MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF AIR NAVIGATION, ELECTRONICS AND TELECOMMUNICATIONS
DEPARTMENT OF AVIONICS

APPROVED
Head of department
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# GRADUATION WORK

**(EXPLANATORY NOTES)**

**FOR THE DEGREE OF MASTER**

**SPECIALITY 173 "AVIONICS"**

**Theme: The features of the operational velocity characteristics limitations of airplane**

Done by: student of the AV-209m group, Volodymyr Romanovich Opareniuk
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Kyiv 2021

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ АЕРОНАВІГАЦІЇ, ЕЛЕКТРОНІКИ ТА ТЕЛЕКОМУНІКАЦІЙ
КАФЕДРА АВІОНІКИ

**ДОПУСТИТИ ДО ЗАХИСТУ**
Завідувач кафедри
С.В.Павлова
«__»_________2021 р.

# ДИПЛОМНА РОБОТА
# (ПОЯСНЮВАЛЬНА ЗАПИСКА)
ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ “МАГІСТР”

**Тема: Особливості обмежень експлуатаційних швидкісних характеристик**

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Київ 2021

**NATIONAL AVIATION UNIVERSITY**

**Faculty of Air Navigation,**

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**Department of avionics**

**Speciality 173 «Avionics»**

APPROVED

Head of department

S.V. Pavlova

“___” ___________2021

**TASK**

**for execution graduate work**

_____V.R. Opareniuk_____

(surname, name, patronymic of a graduate student)

1. The theme of bachelor work: «The features of the operational velocity characteristics limitations of airplane», approved by the Rector`s order on «22» September 2021 № 1945/ст.

2. Duration of which: 18.10.2021 – 31.12.2021.

3. Initial data for the thesis: Process concept of flight safety as a formula of world scientific priority and methodology of light operator protection.

4. The content of the explanatory notes: Introduction. Chapter 1: Examination of aircraft accidents and incidents involving speed characteristics. Chapter 2: Requirements for minimum V-speed. Chapter 3: Calculation and selection of the indicator functional scheme elements. Chapter 4: Labor protection. Chapter 5: Environmental protection.

5. The list of mandatory graphic material: figures, graphs, tables

6. Planned schedule

| № | Task | Duration | Signature of supervisor |
|---|---|---|---|
| 1. | Validate the rationale of graduate work theme | 19.10.2021 | |
| 2. | Carry out a literature review | 20.10.2021–27.10.2021 | |
| 3. | Develop the first chapter of diploma | 28.10.2021–03.11.2021 | |
| 4. | Develop the second chapter of diploma | 02.11.2021–10.11.2021 | |
| 5. | Develop the third and fourth chapter of diploma | 11.11.2021–18.11.2021 | |
| 6. | Develop the fifth and sixth chapter of diploma | 19.11.2021–01.12.2021 | |
| 7. | Tested for anti-plagiarism and obtaining a review of the diploma | 07.12.2021 | |

7. Consultants individual chapters:

| Chapter | Consultant (Position, surname, name, patronymic) | Date, signature | |
|---|---|---|---|
| | | Task issued | Task accepted |
| Labor protection | Ph.D., Associate Professor Kovalenko V.V. | | |
| Environmental protection | Ph.D., Associate Professor Dmytrukha T. I. | | |

8. Date of assignment: «__» _________ 2021

Supervisor _____________ H.A. Polozhevets

(signature)

The task took to perform _____________ V.R. Opareniuk

(signature)

## ABSTRACT


Explanatory paper to the graduation work « The features of the operational velocity characteristics limitations of airplane» contained 70 pages, 15 figures, 16 tables, 15 information sources.

**The object of the research** – the aircraft minimal velocities indicator.

**The purpose of the bachelor work –** installation of aircraft indicators to assist the pilot in determining the approach of critical modes throughout the manual control.

During the process of the study, aircraft indicators were investigated, the benefits of which were discovered and the characteristics of the indicators were examined. Within the limitations of the specified indicator, a course was constructed that comprises data on critical angle of attack, speed loss, and stall warning features.

**Research Method** – collecting information about the aircraft minimal velocities indicator, velocity characteristics limitations, the correlation between the aircraft incidents and the speed characteristics neglect.

**The scientific novelty of the research:** investigated a $V_{min}$ analyzer capable of operating in manual, semi-automatic and automatic modes.

Functional block diagram of a three-mode analyzer was studied a and used Vmin to improve flight safety during landing.



**Keywords:** AIRCRAFT INDICATOR, AIRCRAFT ACCIDENTS, SPEED CHARACTERISTICS, HAZARDS, SAFETY, THREE-MODES INDICATOR.

**CONTENT**

## LIST OF ACRONYMS AND ABBREVIATIONS

| | | |
|---|---|---|
| ACS | – | Automatic Control System |
| SMM | – | Safety Management Manual |
| ADREP | – | The Accident/Incident Data Reporting Decision |
| NTSB | – | National Transportation Safety Board |
| LOC | – | Instrument Landing System Localizer |
| IAS | – | Indicated Airspeed |
| CFIT | – | Controlled Flight into Terrain |
| MOR | – | Mandatory Operator Report |
| AFM | – | Airplane Flight Manuals |
| VSI | – | Vertical Speed Indicator |
| EFIS | – | Electronic Flight Instrument System |
| EADI | – | Electronic Attitude Direction Indicator |

# INTRODUCTION

If we take a look onto the statistics of the flight accidents, we will see that the root of the issue for such notion is the crew mistakes in critical flight conditions. Therefore, it is vital important to velocity indicators implementation. By means of such indicators, the pilots will be alerted about the approaching to the maximum permissible values of flight parameters.

One of the biggest threats to aircraft is spin stall due to speed decreasing or increasing the angle of attack beyond the critical value. These two parameters are essential for the presence of lift on the wing and the operation of the control surfaces.

$$Y = C_y \frac{\rho V^2}{2} S,$$

where $C_y = f(\alpha)$- lift force coefficient, S – wing area, V – speed, ρ – airflow density.

In most cases, passenger aircrafts do not operate at extremely low speeds and do not execute dangerous maneuvers at critical angle of attack. Moreover, in its majority, the automatization process has also affected passenger aircraft, which leads the pilot work to become easier at night or during the bad weather conditions. Nevertheless, the negative properties are present as well. The pilots should perform all the control movements manually from their side in case of the failure or the operational unavailability. Additionally, in some cases the automatization can induce the spin. The most precise example of such situation is when the aircraft operates at high angles of attack at low speeds. During the stall, the roll will be observed alongside. In this case, if the pilot tries to reduce it, this maneuver can cause the robust stalling instead of the resolving the critical situation. This leads us to the conclusion that the pilots should perform the aircraft control manually from their end while operating at high angles of attack at low speeds.

As for the indicators, they are required to be installed in order to assist the pilot with the designation of the manual critical modes approach. The most noticeable consideration is such systems are highlighted for critical angle of attack, maximal overloading values, and maximum permissible vertical and horizontal velocities characteristics. In addition, the minimal indicator speed signalization may be disregarded due to the separation of its presence on auto-throttle of ACS power unit. Sometimes, it can cause the loss of aircraft control in case of auto-throttle failure during the landing on minimal velocities and angle attack presence.

Hereupon, it is obligatory to implement the velocity indicators into system of altitude-velocity parameters as a function of angle of attack, roll angle, the aircraft weight and altitude of flight. This will help with the increasing of the safety of aircraft control through the landing stage at high angles of attack and low speeds.

# CHAPTER 1
# EXAMINATION OF AIRCRAFT ACCIDENTS AND INCIDENTS INVOLVING SPEED CHARACTERISTICS

## 1.1 Aviation accidents examination of An-24 and An-124-100 aircrafts.

In comparison to another types of transport, the civil aviation is definitely the safest one. The probability of the aviation accident for the system “Aircraft-crew” is $10^{-9}$, regarding to the integrated norms of flight suitability. Per one accident, it correlates to the middle flying hours $10^{9}$ hr. The overall probability of an emergency scenario is $10^{-7}$. As for the difficult scenario, the overall probability is $10^{-5}$ per 1 flight hour. The Safety Management Manual (SMM) was implemented by the ICAO. The information regarding aircraft incidents and accidents is accumulating in the SMM database. SMM collects, stores, and processes information about aviation events and accidents in order to investigate the reasons and factors impacting aviation safety.

Accidents are seldom the outcome of a single cause; rather, they are the consequence of the interactions among multiple variables. They are called factors. That is, "emergency factors" refers to any circumstance, event, or scenario that could cause an accident. For example, improper crew activities, airplane component issues, and environmental influences.

An-124 is an example of incorrectly specified higher velocity range limits, while An-24 is an example of incorrectly established minimal velocity range limits.

An-24 is a twin turboprop transport/passenger airplane developed in 1957 and constructed by the Antonov Design Bureau in the Soviet Union.

a) An Antonov 24 passenger aircraft was crashed in a landing accident at Nizhneangarsk Airport. An-24RV airliner of Angara Airlines operated a scheduled flight IK-200 on the Ulan-Ude-Nizhneangarsk-Irkutsk route. During the approaching the Nizhneangarsk airport, the aircraft rolled out of the runway and crashed into the building of a health clinic. After landing, the aircraft was not able to stay within the concrete runway. The airplane began to dodge to the right and left the runway. The liner then proceeded along the ground, smashing through the airfield's barrier before colliding with a facility housing rehab centers and catching fire. Furthermore, it was confirmed that due to the fact that the crew commander became ill before departure, the airline replaced him with an inspector pilot.

b) The first aviation crush with the Ruslan happened on October 13, 1992. The Antonov Design Bureau airplane collapsed in Kiyv, Ukraine.  The accident happened throughout a flight-testing and it was caused by maximum velocity breach.

Take into account the characteristics of the account aspects relevant to the pilot mentioned in the ICAO's Accident Prevention Manual. The presence of a so-called "chain factor" is the central idea of this work (Figure 1.1).

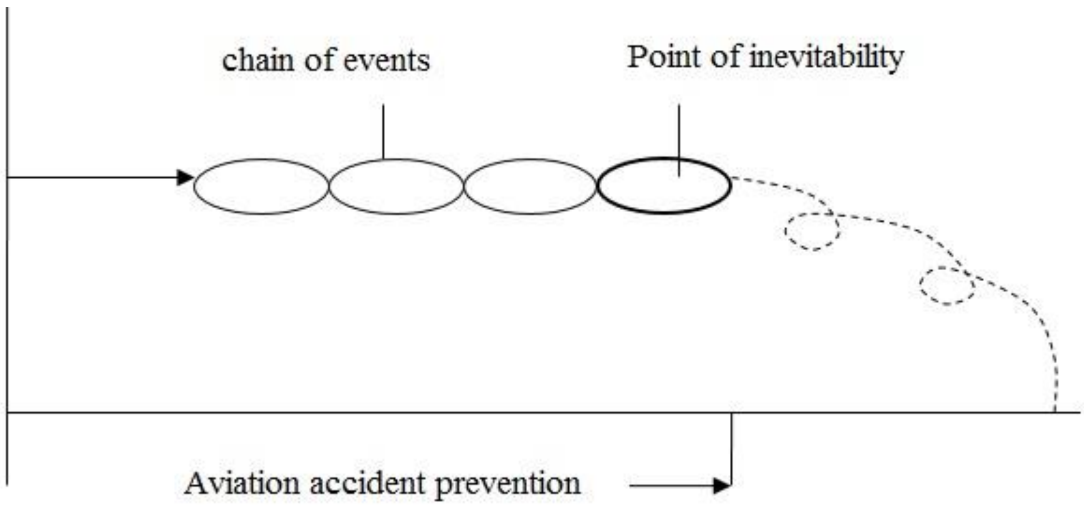


Fig 1.1 Model ICAO - factorial chain of events expansion - AP, 1984

According to the factor method, ICAO1984 assigned 114 factors and generated a set of factors that acted on all potential accidents. In this element group, the 13-element circuit (group) element that exists in flight and leads to the so-called "point of need" limits the pilot's ability to neutralize element loads. However, the nature and mechanism of the "need" is not yet clear. The chain length limiting factor for incident 13 is based on the vast amount of data demonstrated in the ICAO incident analysis. In 1997, "Boeing" increased the number of maximum accident rate coefficients corresponding to the entropy model to 20.

In this review, notifications for ADREP-type emergency factors were created and safety recommendations were made and sent to the relevant authorities.

Of course, ICAO's position is quite positive. This is because the purpose is not to prevent accidents, but to collect and analyze statistical data. In addition, the aforementioned accident prevention manual points out that the burden of flight factors on the pilot cannot be basically eliminated because new emergency factors will be incorporated in future aircraft.

When evaluating "chain factors", it is important to remember that the applicable limit is the maximum number of factors involved. There is no transition from factor level to outcome in this concept. In other words, it is a concept that randomly arranges and executes several factors given at the beginning considering the boundary. Therefore, it is possible to analyze only typical and often additive factor loads without considering the influence of some factors acting simultaneously.

There is also a concept proposed by 'Boeing' in 1997. This model is referred to as the “Dutch Cheese” model, which states that the AP has up to 20 elements that make up an individual event (Figure 1.2). Accidents occur when rotating disks coalesce.

