denominator of a fraction (α_ech).

Chapter 6

6. Aerospace Risk Management Consulting Services

This chapter includes the business plan that has a wide applicability because the entrepreneur initiates the company in relation to the field of study followed, which makes it known exactly what are the priorities, well-established goals and results to be achieved by the company in a given term. This business plan can be successfully implemented in the Bucharest metropolitan region due to the large number of third-party companies, dependent on the company's services and active in the field of Risk Management. For the sustainability of the business, the manager of the company will implement various types of services, to be applied individually to each client, and the PR - Public Relations department must be adequately developed to achieve an extended framework of types of clients be attracted to the sphere of activity carried out. The manager will promote a competitive marketing strategy to make the company's offers known to existing customers in the market, by participating in conferences, symposia and scientific congresses.

6.1 General information

General information on the provision of consulting services is presented in Table 6.1. The main activity of the business is the provision of consulting services on Risk Management in the Aviation Industry.

The CANE code for this activity is **7022: "Business and management consultancy activities".**

Table 6. 1 CANE code for consulting services

Domeniul de activitate	**Producție**	**Servicii**	**Comerț**	**Cod CAEN**
Servicii de consultanță privind Managementul Riscurilor		x		7022

6.2 Summary of the business idea

The services offered by the company are provided in strict compliance with high scientific and quality standards and provide consulting in Risk Management by qualified staff, who help the client in understanding the approach to the issue.

SC BLS S.R.L. is a company with a great potential for implementation, because it takes into account the field of activity, correlated with the field of study of the manager and the growing demand for these types of services on the Romanian market.

In order to set up and carry out the activity of this company in the first year, an investment budget of **286,173** lei is required.

The turnover of the company at the end of the first year of activity is forecast at **614,550** lei, and the expected net profit is **29,011.50** lei.

6.3 The vision, mission, purpose, objectives and activities of the business

The vision of S.C BLS S.R.L is to become a leading provider of Risk Management consulting. The company wants to help companies in choosing IT strategies related to risk factors and to act in case of possible unfavorable consequences, to develop their business and to increase their reputation, by identifying each risk scenario for determine the size of the individual risks.

The mission of S.C. BLS S.R.L. is to help organizations reduce the negative impact on risks that can cause material and human losses in the aviation industry where the company's task is to reduce, estimate and manage risk factors by transforming the ways in which they can influence customers and connections with third parties, technological factors, computing data, business environment and command and control systems.

Thus, the purpose of this business is the need for these consulting services that complement and develop new procedures or methods for managing material and human waste in the aerospace industry. One of the methods is based on the functional accident resonance model or FRAM.

We target the main classes in the aerospace industry (airports, aerospace research institutes, etc.) while maintaining that our control methods include planning robust strategies for assessing risks and opportunities.

The objectives of the proposed business

- **O1**: The company will set up 3 jobs in the first year of activity.
- **O2**: The market share in the second year of activity will be 5%.
- **O3:** In the third year of activity, the turnover will be 650,000 lei per year

Activities through which the assumed objectives will be achieved:

- **A1**: Firm foundation
- **A2**: Rental and arrangement of space
- **A3**: Obtaining authorizations according to the legislation in force
- **A4**: Staff recruitment, employment and training
- **A5**: Purchase of equipment and commissioning
- **A6**: Offer promotion activities
- **A7**: Providing consulting services

6.4 Description of the proposed business

The company will provide consulting services for risk management in aerospace activities. This process is carried out through multiple information and support for the establishment of appropriate measures and specific procedures within the Internal Management Control System. Thus, in order to streamline the whole process, a good collaboration is required, which can be structured in three stages. The company will also ensure that the resulting systems will be perfectly adapted to the competitive level, the level of complexity, as well as the policy applied by our potential business partners.

6.5 The location of the company and the facilities offered

The location in the physical plan of the company is on Ficusului Boulevard, no. 44, being an excellent chance for a company of this type, taking into account the area that is in a wide development, having access to the Bucharest - Ploiești road, as well as to the bus station - Pasaj Băneasa.

6.6 Details of the proposed business

The main activity of the business is the provision of consulting services on Risk Management in the Aviation Industry. The CANE code for this activity is 7022: "Business and management consultancy activities".

