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

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
д-р техн. наук, проф.
____________В.Ю. Ларін
«__»____________2023 р.

ДИПЛОМНА РОБОТА

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА
ЗА ОСВІТНЬО-ПРОФЕСІЙНОЮ ПРОГРАМОЮ
«ОБСЛУГОВУВАННЯ ПОВІТРЯНОГО РУХУ»

Тема: «Керування ризиками, при виконанні польотів в повітряному просторі класу G»

Виконавець:	Россол Анна Сергіївна
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Київ 2023

MINISTRY OF EDUCATION AND SCIENCE, OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF AIR NAVIGATION, ELECTRONICS AND TELECOMMUNICATION
AIR NAVIGATION SYSTEM DEPARTMENT

PERMISSION TO DEFEND GRANTED
Head of the Department
___________V.Yu. Larin
“__”______________2022

MASTER’S DEGREE THESIS

Theme:

“RISK MANAGEMENT DURING PERFORMING FLIGHTS IN CLASS “G” AIRSPACE”

Completed by:	Rossol A. S
Supervisor:	Kolotusha V.P.
Supervisors of special chapter	
	Shmelova T.F.
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Standarts Inspector:	Argunov H.F.

Kyiv 2023

Факультет аеронавігації, електроніки та телекомунікацій
Кафедра аеронавігаційних систем
Навчальний ступінь «Магістр»
Спеціальність 272 «Авіаційний транспорт»
Освітньо-професійна програма «Обслуговування повітряного руху»

ЗАТВЕРДЖУЮ
Завідувач кафедри д-р техн. наук, професор
_____________В. Ларін
«__»______________2023 р.

ЗАВДАННЯ

на виконання дипломної роботи

РОССОЛ АННИ

1. Тема дипломної роботи: «Керування ризиками, при виконанні польотів в повітряному просторі класу G» затверджена наказом ректора від «22» серпня 2023 № 1443/ст.

2. Термін виконання роботи: з 23 жовттня вересня по 31 грудня 2023 р.

3. Вихідні дані до роботи: статистичні та теоретичні дані, керівні документи, накази, опитування пілотів та диспетчерів обслуговування повітряного руху, показники UkSATSE.

4. Зміст пояснювальної записки: загальні відомості про обслуговування повітряного руху (ОПР) у неконтрольованому повітряному просторі України; аналіз виконання польотів у неконтрольованому просторі України; порівняння стандартів виконання польотів в Україні та Європі; загальні відомості безпеки польотів в Україні; формування проблем ОПР у неконтрольованому повітряному просторі України та пропозицій їх вирішення.

5. Перелік графічного (ілюстрованого) матеріалу: 24 рисунків, 9 таблиць та діаграма, що ілюструють теперішній стан проблем та шляхи їх вирішення.

6. Календарний план-графік

№ пор.	Завдання	Термін виконання	Відмітка про виконання
1.	Вивчення міжнародного та національного досвіду стосовно менеджменту ризиками у світової та вітчизняної аеронавігаційної системі та управління ризиками у неконтрольованому повітряному просторі	23.10 – 30.10. 2023	Виконано
2.	Підготовка та написання 1 розділу «**Flight performance and ATC rules**»	31.10 – 07.11.2023	Виконано
3.	Підготовка та написання 2 розділу «**Threats in air traffic control and basics of flight safety manaement** »	08.11 – 15.11.2023	Виконано
4.	Підготовка та написання 3 розділу «**Ways to minimize risks when flying in the airspace of class "G" of Ukraine**»	16.11– 22.11.2023	Виконано
5	Підготовка та написання 4 розділу « **Automated big data processing air naviation. Statistical analysis. Correlation-regression analysis. Forecasting the efficiency of passenger traffic** ».	23.11 – 30.11.2021	Виконано
6.	Підготовка та написання 5 розділу **«Aviation occupational health and safety. ICAO's role in environmental protection »**	01.12 – 08.12.23	Виконано
7.	Оформлення пояснювальної записки та ілюстративного матеріалу	09.12 – 12.12.2023	Виконано