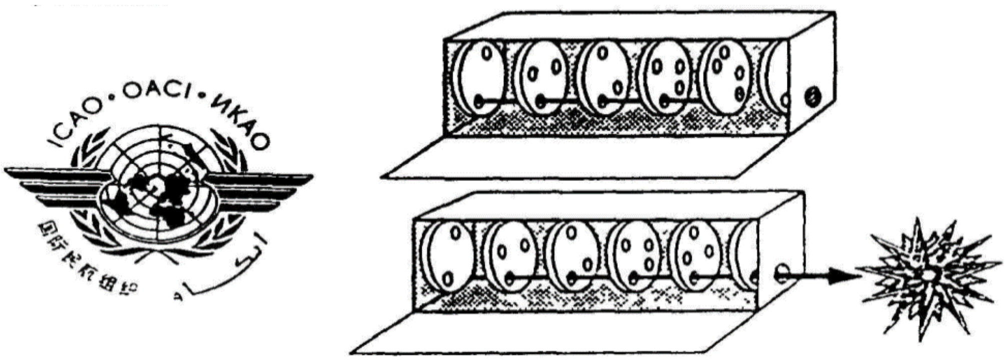

Fig 1.2. Model of "Dutch cheese"

Consider receiving data from a spinning disk to reduce the number of holes per disk to avoid accidents. This method is just an example. We have identified many elements in the same accounting method.

Currently, the International Civil Aviation Organization is publishing a new document called 'Safety Management Guidelines'. Figure 1.3 shows the structure of this manual. For example, you can see that the section "Solar Business" contains only air traffic services, airport and aircraft technical maintenance and approval processes to avoid errors in the maintenance process. The bottom line is that the ICAO BP concept is based on a systems approach, implies consideration of factors related to the above two modes, and includes very limited flight operations (without flight management forms).

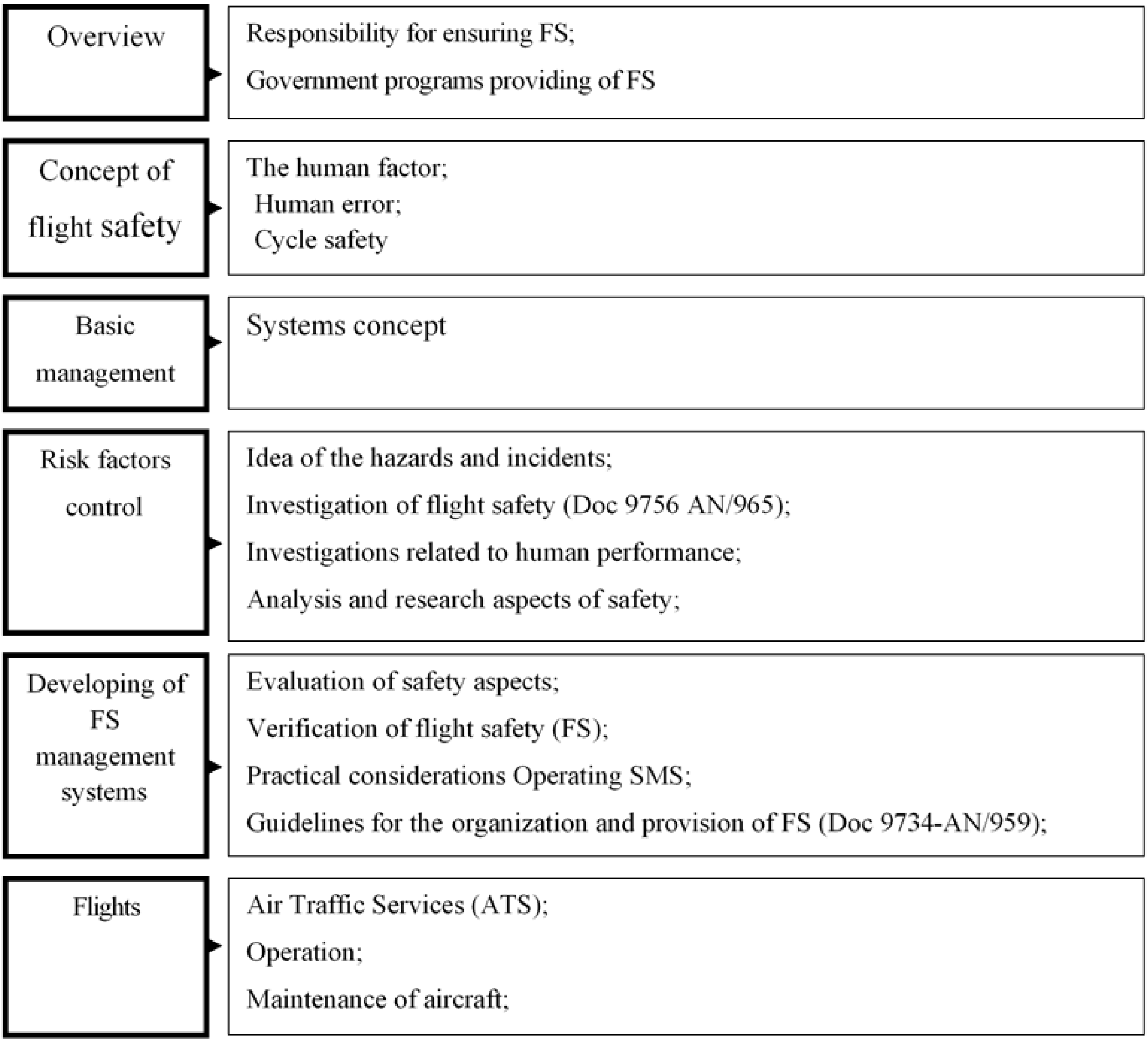


Fig 1.3 The structure of the Guidance on safety management

The following ICAO documents point out that the identification and control of safety factors is a key process safety control. In addition, factors arising from the absence of a model that considers the interaction of various factors must also be considered. Therefore, in order to analyze and prevent accidents, it is essential to establish a general model that considers the interaction of various factors (currently, ICAO uses 1500~2000 factors).

## 1.2 Critical angles of attack, bank angle and stall speeds

The slower the aircraft, the greater the angle of attack required to achieve lift equal to the weight of the aircraft. If the velocity drops further, this angle becomes the ultimate angle of attack (stall) at some point.

This speed is called stall speed. Airplanes flying over the stables cannot go up, and airplanes flying below the stables cannot stop descending. If you increase your angle of attack without increasing your relative speed, you will stall.

Actual stall speed depends on the weight, altitude, configuration and vertical/horizontal acceleration of the aircraft. The reference for a zero-throttle situation is given by the following V-Speed:

- $V_S$: The calculated stall rate when the window frame retracts at its design rate. Usually the same value as $V_{S1}$.
- $V_{S0}$: Stall during landing (flaps fully open, gear down and spoiler folded).
- $V_{S1}$: Stall in a "clean" configuration (flaps, landing gear and spoiler folded as much as possible).
- $V_{SR}$: Reference stall speed.
- $V_{SR0}$: Reference stall speed in the landing configuration.
- $V_{SR1}$: Reference stall speed in the clean configuration.
- $V_{SW}$: The rate at which a natural or artificial stall alarm is triggered.

On the speedometer, the bottom of the white arc represents the maximum weight of $V_{S0}$ and the bottom of the green circle represents the maximum weight of $V_{S1}$. While the $V_S$ speed of an aircraft is calculated by design, the speeds of $V_{S0}$ and $V_{S1}$ must be empirically proven through flight tests.

The critical angle of attack is the angle of attack that gives the maximum coefficient of lift. This is also called "stall attack angle". Below the critical angle of attack, the coefficient of lift (Cl) increases as the angle of attack increases. At the same time, above the critical angle of attack, as the angle of attack increases, the air does not flow uniformly over the top of the wing and begins to move away from it. For most wings, as the angle of attack increases, the point of separation from the top of the airflow moves from the trailing edge to the leading edge. At the critical angle of attack, the airflow in the upper plane is more separated, resulting in the highest coefficient of lift for the wing and fuselage. The larger the angle of attack, the more separated the airflow in the upper plane and the smaller the lift coefficient of the wing and fuselage.

Beyond this critical angle of attack, the aircraft stalls. A fixed-wing aircraft, by definition, stalls above its critical angle of attack and not below its relative speed. The relative speed of an airplane stall depends on the weight of the airplane, its load factor, the airplane's center of gravity, etc. However, the aircraft always stalls at the same critical angle of attack. The critical angle of attack and stall angle of most wings is typically between 15° and 20°.

Some aircraft are equipped with flight computers that automatically control the angle of attack when the maximum angle of attack is reached, regardless of pilot manipulation. This is called the "angle of attack limiter" or "α limiter". Thanks to the software in the computer system controlling the flight control surfaces, the most advanced commercial aircraft equipped with Flight-by-Wire technology can avoid critical angles of attack.

Aircraft can be equipped with angle-of-attack and lift reserve indicators when taking off and landing on short runways, such as naval carrier operations and rear STOL flights. These instruments directly measure the angle of attack (AOA) and wing lift potential (POWL or lift reserve), allowing the pilot to fly closer to the stall point. For STOL operation, it should be possible to operate at an angle close to the critical angle of attack upon landing and at the optimal angle of ascent during take-off. Because relative speed information relates only indirectly to stalling behavior, pilots use the angle of attack indicator in these maneuvers to achieve maximum performance.

Recently, concerns have been expressed about accidents that occurred prior to working at relatively slow high angles. Any accident can be regarded as a single accident. If there are multiple accidents, can the average pilot understand the relationship between stall and lateral pitch angle? The problem still exists. Here, basic aerodynamic characteristics are identified and a simple method to prevent such accidents is proposed.

First of all, why does the plane stall? The only answer to this question is that the maximum angle of attack has been exceeded. Technically speaking, the pitch angle is either 0 degrees or 90 degrees, regardless of whether the relative speed is high or low. In practice, however, relative speed and pitch angle are closely related to aircraft stall. Why?

Figure 1.4 shows the curved flight of an airplane. Let's look at the lift and gravity acting on this plane. To initiate and maintain the turn, the pilot began to lean. The lift vector then rotates to be perpendicular to the wing and the vertical component of the lift vector decreases without the pilot doing anything. If no action is taken, it becomes a "fly" destination.

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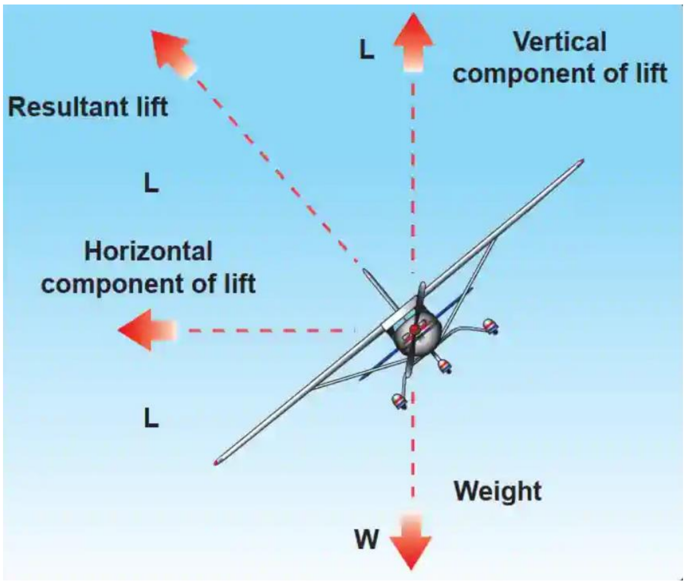



Fig 1.4 Airplane in turning flight

If no action is taken, it becomes a "fly" destination. Therefore, to maintain flight level, the pilot must increase lift to keep the vertical lift component equal to the weight. To do this, increase the angle of attack of the wing by pulling the poles. Of course, with any wing, the maximum angle of attack is

The ability of wings to produce. As the pitch angle and lift vector increase and exceed the maximum angle of attack, the aircraft loses control.

Basic trigonometry can be used to determine how much support vector must be added to balance the weight at a given angle. There is a formula called:

$$\cos\varphi = \frac{W}{L} = \frac{1}{n}, \quad (1.1)$$

where

φ is the bank angle

W is the weight

L is the lift force necessary to sustain the turn

n is the load factor, or “G” forces for that angle of bank.

Since lift is proportional to the square of the relative velocity, it can be seen that the increase in stall velocity due to pitch angle is proportional to the square root of the load factor.

$$V_{S\varphi} = V_S\sqrt{n}, \quad (1.2)$$

where

$V_{S\varphi}$ - is stall speed at some angle of bank φ;

$V_S$ - is stall speed for wings level, one G flight.

Using this formula and the flight manual for the MU-2B-60, Table 1 was created.

Table 1

| Bank angle φ | 0˚ | 15˚ | 30˚ | 45˚ | 60˚ | 75.5˚ |
|---|---|---|---|---|---|---|
| Load factor n | 1 | 1.035 | 1.154 | 1.414 | 2 | 4 |
| Percent increase in Vs | 0 | 1.7% | 7.4% | 18.9% | 41.4% | 100% |
| Stall speed of an MU-2B-60 at maximum weight, flaps up | 105 KCAS | 107 KCAS | 113 KCAS | 125 KCAS | 148 KCAS | 210 KCAS |

More importantly, the stall speed increases only slightly at low tilt angles, but increases significantly when the tilt angle exceeds 45°. This can be seen in Figure 1.5. For example, suppose a pilot is maneuvering at a speed of 140 knots in the terminal area. If you fire at 60˚, you will stall.