The proposed business plan covers strategic and organizational baking, change management, cost reduction and other financial issues; planning, and human resource policies. The consulting activities carried out within the company S.C BLS S.R.L consist in the operational assistance for the coordinated companies as well as for other companies having as specific activity the Risk Management.

6.7 Applicability, scientific relevance and innovative character

To highlight the phenomenon of accident over the years several authors have developed a lot of conceptual models. At first glance, they seem as diverse as the problem they intend to solve, but a more detailed analysis shows that there are some common issues.

The GANTT chart that includes the key activities in the implementation of the business idea is represented in Figure 6.4.

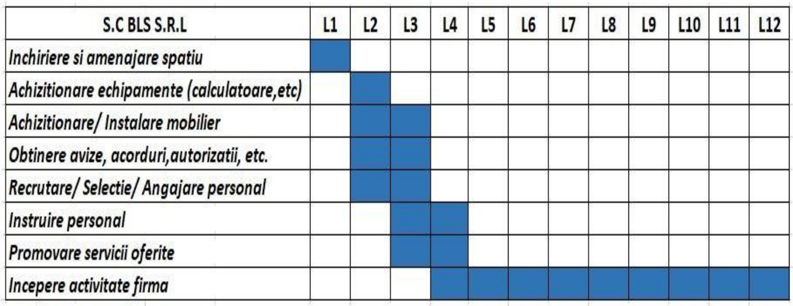


Fig. 6. 4: Gantt Chart

6.8 Human resources management

The organizational scheme is presented in Figure 6.5.

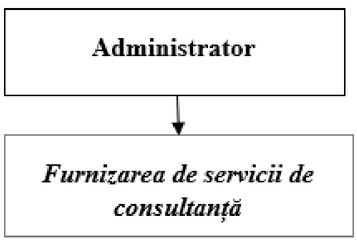


Fig. 6. 5: Company organization chart

6.9 Analysis of the company's market position and marketing policy

The company's initial goal is to establish itself and remain competitive in the services market through aviation risk management consulting. Airports and other businesses in the aeronautical industry will be the company's customers (research institutes). The planned business will provide aviation services to Romanian companies. As advantages, the clients benefit from the company's established reputation, business environment expertise, the breadth of services provided, and the ongoing promotion of its image. We anticipate the company will operate in a highly specialized niche market for this reason.

6.10 Profile of customers, suppliers, distributors and competitors

SC BLS S.R.L. clients include organizations, independent of their legal form of incorporation, as well as individuals, entrepreneurs, who want risk protection advice in air transport classes covered by SC BLS S.R.L. services. Especially in a large city like Bucharest, competition in this industry might be considered to be extremely strong. There is no company with this profile in the area where the company will open, however there are a number of businesses and the Băneasa airport that perform comparable operations.

6.11 Marketing mix analysis

The company wants to help customers manage risk in transportation class organizations. The need for clients to identify risks in a way that is as developed as possible based on FRAM analysis will lead to a robust strategy and the need for new risk identification models.

Product policy

For a start, the company wants to enter and be able to stay on the market of services with consulting activities on risk management in the aeronautical field. The company's customers will be from the aerospace industry, including airports, aerospace research institutes. The proposed business will operate for companies in the transport classes in Romania.

Price policy

The initial discussions, regarding the services offered, the processes and procedures to be followed for the elaboration, development or implementation of a risk analysis have a standard company tariff of 150 RON / hour (excluding VAT).

Distribution policy

The company will conclude contracts directly with customers. It does not provide for the use of intermediaries.

Promotion policy

In the initial stage, a marketing strategy is developed that provides an aggressive promotion policy, which is addressed to those companies that are likely to become future customers by:

- Creating a WEB site (company website)
- Advertising materials (leaflets, folders, brochures, business cards)
- Participation in exhibition fairs, conferences
- Social media advertising: Facebook, Instagram, Linkedin

6.12 Financial forecast

Working assumptions:

The financial plan was made, which included the working hypotheses that were taken into account, as follows:

- The forecast is made for 1 year (12 months);
- Income tax will be 1% on turnover;