Дата видачі завдання: «23» жовтня 2023 року

Консультанти з окремих розділів

Розділ	Консультант (посада, П.І.Б.)	Дата, підпис	
		Завдання видав	Завдання прийняв
Спеціальний розділ	Проф. д.т.н Остроумов І.В.	23.10.2023	23.10.2023
	Проф. д.т.н Шмельова Т.Ф.	23.10.2023	23.10.2023

Керівник дипломної роботи: _________________________ Колотуша В.П.
(підпис керівника) (П.І.Б)

Завдання прийняв до виконання: ________________ Россол А.С
(підпис випускника) (П.І.Б

NATIONAL AVIATION UNIVERSITY

Faculty of Air navigation, Electronics and Telecommunication
Air Navigation Systems Department
Specialty: 272 “Aviation transport”

APPROVED BY
Head of the Department
_____________ V.Yu. Larin
“_ _” _____________ ______2023

MASTER’S DEGREE THESIS

Task assigned to:

ANNA ROSSOL

1. *The Project topic:* “*Risk management during performing flights in class “G”airspace*” approved by the Rector’s order of 22.08.2023 № 1443/st.

2. *The Project to be completed between:* 23.10.2023 – 31.12.2023.

3. *Initial data to the project:* statistical and theoretical data, guidance documents, orders, surveys of pilots and air traffic controllers, UkSATSE indicators.

4 *The content of the explanatory note (the list of problems to be considered):* general information about air traffic services (ATS) in the uncontrolled airspace of Ukraine; analysis of flights in the uncontrolled space of Ukraine; comparison of flight performance standards in Ukraine and Europe; general information on flight safety in Ukraine; formation of ODA problems in the uncontrolled airspace of Ukraine and proposals for their solution.

5. *The list of mandatory graphic (illustrated) materials:* graphs of results data, tables, formulas, algorithms.

6. Calendar timetable

№	Completion stages of Degree Project	Stage completion dates	Remarks
1	Study of international and national experience in risk management in the global and domestic air navigation system and risk management in	23.10 – 30.10. 2023	completed
2	Preparation of chapter 1: «**Flight performance and ATC rules**»	31.10 – 07.11.2023	completed
3	Preparation of chapter 2: «**Threats in air traffic control and basics of flight safety manaement** »	08.11 – 15.11.2023	completed
4	Preparation of chapter 3: «**Ways to minimize risks when flying in the airspace of class "G" of Ukraine**»	16.11– 22.11.2023	completed
5	Preparation of chapter 4: « **Automated big data processing air naviation. Statistical analysis. Correlation-regression analysis. Forecasting the efficiency of passenger**	23.11 – 30.11.2021	completed
6	Preparation of chapter 5: «**Aviation occupational health and safety. ICAO's**	01.12 – 08.12.23	completed
7	Preparation of report and graphic materials	09.12 – 12.12.2023	completed

7. Consultants from separate departments chapters

Chapter	Consultant (position, full name)	Date, signature	
		Task issued	Task accepted
Special chapter	D. Sc., prof. Ivan Ostroumov	02.11.23	02.11.23
	D. Sc., prof. Tetyana Shmelova	02.11.23	02.11.23

8. Assignment accepted for completion 23. 10. 2023

Supervisor____Kolotusha V.P

Assignment accepted for completion ______________________ Rossol A. S

РЕФЕРАТ

Пояснювальна записка до дипломної роботи «Проблеми виконання польотів у неконтрольованому повітряному просторі класу «G»: 97 сторінок, 24 рисунків, 9 таблиць,1 діаграма, 53 використаних джерел.

Об'єкт дослідження – система обслуговування повітряного руху України.

Мета дипломної роботи – формулювання проблем під час ОПР у неконтрольованому повітряному просторі класу «G» та шляхи їх вирішення.