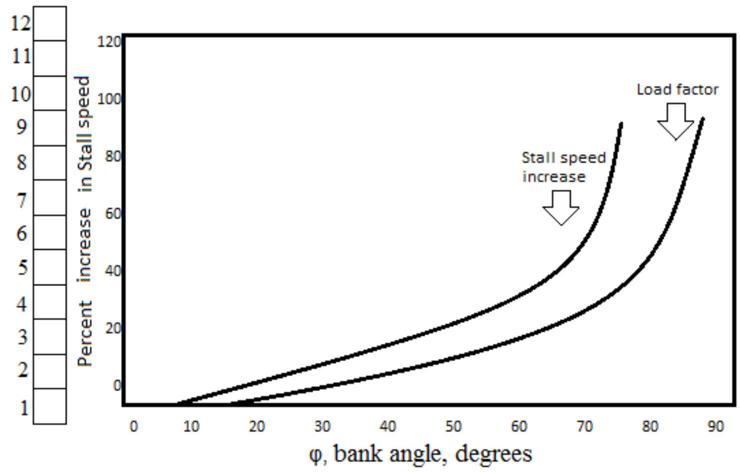



Fig 1.5 Stall speed & bank angle dependence

Consider this excerpt from the NTSB final report for an accident in Puerto Rico:

"Review of NTSB plotted radar data revealed that the pilot performed one 360-degree orbit to the left with varying angles of left bank … flying initially at 1,300 feet, climbing to near 1,500 feet, then descending to approximately 800 feet. The airplane continued in the left turn and between 1502:10 and 1502:27, the calibrated airspeed decreased from 160 to 100 knots. At 1502:27, the bank angle was 48 degrees…".

The dangers of low relative speeds and high inclination angles are no longer clear. To avoid such accidents, it is important to avoid high inclines and maintain sufficient flight speed. Some airlines prohibit pitch angles of more than 30 degrees during maneuvers and more than 15 degrees during finals. Also, these airlines are designed to rotate at a very clear speed before approaching, leaving plenty of room for stalling depending on their configuration. This should be a standard operating procedure for all pilots. The MU-2 flies over 150 knots in a clean state, and 140 knots or more when the flaps are set to 5˚. This provides a stall margin of over 40 knots even when the pitch reaches 30 degrees.

Even if there is only one engine, this rule can guarantee a sufficient factor of safety. A lap is required whenever the driver believes that access is not possible without exceeding these limits. The earlier the circle starts, the less busy it is. Also keep in mind that packaging is more popular than NTSB's report.

**Conclusions**

If the current $V_{min}$ and Vmax are disturbed, aircraft accidents and incidents can occur. An example of such an accident is the destruction of the Antonov 24 airliner in a landing accident due to a violation of $V_{min}$ rules on February 13, 2013, and the first accident with Ruslan has happened on October 13, 1992. The aircraft of the design bureau crashed throughout flight tests near Kiyv, Ukraine for a violation of $V_{max}$.

# CHAPTER 2
# MINIMUM V-SPEED. REQUIREMENTS FOR MINIMUM V-SPEED

## 2.1. General analysis of airworthiness standards according to the range of minimum speeds

The requirements for flight characteristics, stability and control include a set of indicators that determine the allowable dynamic properties of the aircraft at each stage of the flight. One of the main principles of normalization of characteristics is a detailed study of critical flight modes, namely: minimum speed with asymmetric thrust, called at large angles of attack, the behavior of the aircraft at maximum speeds and accelerations, etc. and that is why exceeding critical flight modes for aircraft is prohibited, as an emergency or catastrophic situation may occur.

Let's focus on the minimum speed, moreover, we want to create an indicator to signal the allowable minimum speed. Based on the data obtained from the analysis of flight accident statistics for the last decade, we have that a significant part of them are errors of flight personnel, especially in critical flight conditions. Figure 2.1 shows that 46% of accidents are caused by LOC and CFIT, while the number of accidents related to loss of control has increased over the last 35 years, especially during takeoff, route, landing and landing. These cases are associated with a high level of automation to simplify the work of the crew, which also leads to the loss of the pilot's ability to fly in extreme conditions to emergencies.

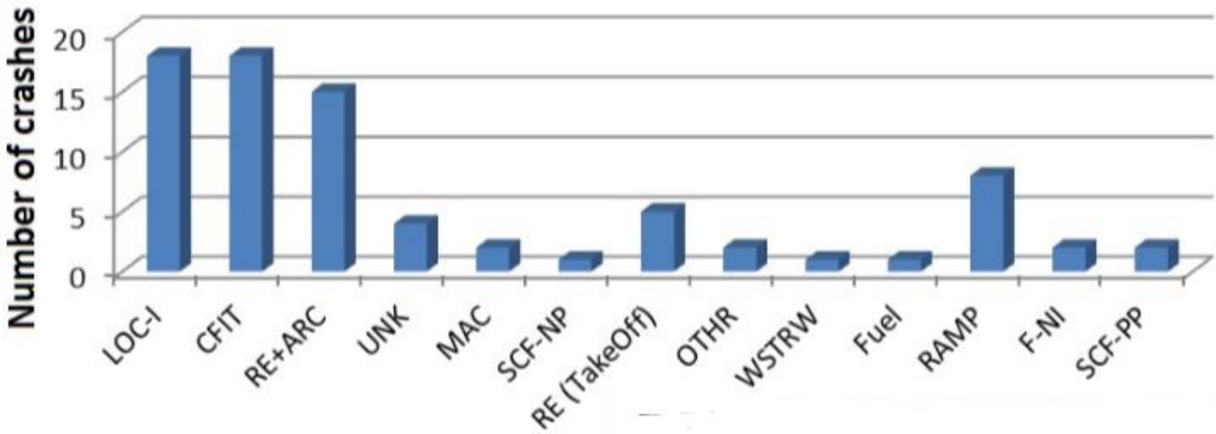



Fig 2.1 Analysis of the main crash categories

Simplifying manual piloting and controlling the exclusion of critical modes requires the installation of indicators on the aircraft, which help the pilot to determine the critical modes, and in some cases to correct them automatically.

It is known that the aircraft flies due to the lifting force, in turn, the lifting force varies according to 2 main parameters: air speed and lift coefficient as a function of wing pickup angle.

$$Y = C_y \frac{\rho V^2}{2} S \,, \tag{2.1}$$

where

$C_y = f(\alpha)$- lift force coefficient;

ρ - density of the airflow;

V – speed;

S - wing area.

Moreover, the parameter that expresses the totality of all forces acting on the aircraft is the overload (n), which characterizes the control of the aircraft.

When the lifting force is reduced to a level less than the force of gravity, it leads to loss of height and failure, so one of the main emergencies is to increase the angle of its attack above the allowable or stop due to loss of speed.

Modern aircraft are equipped with warning systems, for example, IL-76 has a warning system that the level of the angle of attack exceeds the allowable, and the An-148 set of altitude and speed parameters includes a signal unit that receives information from the linear accelerometer unit (overload ) and from the flow angle sensor - about the angle of attack.

It should be noted that the modern indication system focused on the following parameters: allowable vertical speeds, critical angle of attack, maximum acceleration values and others, but neglects the signaling of the minimum allowable speed. They provide control to prevent it from occurring in automatic traction, such neglect can lead to the failure of the throttle during approach and difficult weather conditions, which in turn will lead to loss of control.

When connecting pilots, use a minimum landing speed, which should not be less than the minimum control speed, so phase alignment can increase the angle of attack to set the vertical and longitudinal speed. Smaller pickup angles increase resistance and decrease loss of speed and height. In critical flight modes, a pilot who does not have sufficient appropriate skills will begin to pull the rudder to take off.

Because the speed is not critical, the aircraft gains altitude, and increasing the angle of attack increases the resistance, so the speed decreases, which leads to a more intense loss of lift and stop the aircraft. In addition, increasing the angle of attack to a critical minimum at low speeds can lead to disruption of airflow at the top of the wing, which dramatically reduces the coefficient of lift. The presence of rolling angles at low speeds and the excess weight of the aircraft during landing also have an important influence on the conditions of dumping. Based on this, some types of aircraft have a fuel capacity similar to the dry weight of the aircraft, in such cases during the flight the aircraft weight is reduced by almost half, and such aircraft have strict restrictions on landing weight, as well as changing the minimum controlled air speed and critical angles.

All these parameters must be taken into account when calculating the minimum controlled air speed and the critical angle of attack. Therefore, it is proposed to introduce an analysis that can determine the critical flight parameters, such as maximum allowable overload, critical angle of attack, information about the actual weight of the aircraft. It calculates the impact by characterizing the aircraft's gravity and angle.

## 2.2 Hazards, understanding the risks and consequences

According to the information obtained from the Safety Management Manual, hazard identification is a prerequisite for the safety risk management process. Therefore, incorrect definitions of hazard and safety hazard can lead to confusion. Risk identification is an important step in risk assessment and management, and a clear understanding of risks and their consequences is an important way to implement sound security risk management.

Hazard is generally defined as a condition or object that can cause personal injury, equipment or structural damage, death, material loss, or damage to its intended function. To manage aviation safety risks, the risks must be focused on the conditions of aircraft operation or aviation safety equipment, products and services that may or may not pose a hazard.

For example, consider 15-node of wind that is not necessarily dangerous (15 knots of wind blowing directly on the runway actually improves the take-off and landing characteristics of the aircraft), but 15- node of wind is converted into wind and the intended Crossing a take-off or landing runway 90 degrees creates a crosswind condition.

Crosswind conditions can be hazardous as they can contribute to operational events of the aircraft, such as a lateral misalignment of the runway.

Obviously, risk is an essential part of aviation, but its manifestations and possible consequences can be fundamentally overcome through a variety of mitigation strategies to include potential hazards that could lead to hazardous operation of an aircraft or aircraft equipment.

In general, we tend to confuse risk with consequences and sequelae. Consequences are the end result of risk. For example, flying a runway with respect to the risk of runway contamination is a predictable outcome. This risk must be clearly recognized and appropriate outcomes designed. It should be noted that the results can be multi-step. For example, there are several moderately dangerous events before the final outcome (accident). See Table C in Appendix 2 for details.

In the example above, unusual winds could result in a risk of loss of lateral control, drifting out of lane, and ultimately an accident. Therefore, potential risks emerge from multiple outcomes, and safety assessments can include a comprehensive description of all possible outcomes in realistic and accurate language. More importantly, the most extreme outcome is loss of life, which must be distinguished from those that lead to minor consequences such as passenger discomfort, increased burden on crew and reduced safety. A full understanding of the risks allows you to better assess the potential impact. A description of expected outcomes helps implement and formulate effective mitigation strategies through appropriate prioritization and allocation of limited resources.

Hazards should be distinguished from errors, which are a normal and inevitable component of human activity that need to be managed.

### 2.2.1 Hazard identification and setting priorities

Risks exist at all levels of an organization and can be identified through reporting systems, inspections or audits. When a hazard interacts with a specific trigger, a failure can occur, so the hazard must be identified before it can lead to an accident, accident, or other safety-related event. One of the most important risk identification factors is the voluntary hazard/accident reporting system, the information gathered through these reporting systems can be supplemented by observations or findings recorded during regular on-site inspections or organizational audits.

In particular, threats that are considered to be direct factors or threats that may not be properly addressed by corrective actions taken in the course of the investigation may be identified or deleted from the investigation report. Based on this, the system review process of incident investigation/hazard identification incident reporting is a good mechanism to improve the organization's risk identification system and improve overall safety.

Risk factors can be classified according to the source or location, the priority of risk factors can be determined objectively, and classification may be necessary according to the severity/probability of expected results. This allows you to prioritize risk mitigation strategies to make better use of scarce resources.

### 2.2.2 Hazard identification methods

There are three main methods for determining hazards:

1. *Proactive* - by analyzing existing or real-time situations. This is the core work of the security function with its audits, evaluations, employee reports and related analysis and evaluation processes, and includes an active search for hazards in existing processes.

2. *Reactive* - by analyzing past results or events, that hazards are determined by studying safety events. Incidents and accidents are clear indications of a system's faults and can therefore be used to identify the risk that is behind or hidden behind an event.

3. *Forecast* - a method that by collecting data to determine possible negative future results or events. By analyzing system processes and the environment, potential hazards are identified in the future in order to take further mitigation measures.

### 2.2.3 Distinguishing between aviation and occupational health, safety and the environment (OSHE)

The hazard depends on its potential or foreseeable consequences or risks, which may provide insight into whether the hazard is related to aviation safety or health, safety and the environment (OSHE). Any hazard that may affect (directly or indirectly) the operational safety of aircraft or aviation safety equipment, products and services should be considered relevant to aviation SMS. Hazards that have only safety and health implications (that without any impact on safety) should be considered separately in the organization's OSH system / procedures in accordance with the relevant national or organizational health and safety requirements, respectively.