- The depreciation of the equipment will be done according to the linear method, for a period of 3 years, according to the Catalog regarding the classification and the normal operation durations of the fixed assets, approved by the Government Decision no. 2 139/2004;
- An 8-hour work schedule was considered, from 09:00 to 17:00;
- In the first year, employees are to perform an average of 21 hours of service / day;
- The average price of a service / hour of services provided is 150 lei;
- For each service the indirect costs related to the consulting hour (40%) are 60 lei;
- The space of 60 sqm is rented for a period of 12 months, with a monthly rent of 2500 lei;

6.13 Investment budget

Ways to substantiate expenses, by categories:

According to the Investment Budget, the following indicators for the first year of activity resulted:

Fees for setting up the company: 550 lei;

Salary expenses

The company will have 3 employees who will be remunerated with 3,500 lei / month net, respectively 5,983 lei / month gross, which means an actual expense for the company in the amount of **6,118 lei** / month.

It will be taken into account that the staff will be employed starting with the **third month of activity**.

Total: 6,118 lei * 3 employees * 10 months = **183,540 lei**

6.14 Revenue forecast

According to the business plan, the activity is expected to start starting with the third month of activity. As a result of the advertising carried out according to the marketing plan, we expect to reach the level of 21 hours of services / services provided in one day. In this context, sales for year I will be according to Figure 6.7:

Vanzari	Luna 1	Luna 2	Luna 3	Luna 4	Luna 5	Luna 6	Luna 7	Lna 8	Luna 9	Luna 10	Luna 11	Luna 12	Total An 1
Nr. ore consultanta facturate	0	0	55	78	137	225	328	459	550	685	780	800	4097
Tarif ora consultanta	0.00	0.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	
Servicii consultanta	0 lei	0 lei	8,250 lei	11,700 lei	20,550 lei	33,750 lei	49,200 lei	68,850 lei	82,500 lei	102,750 lei	117,000 lei	120,000 lei	614,550 lei

Fig. 6. 7: Revenue forecast

6.15 Conclusions

The business plan has broad applicability because the entrepreneur begins the firm in relation to the topic of study pursued, so making it clear what the company's priorities, well-defined goals, and expected outcomes are for a given period. Due to the huge number of third-party enterprises relying on the company's service and active in Risk Management, this business strategy can be successfully implemented in the Bucharest metropolitan area. For the business's long-term viability, the company's management will execute and invent new and original services, relative to the competitive environment, which will be heavily promoted and attract a substantial number of prospective customers. By participating in conferences, symposia, and scientific congresses, the manager will advocate an aggressive marketing plan to make existing consumers aware of the company's offerings.

Chapter 7

7. General Conclusions, Original Contributions, Future Reseach Direction and Syntesis of the Papers

7.1 Generale Conclusions

The doctoral thesis addresses a field of maximum interest and topicality, which is in a continuous development as we move to the current 4D digital age, it is necessary to pay special attention to Risk Management applied in the top field of Aerospace Engineering. The approached topic covers the following general objectives that can be summarized as follows:

- Chapter 1

- this first chapter outlines the general framework of Risk Management in the aviation industry, and the application of the Bayesian methodology will result in a similar Bayesian interpretation of probability which was approached as an extension of the logic of sentences that allows simplified reasoning of the hypotheses considered, i.e statements whose truths are false or uncertain.
- In the case study conducted for Air France 447, the basic distribution was the probability of analyzing the wreckage located in a certain location, interpreting the results and then incorporating the data that were determined using the Bayesian model.

- Chapter 2

- This chapter presents the comparative study of the analysis of four types of fighter aircraft for the development of the air fleet, based on the following criteria: maximum speed, maximum operating altitude, maximum payload and military equipment. An assumption has been made about these criteria, and the optimal version is Mig 21 Lancer, which leads to the best choice in the Romanian fleet of fighter jets.

- Chapter 3

- Solving the case study with the decision analysis module using WINQSB software provides a new perspective on assisting in decision making and selecting the best risk strategy for studying the effect of humidity in wind tunnel experiments.

- Chapter 4

- Surface protrusions are analyzed that can improve an aircraft's performance by changing its flow characteristics. A protrusion on a NACA 1410 aerodynamic profile proved to be more necessary in adjusting the lift, drag and pitch forces when using a conventional profile.