Методи дослідження – при написанні роботи використовувалися статистичний та аналітичний методи, а також методи спостереження, узагальнення та прогнозування.

Теоретична частина описує особливості виконання польотів та ОПР у повітряному просторі класу «G» та загальні положення, щодо системи управління безпекою польотів.

Аналітична частина дипломної роботи вміщує аналіз та облік авіаційних подій, а також статистику стану безпеки польотів з 2017 по 2021 роки.

Проектна частина містить пропозиції щодо усунення проблем при ОПР у неконтрольованому повітряному просторі класу «G».

Описаний у дипломній роботі вид польотів є дуже розповсюдженим на території України, виходячи з цього, є доцільним його аналізувати та вносити пропозиції щодо вирішення проблем при виконанні польотів та наданні ОПР.

КЛЮЧОВІ СЛОВА: АВІАЦІЯ, БЕЗПЕКА ПОЛЬОТІВ, ПОЛІТ, ПОВІТРЯНИЙ ПРОСТІР, ЕКІПАЖ, АНАЛІЗ, ФАКТОР, СТАТИСТИКА, ПРОЦЕС, КОНТРОЛЬ, УПРАВЛІННЯ.

ABSTRACT

Explanatory note to the diploma thesis work “Risk management during performing flights in class “G” airspace: 97 pages, 24 figures, 9 tables, 1 diagram, 53 used sources.

The object of the research – Air traffic service system of Ukraine.

The purpose of the work – Maintaince of sufficient level of flight safety in the uncontrolled airspace of class "G", to analyze and assess risks and to minimize them.

Methods of research – statistical and analytical methods, as well as methods of observation, generalization and forecasting were used when perorming the thesis work.

The theoretical part describes the specifics of flights and ATC in the airspace of class "G" and general provisions regarding the flight safety management system.

The analytical part of the diploma work contains the analysis and accounting of aviation incidents and accidents, as well as statistics of flight safety from 2017 to 2021.

Project part contains proposals for determining and taking into account the risks during flights in the uncontrolled airspace of class "G".

The type of flights described in the diploma work is very widespread on the territory of Ukraine, based on this, it is appropriate to analyze it and make proposals for solving problems in the execution of flights and providing of ATC.

KEY WORDS: AVIATION, FLIGHT SAETY, FLIGHT, AIR SPACE, CREW, ANALYSIS, FACTOR, STATISTICS, PROCESS, CONTROL, MANAGEMENT

АРКУШ ЗАУВАЖЕНЬ

CONTENT

LIST OF TERMS AND ABBREVIATIONS

AC – aircraft;

ACC – area control center

ADF - automatic direction finding

AE – aviation event;

AFIS - aerodrome flight information service;

AIP - aeronautical information publication;

AIREP – aircraft report

AIRMET - airman's meteorological information

AIS - aeronautical information service;

AMS – aviation meteorological station;

AMSL - above mean sea level;

ARO - airport reservation office;

ATC - air traffic control;

ATC - air traffic service;

ATZ - aerodrome traffic zone;

CA – civil aviation;

CTA - control area;

CTR - control zone;

DME - distance measuring equipment;

FC – flight crew;

FS – flight safety;

FIR - flight information region;

FL - flight level;

FPL – flight plan;

GAMET - general aviation meorological forecast

GPS - global positioning system;

ICAO - international civil aviation organization;

ILS - instrument landing system;

IRS - inetrtial reference system;

KT – Kyiv time;

METAR - meteorological aerodrome report

NBAAI - National Bureau of Air Accidents Investigation of Ukraine

RVSM - reduced vertical separation minimum;

SERA - standardized European rules of air;

TAF - terminal aerodrome forecast

TCAS - traffic collision avoidance system;

TMA - traffic maneuvering area;

SIGMET – significant meteorological information

SIGWX - significant weather chart

UTC - coordinated universal time;

VOR - very high frequency omni directional radio range;

VFR - visual flight rules;

VMC - visual meteorological conditions.