Not relevant to aviation SMS hazards and safety that do NOT affect aviation safety.

Safety risks associated with complex hazards that affect both health and aviation safety can be managed through parallel risk mitigation processes to address individual health and aviation effects, respectively, as an alternative, To eliminate such complex hazards, you can use an integrated system of risk reduction in aviation and health, for example, consider the complex hazard "lightning strike in the plane" (at the airport transit gate): the labor inspector can consider this hazard as "hazard workplace ”(ground safety / workplace safety), at the same time for the aviation SMS inspector it is also an aviation hazard with the risk of damage to the aircraft and the safety of passengers. Such consequences need to be properly considered separately, as the consequences of such complex hazards related to condominiums and aviation security are not the same, and the purpose and direction of preventive control over the consequences of safety and security will be different.

## 2.3 The concept of V-speed

V-speed is a term used to determine an important or useful factor in any aircraft operation, namely airspeed. These speeds are based on data obtained by aircraft designers and manufacturers during flight tests and are tested by state flight inspectors during aircraft certification tests in most countries. Its use is considered best practice for maximum aircraft performance, aviation safety, etc.

The actual speed indicated by the special mark is indicated by the specified airspeed and is unique to a particular aircraft model, so the pilot uses it without applying a correction factor. In typical aircraft, they are most often used for safety and, most importantly, in front of the aircraft's speed indicator, which is indicated in the form of arcs and colored lines. The failure rate with flaps removed is indicated by the bottom of the green arc, and the dump speed with flaps fully extended is indicated by white arcs, respectively, and is the stopping speed of the aircraft at full weight. Proper indication of V speed is a prerequisite for airworthiness of aircraft certified in most countries.

Minimum Control speeds (VMC’s) are the so-called V-speeds, which are included in the Air Traffic Control (AFM) section of all multi-engine airplanes. In general, the minimum control speed is the calibrated air speed below which the guide and / or lateral control of the aircraft (ie desired course and / or roll angle) on the runway or in the air can no longer be maintained by the pilot after engine failure. mounted on the wing, or when such an engine is not running while the thrust of the opposite engine on the other wing is at maximum installation. The VMC can also be used by aircraft designers to determine the dimensions of the aerodynamic surfaces of the flight control and the stabilizer or vertical tail.

Most pilot manuals and accident investigator report present and use VMCs as defined in the Aviation Regulations, which are intended for the design and certification of multi-engine airplanes, such as FAR 23 or FAR 25 or equivalent, and not as they apply to operational use. aircraft pilots. Thus, this work aims to bridge the knowledge gap between design engineers, pilots and crash investigators, flight test crews, explaining the minimum control speeds of VMCs, how they are used in aircraft and teaching aviation universities, teaching test pilots in schools, for example such as the U.S. Air Force Test Pilot School, the Empire Test Pilot School, and the US Navy Test Pilot School. The following is a table of basic definitions of minimum V-speeds for the period 1993-2005, using the Airworthiness Standards and Aviation Regulations (Table 2.1).

Table 2.1

Basic determinations of minimum V-velocities for the period 1993-2005

| Description | V-speed designator | НЛГС/AR | Year |
|---|---|---|---|
| Minimum control speed in the air (or airborne) | $V_{MCA}$ | aircraft flight manual (Chpt. II) | 2001 |
| Minimum control speed on the ground is the lowest speed at which the takeoff may be safely continued following an engine failure during the takeoff run. | $V_{MCG}$ | AR-25 | 2004 |
| Minimum unstick speed | $V_{MU}$ | aircraft flight manual (Chpt. II) | 2001 |
| Engine failure recognition speed. | $V_1$ | НЛГС-2 | 2005 |
| Minimum takeoff safety speed | $V_{2\,min}$ | НЛГС-2 | 2005 |
| Minimum control speed in the landing configuration with one engine inoperative | $V_{MCL}$ | AR-25 | 2004 |
| Minimum control speed in the landing configuration with one critical engine inoperative | $V_{MCL-1}$ | aircraft flight manual (Chpt. II) | 2001 |

| | | | |
|---|---|---|---|
| Minimum control speed in the landing configuration with two critical engines inoperative (for airplanes with 3 or more engines) | $V_{MCL-2}$ | aircraft flight manual (Chpt. II) | 2001 |
| Minimum control speed of go-around mode | $V_{min\ эк}$ | НЛГС-2 | 2005 |
| Minimal simulated Landing reference speed | $V_{ВКД\ min}$ / $V_{Ref}$ | НЛГС-2 | 2005 |
| **Stall speed** is defined as the minimum steady flight speed at which the airplane is controllable. | $V_s$ | AR-23 | 1993 |
| Stall speed or minimum steady flight speed for which the aircraft is still controllable in a specific configuration | $V_{s1}$ | AR-23 | 1993 |
| Stall speed or minimum flight speed in landing configuration | $V_{s0}$ | AR-23 | 1993 |
| Safe single engine speed | $V_{SSE}$ | AR-23 | 1993 |

## 2.4 Safety indicators and performance monitoring

Organizations' safety data collection and analysis systems typically present results in graph and tabular format. Tables and charts commonly used in traditional quality/reliability management systems can provide a "snapshot" of data analysis with a single query. An example of this analysis diagram is as follows (Figure 2.2).

The graph below shows the absolute number of Mandatory Operator Report (MOR) accidents by vehicle type in 2009. This alone is not sufficient as a continuous indicator of safety performance, but as you can see the main figure reflects the number of aircraft in each fleet, not the number of flights in each fleet. Therefore, we conclude that the usefulness of this type of graph is limited.

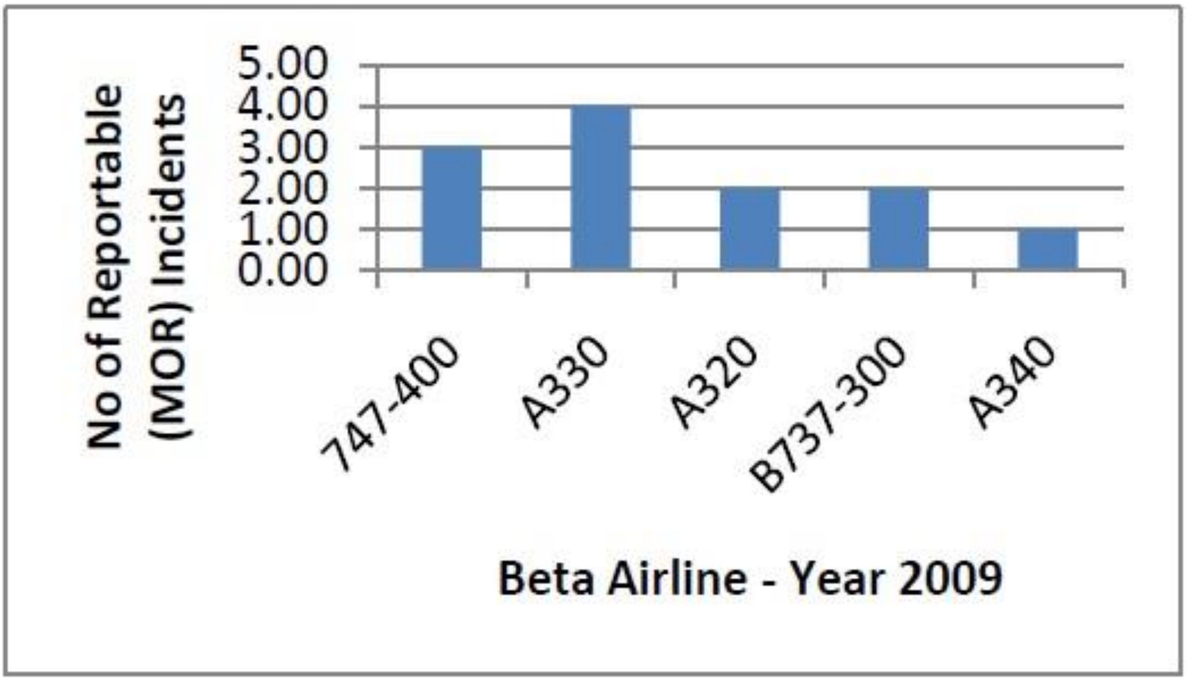



Fig 2.2. A basic (screen shot) data analysis chart

Analysis for continuous safety monitoring comes in the form of regularly extracting data and generating charts and trend graphs that are updated monthly or quarterly (Figure 2.3). This data graph provides details. Monthly information reports taking into account the fleet cumulative flight time (FH) of the report operator. For continuous trend monitoring, downloading monthly incident data is useful when a continuous trend monitoring indicator chart is generated. The next step is to define the target level and warning level in the graph, which is converted into a measure of safety performance. This step is recommended if historical data points have already been created in the chart, and historical data points are intended to identify or identify unacceptable levels of trends and levels of improvement that must be achieved. It works as a basis. in extra time.

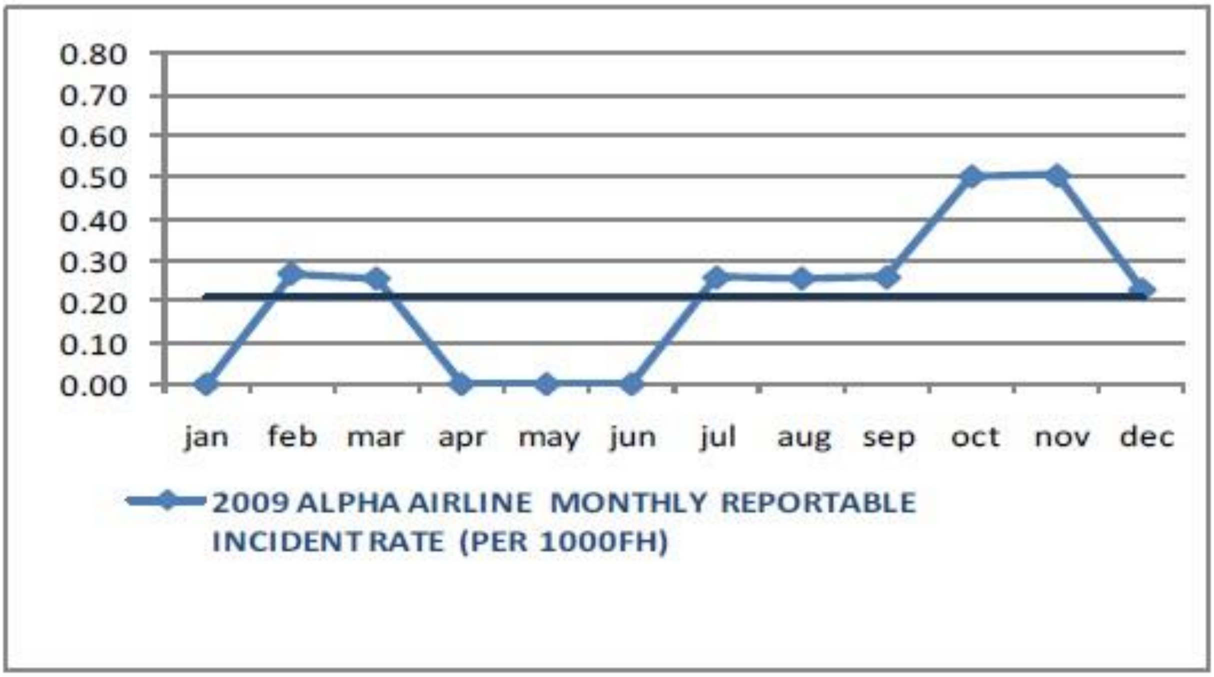



Fig 2.3. A continuous monitoring safety indicator chart

**2.5 Safety risk**

Security risk management is another important element of a security management system.

The term “security risk management” is used to distinguish this function from financial risk, legal risk and economic risk management. This section introduces you to the basics of managing security risks, including:

a) security risk determination;

b) the probability of security risk;

c) the severity of the security risk;

d) tolerance of security risk;

e) security risk management.

Safety risk is the expected probability and severity of the consequences or consequences of an existing hazard or situation, the outcome being an accident, a 'moderate risk event/consequence' and can be defined as the 'most reliable outcome'. do. Ensuring that these effects are clearly identified at multiple layers often involves advanced risk mitigation software.

### 2.5.1 Safety Risk Probability

The safety risk management process begins with an assessment of the likelihood of hazardous outcomes occurring during an organization's aviation activities.

The probability of a safety risk is interpreted as the frequency with which a safety result or consequence may occur. Probability will help identify issues such as:

- How many employees are affected or follow these procedures?
- To what extent is the organizational, managerial or regulatory impact likely to pose a significant threat to public safety?
- What percentage of the time suspicious equipment or suspicious procedures are tested and investigated?
- What similar equipment/components or others of the same type may have similar defects?
- Is this an isolated case, or is there a history of events similar to the one under consideration?

Considering all possible scenarios, one of the fundamental factors in these questions helps to assess the likelihood of a risk. Determining future probabilities will help you determine your security risk probabilities.

Table 2.2 is a table of common security risks, and here are five tables. The table includes five categories, a description of each category, and an assignment to each category to show the probability of an event or crisis occurring.

This is just one example, the level of detail and complexity of tables and matrices should be tailored to the specific needs and complexity of different organizations, and a value of 15 should be respected.