- Chapter 5

- As long as the speed is less than the divergence, aircraft whose wings have a profile with a protrusion can move at a higher speed than those whose wings have a standard profile. The phenomenon of divergence is a limitation of aeroelastic stability. The interpretation of this crucial value is dependent on the concept of the stability criterion.

- Chapter 6

- The business plan is presented in detail, with broad applicability in the entrepreneurial environment, initializing the company in relation to the field of study pursued by the consultants, and elucidating precisely what the company's priorities, well-defined objectives, and desired outcomes are in order for them to be attained within a given time frame. Due to the significant number of third-party businesses depending on this company's services and engaged in Risk Management, this business plan can be implemented successfully in the Bucharest metropolitan area.

7.2 Original Contributions

1. I conducted a case study for the Air France 447 aircraft in which the likelihood of examining the wreckage found in a certain area, interpreting the results, and synthesizing the data calculated using the Bayesian model was considered the basic distribution.

2. I presented a comparative analysis of four models of fighter aircraft for the development of the air fleet, based on the maximum speed, maximum operating altitude, maximum permissible payload, and military equipment. I made a simplistic assumption regarding these criteria, and the Mig 21 Lancer was considered to be the optimal variant, leading me to conclude that it is the greatest fighter jet in the Romanian fleet.

3. I created a Matlab program for Trisonic wind tunnel experiments from which statistics were obtained to highlight the need to increase the tests' precision and quality.

I resolved the humidity issue utilizing WINQSB software, which provides a fresh viewpoint on decision support and choosing the most effective Strategy.

4. I utilized various flow separation delay methods to analyze turbulent flow and calculate the boundary layer separation delay.

I did numerical simulations with ANSYSY Fluent to examine the protrusions on an aerodynamic profile that can improve an aircraft's performance by altering the surface flow characteristics.

I calculated the aerodynamic coefficients using the Xfoil software, into which we entered the values of the coefficients derived from the Matlab code.

5. Following the execution of the code in Xfoil, i calculated the aerodynamic coefficients. I utilized three mathematical approaches to estimate the NACA 1410 aerodynamic profile's features.For the numerical validation of the results, i collected the parameters from the CFD simulation, those from the Abbott diagram, and those derived in Matlab. In fact, I studied the rigid wing supported elastic - typical section for the NACA 1410 profile and found that in the case of the profile equipped with C_L^α protrusion decreases, resulting in an increase in divergence pressure, compared to the study of the simple profile. The phenomenon of aeroelastic instability is determined by exceeding the value of the pressure / velocity divergence.

6. I have developed a business plan with broad applicability due to the fact that the entrepreneur initiates the company in relation to the field of study pursued, which makes it clear what his priorities are, as well as the well-defined objectives and results that the company will achieve within a given time frame.

In order to ensure the business's long-term viability, the firm management will implement and develop services that are distinctive and original in comparison to those offered in the competitive market. These services must be proactively promoted and will determine an extensive clients.

7.3 Future research direction

1. An in-depth examination of the NACA 1410 asymmetric profile and validation of numerical results with experimental data, which included testing the NACA 1410 profile in the INCAS subsonic tunnel.
2. Extending the study of the NACA1410 asymmetric profile with Gurney flaps is an additional field of investigation. In the wind tunnel, this high-flow control device will be examined and evaluated. This configuration to be evaluated consists of a tiny plate positioned in a plane perpendicular to the leading edge of the aerodynamic profile and facing the variable pressure surface.
3. The third avenue of future research and development is the expansion of the capabilities of next-generation software applied to the method of moments in decision-making problems. The optimally-obtained experimental data will be analyzed, allowing the applicability of these studies to be effectively extended to military missions conducted in various theaters of operations.

7.4 Synthesis of the Papers

The doctoral student has published 14 scientific papers in the field of Engineering and Management, all of which were developed during her doctoral studies, of which 3 as first author and 11 as co-author, as follows:

- 10 (ten) articles / studies published in ISI-rated journals (of which **2 articles as first author**), as follows: 1 article with an impact factor of 2,127 and 9 articles indexed by ISI Proceedings (2 in progress;)
- 4 (four) articles / studies published in BDI-rated journals (of which **1 article as first author**);

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