INTRODUCTION

Despite the difficulties that Ukrainian aviation has faced in recent years, the need to use airspace while taking into account the requirements of the appropriate level of security has not disappeared. The development and implementation of new international concepts in the field of air navigation also requires constant improvement of the airspace structure to improve flight performance indicators.[18]

In order to synchronize with the rules, standards and Recommended Practices of the International Civil Aviation Organization ICAO, of which Ukraine has been a member since 1992, the "General Rules of Flight in the Airspace of Ukraine" were developed, approved by the Resolution of the Government of Ukraine dated 02.06.2017 No. 66/73. [1] These rules establish three of the seven airspace classes over the territory of Ukraine proposed by the Convention on International Civil Aviation "Air Traffic Services", namely: C, D and G. According to the structure and classification of the airspace of Ukraine, on the basis of Order No. 1009 of 10.12.2013, depending on the type of air traffic service, a controlled or uncontrolled procedure for the use of air space is established.[2]

Controlled airspace is introduced in classes C and D. Class C operates in the upper airspace from an altitude of 2900 m (exclusively) to FL 660, and class D below an altitude of 2900 m (inclusively) to an altitude of 1500 m (exclusively). In each of these classes, air traffic control service is conducted. (see Fig. 1. Classification of the airspace of Ukraine).

The uncontrolled use of airspace is valid only in the airspace of Class G - the space where classes C and D are not established, and which is located from the earth's surface up to a height of 1500 m (inclusive). Class G airspace users are provided with air traffic information service and emergency notification.[2]

Analyzing the data related to flight safety, we can see that the implementation of simplifications in the use of airspace against the background of the general increase in the volume of flights is marked by a significant decrease in the total number of violations of the order of airspace use, and a decrease in related violations. with unauthorized flights of general aviation aircraft.

Therefore, our conclusion is that the reduction in the number of airspace use violations is due to the simplification of airspace use procedures.

The purpose of the work: Compliance with a sufficient level of flight safety in the uncontrolled airspace of class "G", analysis and assessment of risks and their minimization.

Tasks:

1. To analyze the peculiarities of flights within the airspace of class "G" and the general provisions regarding the flight safety management system.
2. Conduct an analysis of the state of flight safety from 2017 to 2021 in Ukraine.
3. Formulate problems and proposals for their elimination when flying within uncontrolled airspace of class "G".

CHAPTER 1

FLIHT PERFORMANCE AND ATC RULES

1.1. VFR flights performance

Visual flight rules (VFR) - *a set of aviation rules and instructions that provide for fliht crew orientation and maintaining safe intervals by visual observation of the natural horizon line, terrain landmarks, and other aircraft.[20]*

- According to Annex 6 of the Convention on International Civil Aviation, an aircraft flying visually must have on board the means of measurement and display:

- - instrument airspeed (allows you to maintain a speed that is safe for maneuvers);
- - barometric altitude (to maintain the altitude necessary for flight);
- - magnetic course (gives the ability to maintain the direction to the destination point);

- time (allows you to know the distance to a point through speed).

The flight rules themselves are quite simple:

- - spatial placement of the aircraft, necessary for safe maneuvering, is maintained along the natural horizon line;
- - conflicting traffic is determined visually by the pilot, and the dispatcher's help is not required for its separation (two planes on opposite courses each turn to the right);
- - navigation is provided by reading the aeronautical map and the correlation of its landmarks with the surface, as well as by performing accurate navigation calculations on the ground;
- - procedures are built according to the same guidelines and published in special collections. For example, you can cite procedures for landing: fly to such a populated place, turn from it to such a lake, in the middle of which turn right and the runway will become visible;

- height restrictions or landmarks can be used to manage traffic.

In addition to aircraft control, the pilot’s task is to scan the traffic and landmarks on the ground. Therefore, most of the time, the pilot is oriented outward visually. This leads to a decrease in the accuracy of maintaining flight parameters (altitude, speed, course).