Table 2.2.

Safety risk probability table

| Likelihood | Meaning | Value |
|---|---|---|
| **Frequent** | Likely to occur many times (has occurred frequently) | **5** |
| **Occasional** | Likely to occur sometimes (has occurred infrequently) | **4** |
| **Remote** | Unlikely to occur, but possible (has occurred rarely) | **3** |
| **Improbable** | Very unlikely to occur (not known to have occurred) | **2** |
| **Extremely improbable** | Almost inconceivable that the event will occur | **1** |

### 2.5.2 Safety Risk Severity

Once the probability assessment is complete, the next step is to assess the severity of the risk, taking into account the potential impact of the risk.

The severity of a security risk is defined as the degree of consequences or harm that could reasonably be caused by the identified risk. Severity assessment can be based on:

a) Casualties: How many lives could be lost (staff, passengers, spectators, public)?

b) Damage: What is the possible extent of damage to the aircraft, property or equipment?

The severity assessment should consider the worst foreseeable and all consequences associated with a hazardous situation or object. Table 2.3 is a table of typical security risk severities. It includes the severity, a description of each category, and the five categories assigned to each category. As with the Security Risk Probability table, this table is an example only.

Table 1.3

Safety risk severity table

| Severity | Meaning | Value |
|---|---|---|
| **Catastrophic** | — Equipment destroyed<br>— Multiple deaths | **A** |
| **Hazardous** | — A large reduction in safety margins, physical distress or a workload such that the operators cannot be relied upon to perform their tasks accurately or completely<br>— Serious injury | **B** |
| **Major** | — A significant reduction in safety margins, a reduction in the ability of the operators to cope with adverse operating conditions as a result of increase in workload, or as a result of conditions impairing their efficiency<br>— Serious incident | **C** |
| **Minor** | — Nuisance<br>— Operating limitations<br>— Use of emergency procedures<br>— Minor incident | **D** |
| **Negligible** | — Little consequences | **E** |

## 2.5.3 Safety Risk Tolerability

A security risk score can be derived using a process that evaluates the probability and severity of a security risk. The index generated by the above method consists of an alphanumeric value that combines the results of a probability and severity assessment. The security risk assessment matrix in Figure 2.3 shows each combination of severity and potential.

The third step is to determine your risk tolerance. First, you need to get metrics from your security risk assessment matrix. For example, consider a situation where the probability of a safety hazard is sometimes rated as hazard (4) and the severity of the safety hazard is rated as hazard (B). The combined value of probability and severity (4B) is the resulting security risk score.

The metrics obtained from the Security Risk Assessment Matrix should then be output as a Security Risk Acceptance Matrix that describes the acceptance criteria of a particular organization. Security Risk Standard 4B, assessed in the example above, falls into the category of "Not acceptable under current circumstances." In this case, the resulting safety risk index is not acceptable. Therefore, the organization:

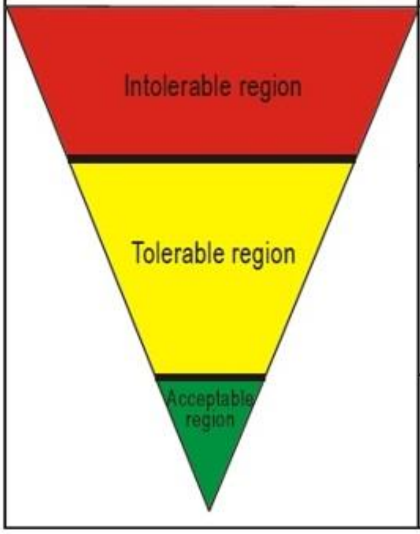
a) Take action to reduce an organization's exposure to a specific risk, such as reducing the potential component of a risk indicator;

b) take steps to reduce the severity of the risk-related consequences, such as reducing the severity of the risk index;

c) stop working if mitigation is not possible.

| Risk probability | | Risk severity | | | | |
|---|---|---|---|---|---|---|
| | | Catastrophic A | Hazardous B | Major C | Minor D | Negligible E |
| Frequent | 5 | 5A | 5B | 5C | 5D | 5E |
| Occasional | 4 | 4A | 4B | 4C | 4D | 4E |
| Remote | 3 | 3A | 3B | 3C | 3D | 3E |
| Improbable | 2 | 2A | 2B | 2C | 2D | 2E |
| Extremely improbable | 1 | 1A | 1B | 1C | 1D | 1E |

Fig 2.4 Safety risk assessment matrix



| Suggested criteria | Assessment risk index | Suggested criteria |
|---|---|---|
| Intolerable region | 5A, 5B, 5C, 4A, 4B, 4C | Unacceptable under the existing circumstances |
| Tolerable region | 5D, 5E, 4C, 4D 4E, 3B, 3C, 3D 2A, 2B, 2C, 1A | Acceptable based on risk mitigation. It may require management decision. |
| Acceptable region | 3E, 2D, 2E 1B, 1C 1D, 1E | Acceptable |

Fig 2.5 Safety risk tolerability matrix

## 2.5 Safety risk management

Security risk management includes security risk assessment and mitigation. The purpose of security risk management is to evaluate the risks associated with the identified risks and to formulate and implement effective and appropriate mitigation measures. Therefore, security risk management has become an important part of the security management process at the national level and at the product/service provider level.

Security risks are conceptually evaluated as acceptable, acceptable and unacceptable. The initial assessment is that under no circumstances will the risk be in an unbearable area to be tolerated. Mitigation action must be taken immediately because the potential risk and/or the severity of the consequences is very high and the potential risk poses a safety threat.

A security risk assessed as being within acceptable limits is acceptable as long as the organization implements appropriate mitigation strategies. Although initially assessed as an intolerable security risk, if the risk is controlled with appropriate mitigation strategies, it can be mitigated and then migrated into an intolerable area. In either case, additional cost-benefit analysis can be performed when appropriate.

A security risk that was initially assessed as acceptable is now acceptable and no action is required to bring the potential and/or seriousness of a risky outcome under the control of the organization.

All efforts to reduce risk should be recorded as necessary. This can be done through basic risk mitigation spreadsheets and tables that include simple tasks, processes, and systems. Identification and mitigation of risks associated with complex processes, systems and operations may require the use of custom risk mitigation software to facilitate documentation. Completed risk mitigation documentation must be approved by the appropriate management level.

### 2.5.1 Human Factors and Risk Management

Because mature SSPs and SMS target human and organizational factors, specific analytical processes are an essential part of a mature and effective risk management system. Human factors (HF) should be taken into account when determining risks, including human factors and risk mitigation, in existing and proposed defenses. Additional high-frequency analyzes can be performed if needed to support specific exercise and risk mitigation teams. High-frequency analysis can help to understand the impact of human error on a situation and ultimately develop more comprehensive and effective corrective/mitigative measures. Human error models define the relationship between performance and error as the basis of the analytical process and classify errors to facilitate identification and a better understanding of potential risks. With this understanding, you can accurately analyze the root cause. An individual's actions and decisions appear to be almost random events when out of context and cannot attract attention. Human behavior is not always random. They usually follow certain patterns and can be analyzed and understood correctly. Ultimately, this important high-frequency perspective offers a more comprehensive and profound relief process. Human factor analysis determines the underlying, contributing and magnifying factors in an organization's risk mitigation process, taking full account of human factors and background, oversight, and organizational influences.

### 2.5.2 Cost Benefit Analysis (CBA)

Cost-benefit analysis, or cost-benefit analysis, is a process that is usually independent of security risk mitigation or assessment. Typically associated with higher-level management agreements such as regulatory impact assessments and business expansion projects. However, there may be situations where the level of risk assessment is high enough or the financial impact is significant. In these cases, additional CBAs or cost-effective processes may be required to support the risk assessment. This is to ensure the cost-effectiveness and legitimacy of the proposed mitigation and preventive measures, taking into account the financial impact.

## Conclusion

It was created to study the limits of the speed range of modern airplanes. This is the biggest problem in modern aviation operations.

Flight accident statistical analysis shows that most accidents are caused by crew errors, especially in critical flight conditions. To do this, an aircraft speed indicator must be installed to notify the crew that the maximum permissible flight parameters have been reached.

# CHAPTER 3
# CALCULATION AND SELECTION OF THE INDICATOR FUNCTIONAL SCHEME ELEMENTS

## 3.1 Selection of the indicator functional scheme elements

A typical graph (Figure 3.2) shows the state of the analyzer in terms of vertical and horizontal speed. This also indicates the need to develop a minimum speed display. A similar device can be considered for selecting an indicator element - a variable gauge.

Transmission and Vertical Speed Indicators (VSIs), also known as RCDI (Rise and Descent Rate Indicators), are tools that display the rate of ascent or descent of an aircraft. VSI uses the aircraft's static pitot tube system to measure vertical velocity and records the results on a conventional needle and circular scale instrument or tape on the side of the EFIS EADI.

Here are two common VSI displays: The first is the traditional display and the second is the vertical speed shown on the scale on the far right of the machine. In a simple VSI, the pressure chamber is housed in a sealed enclosure. Static pressure is provided to the capsule by an electrostatic pitot system and the box is also connected to the system via a calibrated nozzle.

The nozzle restricts the passage of air, creating a time difference between the static pressure change and the pressure change in the tank.

So as the aircraft ascends (or descends), the presence of the nozzle causes the pressure in the cabin to drop (increase) and the pressure in the tank to drop (increase) at a slower rate. The movement of the capsule is converted into movement of the needle by a mechanical system.

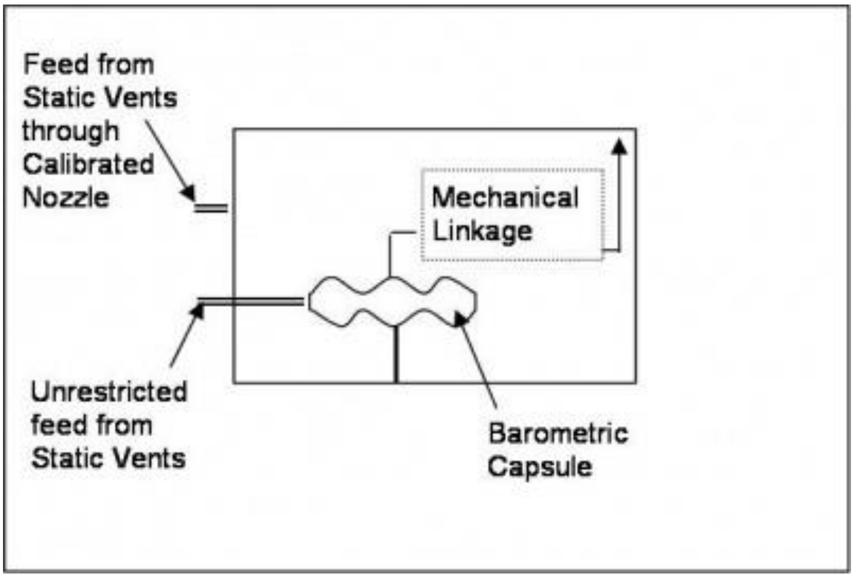



Fig 3.1 Schema of a simple Vertical Speed Indicator

The vertical speed indicator only works at static pressure, but it is a differential pressure gauge. The sealed housing has an indicator and a diaphragm connected to a gear. The inside of the diaphragm is directly connected to the static Pitot tube system line.

The vertical speed display can display two types of information. Trend information is an immediate indication of an increase or decrease in an aircraft's ascending or descending speed. The speed information shows that the rate of change of altitude is stable.

For example, if you climb steadily at 500 feet per minute (fpm) from the nose, the VSI will simultaneously detect these changes and indicate a decrease in your ascent rate. This is called a trend. After a period of time, VSI sets a new export rate. In the example above, the rate is less than 500 frames per minute. The time from when the initial shooting speed changes until the VSI accurately displays the new speed is called the delay. Sudden actuation can cause speed instability and delays due to turbulence, so some aircraft are equipped with an Instantaneous Vertical Speedometer (IVSI) with an accelerometer to compensate for the overall VSI delay.

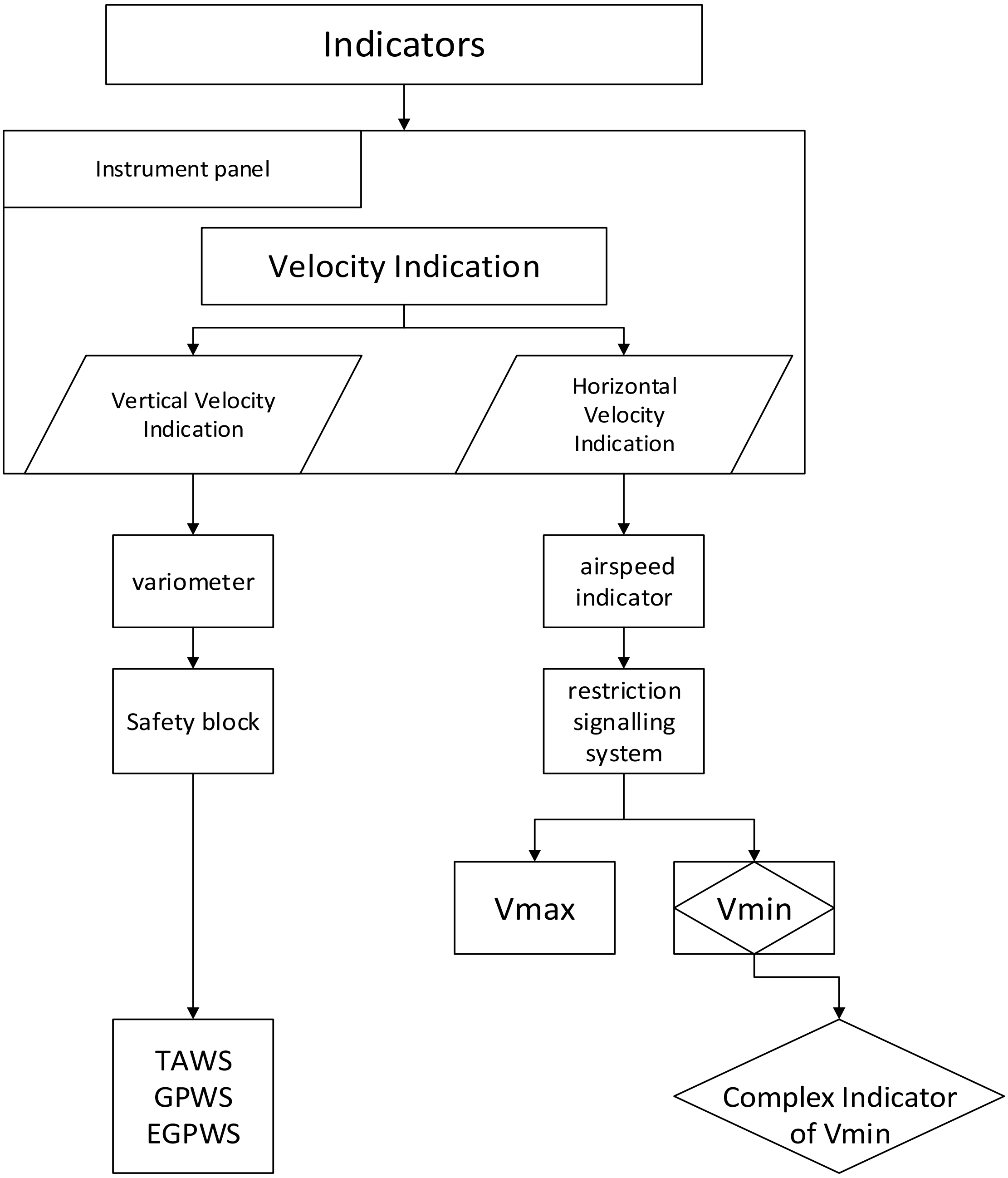



Fig 3.2 Generalized scheme shows state of analyzers by vertical and horizontal speeds.

## 3.2 Airspeed three-modes indicator

All necessary vertical velocity analyzers already exist. However, there is no minimum level of speed. In an extreme way, we introduce a new sub band classification $V_{min}$. Over the full range close to stall speed, the upper limit of $V_{min}$ is - $V_{min}$ min and the lower limit is - $V_{min}$ max.

We created a functional diagram of the speed analyzer (Fig. 3.3). It is an analyzer with 3 modes:

- Manual
- Semiautomatic
- Automatic

The onboard tachometer consists of these elements.

Directed wind speed analyzer ($V_{ind}$), Standard Analyzer of $V_{ind}$ min, $V_{ind}$ Decision planner, V min normal, V min special case, V min weather, V min Current comparator. For manual operation: $V_{min}$ control out-of-control warning, warning panel, $V_{min\ lim}$ negative warning. Semi-auto: $V_{min}$ approach warning, hazardous pilot reaction log analyzer. For automatic: V min limit, V limit discriminator, ΔV in V min, automatic recording of engine pulse control. Cover V min with indicators on landing or stall.

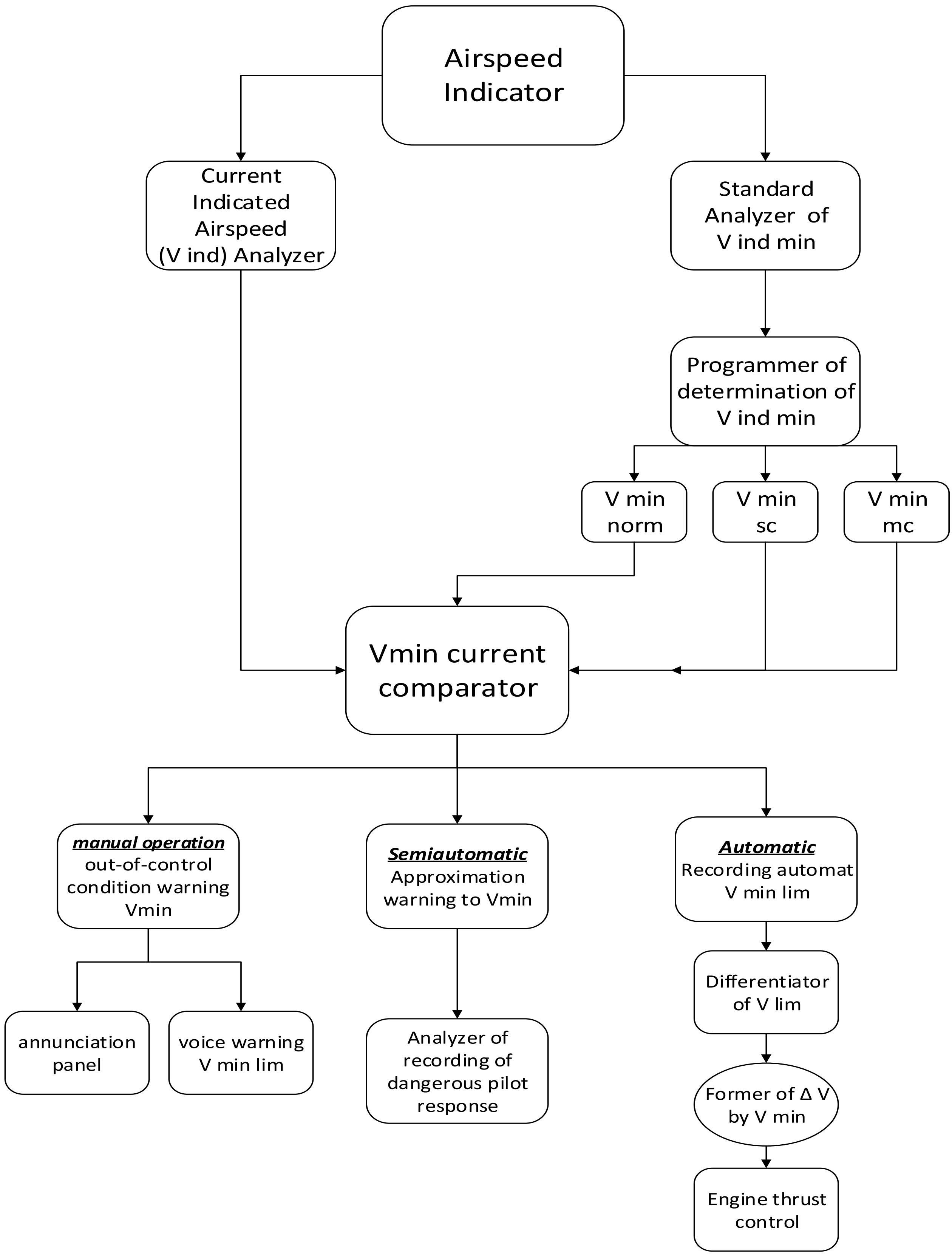



Fig 3.3 Functional scheme of Airspeed Indicator

## Conclusion

Developing a $V_{min}$ analyzer capable of operating in manual, semi-automatic and automatic modes is required.

In a university project in a training course, we studied a functional block diagram of a three-mode analyzer and used $V_{min}$ to improve flight safety during landing.

# CHAPTER 4
# LABOR PROTECTION

## 4.1. Introduction

Labor protection is a system of legal, regulatory, socio-economic, organizational and technical, sanitary and hygienic and treatment and prevention measures and tools aimed at maintaining human health and ability to work.

Due to the Covid-19 all the investigations were conducted in my hometown Vinnitsa. The section "Labor protection" in this thesis is considered and developed on the basis of the Vinnitsa National Technical University, faculty of infocommunications, radiolectronics and nanosystems, radio engineering department, classroom 5-212.

The purpose of the project task on labor protection is to identify potentially harmful and dangerous factors that occur throughout the working with computers, taking into account environmental conditions, which in some conditions may adversely affect the user's body during the investigations conducted in the laboratory. Norms and measures on labor protection and safety will also be considered, which will be aimed at reducing and eliminating negative production factors.

## 4.2. Analysis of the 5-212 classroom

The classroom, which is analyzed in this section, is presented as a classroom for practical and laboratory work. The auditorium is located on the fifth floor of a seven-story building with 16 workplaces for 15 students and a teacher. The floor is covered with linoleum, the walls are covered with water-emulsion whitewash (light color), as ventilation two air conditioners, windows and doors, natural lighting (window facing east) and artificial. In general, the room is free of harmful substances and strong vibrations, the composition of the air is normal, dry, clean, without accumulation of dust. The plan of the audience, its characteristics and equipment are presented in Fig. 4.1, in table 4.1- 4.2.

Table 4.1

Classroom equipment

<table>
<tr><th>Item name</th><th>Quantity</th><th colspan="2">Characteristics</th><th>Element № on the scheme</th></tr>
<tr><td rowspan="3">Personal Computer</td><td rowspan="3">13</td><td colspan="2">Intel Pentium 2117U (1.8 HHz) /RAM 4 GB /HDD 500 GB /nVidia GeForce GB / DVD Super Multi/Wi-Fi /DOS / 13,5 kg / 26 dB / 300 W</td><td rowspan="3">1</td></tr>
<tr><td>Dimensions</td><td>180 mm / 364 mm /398 mm</td></tr>
<tr><td>Cooler noise level HDD</td><td>26 dB</td></tr>
<tr><td rowspan="2">Monitor of the computer</td><td rowspan="2">13</td><td colspan="2">Sync Master 759 DF17" (1280x1024) LED, 312 ± 4 mm 234 ± 4 mm, 250 cd/m², 0.236mm, 412mm x 420mm x 416mm,</td><td rowspan="2">2</td></tr>
<tr><td>Power</td><td>100 W</td></tr>
<tr><td>Lamps</td><td>5</td><td colspan="2">Osram L 36W/765, LD 40</td><td>3</td></tr>
<tr><td rowspan="5">Air conditioning</td><td rowspan="5">2</td><td colspan="2">LG X 09 EHC, Standard, 9 kBTU/hr, 1 F/220-240 V/50 Hz, 280mm x800mm x185mm, 10 kg</td><td rowspan="5">4</td></tr>
<tr><td>When heated</td><td>2,64 kW</td></tr>
<tr><td>When cooling</td><td>2,64 kW</td></tr>
<tr><td>Power Heat. / Cool.</td><td>870/805 W</td></tr>
<tr><td>Noise level</td><td>36-42 dB</td></tr>
<tr><td>Chairs</td><td>20</td><td colspan="2">530mm x 570mm x 750mm</td><td>5</td></tr>
<tr><td>Corner table</td><td>1</td><td colspan="2">1600mm x 1600mm x 850mm</td><td>6</td></tr>
</table>

| | | | |
|---|---|---|---|
| Small table | 3 | 1000mm x 800mm x 850mm | 7 |
| Large table | 6 | 1600mm x 800mm x 850mm | 8 |
| Blackboard | 1 | 4000mm x 1500mm | 9 |
| Window | 2 | 1500mm x 2000mm | 10 |
| Door | 1 | 1600mm x 2100mm | 11 |
| Trash can | 1 | 300mm x 400mm x 300mm | 12 |
| Fire extinguisher | 1 | ОУ-5 | 13 |

### 4.2.1. Workplace organization

The laboratory where all the investigations and calculations were made, is designed for 16 working persons. All the calculations of the classroom characteristics are presented in the table 4.2

Table 4.2

Classroom characteristics

| Parameters | Quantitative and visual characteristics |
|---|---|
| Dimensions of the room | 7500mm x 6500mm x 3500mm |
| Number of workers | 15 persons |
| Audience area | $7{,}50 \times 6{,}50 - 2{,}00 \times 2{,}50 = 43{,}75m^2$ |
| The volume of the audience | $7{,}50 \times 6{,}50 \times 3{,}50 - 2{,}00 \times 2{,}50 \times 3{,}50 = 153{,}125m^3$ |
| Working are of one person | $43{,}75 \div 16 = 2{,}92\ m^2$ /person |
| Laboratory perimeter | 6,5m + 7,5m + 4m + 2m + 2,5m + 5,5m = 28m |

The schematic plan is represented on the figure 1. All the dimensions are approved by the building codes of Ukraine ДБН В.2.2-28-2010 “Administrative buildings”. Additionally, the classroom is equipped with 20 sockets (220 V).

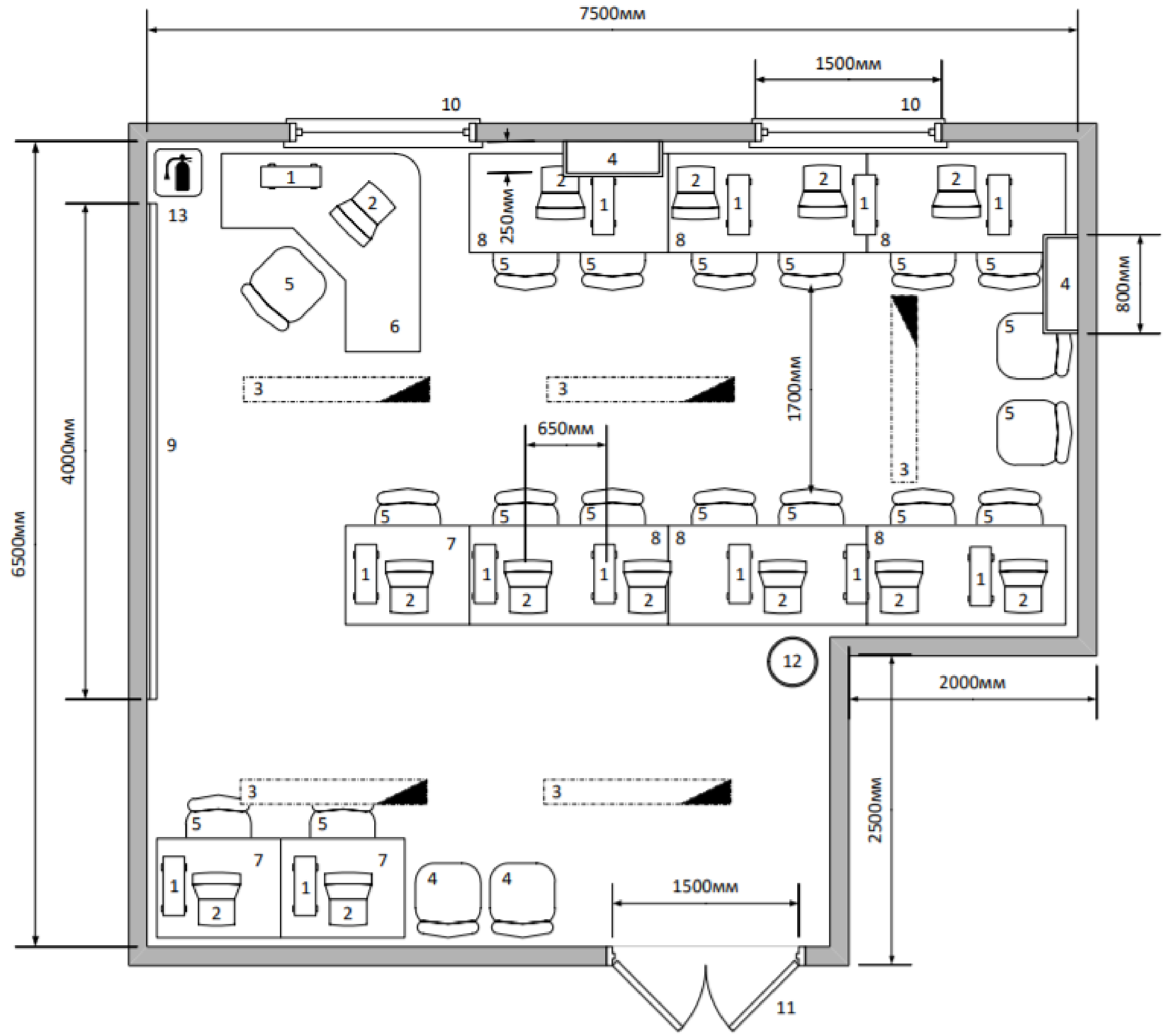



Fig 4.1 Plan of the 5-212 classroom

### 4.2.2. The list of harmful and hazardous factors

This section discusses measures to improve and ensure the normalization of working conditions during the working procedures of students. Dangerous and harmful production factors in accordance with “Hygienic classification of labor according to the indicators of harmfulness and danger of factors of the production environment, the severity and intensity of the labor process: State sanitary norms and rules” of 30.05.2014 by the nature of the action are divided into 4 groups (Table 4.3) [9]. Analysis of the listed harmful and dangerous factors is shown below.

Table 4.3

Dangerous and harmful production factors

| Physical | Chemical | Biological | Psychophysiological |
|---|---|---|---|
| Microclimate, illumination, noise, radiation, electrical safety, fire safety | absent | absent | absent |

#### 4.2.2.1. Microclimate of the working place

The work is performed sitting on a chair, a permanent workplace, with human energy expenditure less than 120 kcal / hour, belongs to the category "Light-1a". Sources of heat radiation are students, teachers, electrical equipment, lamps in the dark, in daylight - solar radiation (Table 4.4).

Table 4.4

Microclimate parameters

| | Season | Air temperature, $^0C$ | Relative humidity, % | Speed of movement, m/s |
|---|---|---|---|---|
| Real conditions | Cold | 22-25 | 52-58 | 0,1 |
| | Hot | 23-27 | 43-50 | 0,1 |
| Regulatory conditions | Cold | 21-25 | 60-40 | ≤ 0,1 |
| | Hot | 22-28 | 60-40 | 0,2 - 0,1 |

According to sanitary and hygienic standardization ДСН 3.3.6.042-99 the main characteristics of the microclimate of the audience meet the standards, the following measures and tools for normalization of microclimate parameters (table 4.5) [10].

Table 4.5

Measures to normalize the parameters of the microclimate

<table>
<tr><th colspan="2">Type of protection</th><th>Means of overcoming danger</th></tr>
<tr><td rowspan="2">Technical measures</td><td>In technological equipment</td><td>Coolers, air cooling radiators are used in personal computers</td></tr>
<tr><td>In building</td><td>In the cold season: central water heating, two cast iron radiators, consisting of 15 sections.<br>In the warm season: two air conditioners (LG X 09 EHC)</td></tr>
<tr><td colspan="2">Organizational measures</td><td>Placement of equipment is effective for ventilation and air conditioning</td></tr>
<tr><td colspan="2">Personal protective equipment (PPE)</td><td>Unforeseen</td></tr>
</table>

#### 4.2.2.2. Illumination, natural, artificial

Insufficient illumination of workplaces is one of the reasons for low productivity. In case of insufficient illumination, the worker's eyes are very tense, at the same time it becomes more difficult to distinguish between tools and surrounding devices, the work rate decreases and the general condition worsens.

Illuminance of industrial premises and workplaces is characterized by light flux, light intensity, brightness, contrast. Rational illuminance must meet a number of requirements:

be sufficient so that the eye can easily distinguish the details seen; constant over time, so the voltage in the supply network should not fluctuate by more than 4%.

Students perform laboratory work in this room. The work is done with the images on the monitor screen. The background of the program interface is light, the size of objects on average is 20-30 px, i.e. 5-7 mm and the size of the minimum objects 3 px - 0.71 mm, so the accuracy of visual work is average.

Natural illumination - versatile, is carried out by two windows facing east. This area of windows is sufficient for room lighting and optimal performance (ДБН В.2.5-56-2010). Artificial illuminance is carried out with the help of lamps (table 4.6) [11].

Table 4.6

Artificial illuminance

| Type of illumination | Characteristic |
|---|---|
| Lamps | 5 pc., two-section, rectangular diffuser |
| Fluorescent lamps | 10 pc Osram L 36W/765 LD 40 |
| Height from the floor | 3.4m, normally not less than 2.5 m |

### 4.2.2.3. Production noise, infrasound, ultrasound

Noise is a general biological irritant and in certain conditions can affect all organs and systems of the human body. Its effect on the organs of hearing, various parts of the brain leads to increased fatigue, general weakness, irritability, etc.

The main source of noise, throughout the work process, is coming from the street. Sources of noise in this audience are listed in table. 4.7

Table 4.7

Real and normative values for sound and noise

| Noise source | Real values | Regulatory values |
|---|---|---|
| Street | 50 dBA | 50 dBA |
| Computer cooler | 18-30 dBA | |
| Air conditioning | 36 - 42 dBA | |

The average noise level in the room does not exceed the established norms according to ДСН 3.3.6.037-99 "Sanitary norms of industrial noise, ultrasound and infrasound" (table. 4.8) [12].

Table 4.8

Measures and means of protection against noise

| Type of protection | | Means of overcoming danger |
|---|---|---|
| Technical measures | Normal | Coolers are in computers, there are no gaps in the connections |
| | In building | To protect against external noise, sound insulation is installed, the windows face the street with a speed limit, located at a distance of more than 30 m from the roadway |
| Organizational measures | | Mode of work and rest, the rules of technical operation are followed, scheduled preventive inspections and repairs are conducted |
| PPE | | Unforeseen |

### 4.2.2.4. Electrical safety

The following electricity consumers are required for research, such as: computers, lamps, monitors, air conditioners, according to the degree of danger of electric shock, the audience belongs to the premises without increased danger (Table 4.9). The room is dry with non-conductive floor, humidity not higher than 75%, without dust.

There are monitors in the audience that give a small amount of electromagnetic radiation. There are no infrared and ultraviolet radiation, except for sunlight, the windows have blinds (Table 4.11).

Table 4.9

Parameters of voltage consumers

<table>
<tr><th>Name of electrical appliance</th><th>Working conditions of application</th><th>Consumer power, W / h</th></tr>
<tr><td>Computer</td><td rowspan="4">AC network voltage 220 ± 20 V at a frequency of 50 Hz, the maximum deviation of the frequency of the supply network ± 0.5 Hz</td><td>300</td></tr>
<tr><td>Source of illumination</td><td>360</td></tr>
<tr><td>Screen</td><td>100</td></tr>
<tr><td>Air conditioning</td><td>810</td></tr>
</table>

According to the category of buildings, electrical safety measures are given in table. 4.10 (ДСТУ 7237:2011) [13].

Table 4.10

Measures to protect against electric shock

<table>
<tr><th colspan="2">Type of protection</th><th>Means of overcoming danger</th></tr>
<tr><td rowspan="2">Technical measures</td><td>Normal</td><td>Concealed and isolated wiring. The lamps are installed at a height of 3.4 m. Electrical safety units. Fuse-type fuses are installed. Computer power supplies are equipped with fuses on 2 A. 5 sockets of controllers.</td></tr>
<tr><td>Emergency</td><td>The equipment is connected to the network via grounding filters. In the corridor there is a circuit breaker S203-C 6kA (ABB) on 63A with protective characteristics C ГОСТ Р50345-99 (МЭК 60898-95).</td></tr>
<tr><td colspan="2">Organizational measures</td><td>All employees are acquainted with the rules of safety, timely training and testing of knowledge of employees on electrical safety.</td></tr>
<tr><td colspan="2">PPE</td><td>Unforeseen</td></tr>
</table>

### 4.2.2.5. Fire safety of production facilities

There are flammable substances in the classroom (Table 4.11). The source of ignition may be a short circuit or the network malfunction.

Table 4.11

Characteristics of the fire zone

| Type of fire | Characteristic |
|---|---|
| Fire class | A – combustion of solid materials, E – combustion of electrical installations, under voltage up to 1000 V |
| Subclass of fire | $A_1$ combustion is accompanied by smoldering ($A_2$ inverted to $A_1$) |
| Explosive | Category B (flammable) |
| Fire zone | Class II-Iia |
| Combustible materials | Fibrous (paper), solid (tables, board, chairs, doors), plastic (window, chairs, linoleum, computer) |

According to "Rules of fire safety in Ukraine: НАПБ А.01.001-14", to prevent fire in the classroom should take the following fire safety measures listed in table. 4.12

Table 4.12

Fire safety measures

| Type of protection | Means of overcoming danger |
|---|---|
| Technical measures | ОУ-5 fire extinguisher. In the corridor, opposite the office, there is a fire hydrant and a hose |
| Organizational measures | Fire safety instruction and periodic control of knowledge of fire safety rules. Fire evacuation plan. Free access to the power switch |
| PPE | Unforeseen |

In accordance with the building norms and rules of ДБН В.1.2-4:2019, evacuation routes were carried out. The problem is the lack of thermal fire alarm sensors on the ceiling that need to be fixed.

Conclusion: In this section of the thesis was considered the audience with all the equipment in accordance with the requirements of the guidelines for the implementation of the section "Labor Protection". Optimal conditions of microclimate, illumination, noise, fire safety and electrical safety rules are provided. In general, the classroom meets the requirements for the educational process, except for a few nuances, such as non-compliance with the rules of operation of the classroom and the dangerous factors that will be changed, for safe working conditions and knowledge of students.

# CHAPTER 5
# ENVIRONMENTAL PROTECTION

## 5.1. Introduction

Environmental protection - the state of the natural environment, which ensures the prevention of deterioration of the ecological situation and the emergence of danger to human health.

An ecosystem is a combination of the abiotic environment and the living organisms that live in it. The global ecosystem is the biosphere, the boundaries of which are determined by the "field of existence of life."

All the diversity of environmental factors is divided by origin and nature of action into two major groups - abiotic and biotic. To abiotic include factors of inorganic, or inanimate, nature, to biotic - the influence of living nature, as well as man. Anthropogenic factor - a factor whose agent is a person (directly or as a result of their activities). The role of anthropogenic factors is constantly growing.

## 5.2 Impact of air sources of air transport on the environment

Aircraft pollute the atmosphere due to emissions of harmful substances from the exhaust gases of aircraft engines.

Aircraft move from one airport to another during the flight, and the atmosphere is polluted on a global scale, i.e. significant pollution occurs both in airport areas and on flight routes. Moreover, if on the flight paths (at an altitude of 8-12 km) the risk of this pollution is small (flights of aircraft at high altitudes and at high speeds cause the scattering of combustion products in the upper atmosphere and large areas, which reduces their impact on living organisms ), it is impossible not to take into account such pollution in the airport area.

Gases emit nozzles and exhaust gases into the atmosphere by the engine pipes. This process is called aviation engines emissions. Gases from aviation engines account for 87% of all civil aviation emissions, which also include emissions from special vehicles and stationary sources.

The most unfavourable modes of operation are low speeds and "idling" of the engine, when pollutants in the atmosphere in quantities significantly exceeding the emission at load modes.

### 5.3 Environmental pollution due to the use of different fuels

Significant sources of environmental pollution are oil and its products. Petroleum products, different in their composition, in case of contact with air and soil, pollute the atmosphere, surface and groundwater, worsen their sanitary and hygienic condition. Pollution of the soil with oil and oil products leads to significant physicochemical changes, which consist in changes in the microelement composition of the soil, its water-air regime. Excess of organic substances containing hydrocarbons and which get into the soil with oil and oil products disrupt the normal interaction of hydrocarbons and nitrogen, as well as lead to a deficiency of oxygen, nitrogen and phosphorus. Due to the deterioration of agrochemical properties of the soil, the growth of cereals, legumes, etc. is delayed.

The impact of fuels on the environment is manifested mainly in three directions: toxic effects on people who are in direct contact with fuel; pollution of the atmosphere with harmful substances contained in the exhaust gases of the engine, and the fire hazard of the fuel.

The fire hazard of fuel can be characterized by the pressure of saturated vapors, as well as its flash point and spontaneous combustion. The standard regulates the flash point in a closed crucible. Sources of emissions of harmful substances are exhaust gases of aircraft engines, evaporation from the power supply system, leakage of fuel and oils in the process of operation and service of aircraft, as well as wear products of clutch friction linings, brake pads, tires. Getting into the atmosphere, water bodies and soil, harmful substances emitted by air transport have a negative impact on the biosphere. The greatest threat is the pollution of the atmosphere with exhaust gases from aircraft engines.

When using electricity, sources of air pollution are aircraft engines, as well as burned fuel. At the same time, along with the products of complete combustion, the products of incomplete combustion - carbon monoxide, partially oxidation and unburned carbon, etc. - enter the atmospheric air.

## 5.4 Features of soil and water pollution by air transport

In addition to air pollution, air transport with the equipment assigned to it pollutes the soil with various mechanical, physical and chemical impurities. Soil pollution occurs due to the deposition of pollutants from the air basin on the soil surface, which enter the atmosphere with the exhaust gases of aircraft, ground aircraft and boiler furnaces. Investigations of soils near airports have shown an increased content of heavy metals in them more than 20 times.

The problem of the impact of air transport on the state of surface waters is more researched and studied. In modern conditions, reservoirs that are in the area of local influence of air transport are under intense man-made influence, which is accompanied by changes in hydrogeological, hydrochemical and hydrobiological regimes. The source of air pollution of airlines is surface runoff. Formed by rain and melt snow water, as well as water during wet cleaning of artificially covered premises, surface runoff from the airport accumulates various pollutants: residues of detergents, disinfectants, anti-icing and anti-icing agents, products of destruction of artificial surfaces. aircraft chassis and ground equipment, waste oil, etc.

## 5.5. Noise pollution from air transport

During ground tests of aircraft engines, aircraft's takeoffs and landings, complex acoustic oscillations occur, including in addition to loud high-frequency noise and low-frequency infrasound, which enhance the harmful effects on living organisms.

Air traffic generates significant noise near both civilian airports and military airfields. Airplane takeoffs are known to create intense noise, including crashing and vibration. The landing of the aircraft creates significant noise along the corridors, within which flights take place, usually at low altitudes. Noise is created not only by the engines, but also by the chassis and mechanization of the wing, as well as when reverse thrust is used (engine reverse mode) during the flight of aircraft on the runway. In general, a larger and heavier aircraft makes more noise than a lighter aircraft.

The extent of noise exposure of transport facilities significantly depends on the structure of the vehicle fleet, the intensity of their operation and construction in the vicinity of highways. For example, with regard to civil aviation, the world's fleet of transport aircraft increased by about 30% during the 1980s, reaching about 12,000 aircraft by 1990. To date, the structure of this fleet is such that the noisiest jet aircraft are 75%, the rest - propeller aircraft. At the same time, 20% of the fleet consists of aircraft with turboprop engines, 5% - with propeller reciprocating engines. Significant efforts have been made primarily to study the mechanisms of noise generation, the main acoustic sources and the development of low-noise engines and aircraft.

The result of these efforts is that modern aircraft, equipped with engines with a high degree of double-loop and significant acoustic processing of flow channels, are 15… 25 EPNdB "quieter" than the first turbojet aircraft. The dynamics of noise reduction of aircraft engines over time since the 1950s is shown in Fig. 6.1.

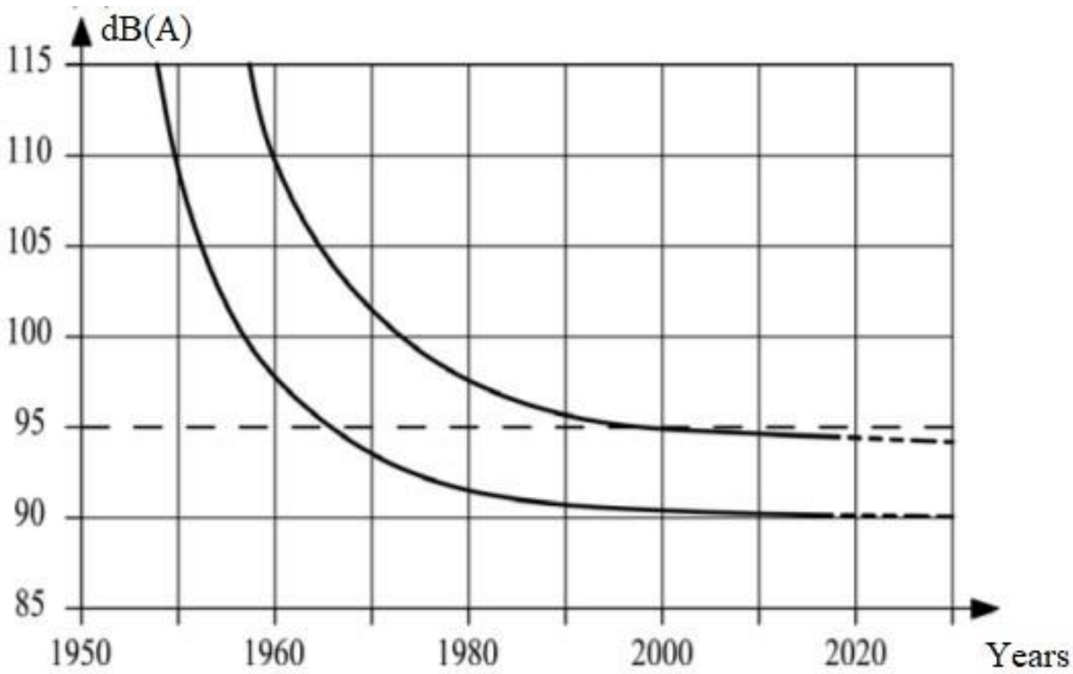



Fig. 5.1 Dynamics of noise reduction of aircraft engines over time

**5.6. Environmental protection measures**

During the manufacture of the device, it is necessary to reduce the amount of waste by recycling it. For the manufacture of a printed circuit board the fiberglass are used. It is necessary to arrange production so that there is the least amount of waste, more rational use of materials, and use of waste as secondary raw materials. During the manufacture of the board, the fraction of elements, vapors of acid, rosin, and solder penetrate into the environment. This has a detrimental effect not only on humans but also on the environment. The device uses a double-sided board mounting, which reduces the time for digestion in the galvanic bath, as well as the waste of energy. To reduce the influence of unfavorable factors, ventilation devices are used with cleaning from unfavorable impurities.

Chemical reagents are poured into a special container, neutralized and used in the production of secondary raw materials. The device being designed uses transistors and piezoelectric material, which contain less precious and liquid materials than a large number of devices that replace them. Since the designed system is a consumer of electricity both during operation and during manufacture, it is necessary to spend the least amount of time on checking the system, which is actually the purpose of its manufacture. To reduce the time and, consequently, the energy consumption for manufacturing and repairs, it is necessary to attract highly qualified specialists. Let us show the specific positive aspects of the action of the calculator on the environment. With the correct and accurate operation of the flight and navigation complexes, the aircraft follows the route more accurately, and also makes takeoff and landing more accurately.

As a result, during a landing event, accuracy increases and the likelihood of a missed approach decreases, and when moving along a route, the deviation from a given flight level and route decreases. As a consequence of this, the time spent by the aircraft in the air is reduced, therefore, the amount of emissions into the atmosphere is reduced. Also, during the descent of the aircraft during landing, the optimal flight speed is maintained (the lowest fuel consumption). Because the developed system provides greater accuracy when changing flight parameters, it provides more accurate piloting.

As a result, the aircraft spends less time in the air, and during a landing event, the likelihood of leaving for an alternate airfield is reduced. Also, with accurate measurements of flight parameters, piloting in difficult meteorological conditions is facilitated. This together gives fuel savings and reduced air emissions from the other.

**Conclusion**: We can say that the activities of airlines cause significant damage to the environment. There is pollution of water, soil and, of course, air. In addition, the harmful effects on the environment are noise, infrasound, sound shock.

To reduce the impact of harmful factors on the environment, measures should be taken to protect it.

# CONCLUSION

The investigation was conducted as part of the following graduation work to explore the velocity range limitations of existing aircrafts. It is a key issue in the use of contemporary aircrafts. Currently, if $V_{min}$ and $V_{max}$ are disrupted, aircraft accidents and mishaps are possible.

An Antonov 24 passenger aircraft was crashed in a landing accident on February 13, 2013, due to a $V_{min}$ breach, while the first Ruslan disaster happened on October 13, 1992, when an Antonov Design Bureau plane came down during flight-testing near Kiyv, Ukraine, due to a $V_{max}$ breach.

The development of $V_{min}$ analyzers is required. Throughout the graduation work learning course, the functional-block diagram of a 3-modes analyzer was explored, which allows for a $V_{min}$ enhancement in aviation safety during landing approach.

## REFERENCES


1. Аль-Амморі Алі. Інформаційно-факторний спосіб розпізнавання небезпечних польотних ситуацій / Ин-т кібернетики ім. В.М.Глушкова. - Київ, 1997.-53 с.

2. Авиационные приборы и навигационные системы / Под ред. Бабича О.А. – М.: Изд-во ВВИА им. проф. Н.Е. Жуковского, 1981. – 648 с.

3. Хохлов Є.М. Пріоритетна науково-методологічна програма виходу на нульовий рівень аварійності по людському фактору (екіпажу) в глобальному авіатранспортному процесі. - Проблеми безпеки польотів.- Москва: ВИНИТИ. - 2000. -№ 1. - С. 16-26.

4. Ільїн О.Ю., Філяшкін М.К., Черних Ю.О. Пілотажно-навігаційні системи та комплекси. – К.: Вид-во КІ ВПС, 1999. – 335 с.

5. Safety Management Manual (ICAO), 2006. Doc 9859 AN/460, 364 c.

6. Стариков Ю.Н., Коврижных Е.Н. Основы аэродинамики летательного аппарата: Учеб. пособие. – Ульяновск: УВАУ ГА, 2004. – 151 с.

7. Настанова по виробництву польотів у цивільній авіації СРСР (НПП ГА -85). - Москва.: Повітряний транспорт, 1985.- 254 с.

8.Воробьев В.Г., Глухов В.В., Кадышев И.К. Авиационные приборы, информационно-измерительные системы и комплексы. – М.: Транспорт, 1992. – 399 с.

9. https://zakon.rada.gov.ua/laws/show/z0472-14#Text

10. Дальский А. М. Технология конструкционных материалов.– М.: Металлургия, 1985. – 281 с.

11. https://zakon.rada.gov.ua/rada/show/va039282-99#Text

12. Самсонов Г. В., Виницкий И. М. Тугоплавкие соединения (справочник).

–К.: Наукова думка, 1976. – 115 с.

13. http://online.budstandart.com/ru/catalog/doc-page?id_doc=30045

14. Китайгородский И. И. (ред.) Технология стекла. Изд. 3-е, перераб. – К.: Наукова думка, 1961. – 152 с.

15. Авиационные приборы и навигационные системы / Под ред. Бабича О.А. – М.: Изд-во ВВИА им. проф. Н.Е. Жуковского, 1981. – 648 с.