Such flights require clear and specific meteorological conditions. The pilot must see:

- - most of the ground during the entire flight, which makes it impossible to fly at high altitudes (above the clouds);
- - the natural horizon line, which makes it impossible to fly in the clouds themselves;

- the runway for take-off and landing, which excludes the possibility of take-offs/landings in fog.

Except for special VFR flights, such flights are performed in visibility conditions and distances to clouds that are equal to or greater than the values specified in Table 1.1. (See Table 1.1. Minimum values of visibility and distance to clouds in visual meteorological conditions).[1]

An exception can only be the presence of a permit issued by the dispatcher (departmental body of ATC). In addition, it should be noted that take-offs, landings or entry into the aerodrome traffic zone under VFR are not performed at an aerodrome that is within the control zone (control zone of state aviation aerodromes) when the height of the lower limit of clouds is less than 450 meters (1500 feet) and visibility near the ground less than 5 kilometers.

Also, VFR flights in the period between sunset and sunrise outside mountainous areas are performed under the following conditions: visibility near the ground is at least 8 km (for helicopters - at least 5 km), the height of the lower limit of clouds is at least 600 meters (1800 feet) (for helicopters - at least 400 meters (1300 feet).

1) The minimum flight height above the earth or water surface is not less than 300 meters (1000 feet) (for helicopters above the earth surface - not less than 150 meters (500 feet), and above the water surface - not less than 200 meters (600 feet));

2) Table 1.1. Minimum values of visibility and distance to clouds in visual meteorological conditions

Range of absolute heights	Class of airspace	Visibility	Ceiling
I At an absolute altitude of 3,050 m (10,000 ft) and above	B, C, D, E, F, G	8 km	Horizontally 1500 m ertically 300 m (1000 ft)
3elow 3,050 m (10,000 ft) nd above 900 m (3,000 ft) or above 300 m (1,000 ft) bove terrain, whichever is greater	B, C, D, E, F, G	5 km	Horizontally 1500 m 300 m vertically (1000 feet)
At an altitude of 900 m ,000 ft) and below or at an ltitude of 300 m (1,000 ft) bove terrain, whichever is greater.	B, C, D, E	5 km	Іо горизонталі 1500 м По вертикалі 300 м (1000 футів)
	F, G	km km* - when flying itside mountainous areas ith an instrument speed f 300 km/h and less than 5 km* - when flying elicopters outside ountainous areas with n instrument speed of 30 km/h or less; 500 m - r helicopters, if they over or move at a height f up to 10 m or perform aneuvers at a speed of o to 10 km/	Horizontally: the sence of clouds in the lirection of flight and hen the earth or water surface is visible. ertically: 50 m** - to the lower limit of clouds when flying outside mountainous areas with an strument speed of 300 n/h and less; 100 m** - to the lower limit of clouds when flying in nountainous areas, as well as outside ountainous areas with n instrument speed of 301-465 km/h

2) The vertical distance to the lower limit of clouds is not less than 300 meters (for helicopters - not less than 100 meters (300 feet)).

3) Flights under VFR in the period between sunset and sunrise in mountainous areas are carried out for the purpose of search and rescue, providing emergency medical

4) aid, preparation for these flights, and on aircraft equipped with night vision system, under the following conditions: visibility of at least 8 km, height of the lower limit of clouds at least 800 meters (2,700 feet).

5) VFR clearance is not granted in areas above 8,850 meters (FL 290) where a reduced vertical separation minimum (RVSM) of 300 meters (1,000 feet) applies.[1]

If there are no other instructions in the dispatcher's permission of the relevant air traffic control authority (departmental air traffic control authority), horizontal cruise flights under VFR at altitudes higher than 900 meters above the ground or water surface are performed at cruising levels corresponding to the table of cruising echelons of flight in the airspace of Ukraine.

When flying under VFR in part of the airspace of classes C, D, VFR cruising levels are not applied.[1]

Flights under VFR are provided by dispatcher service when:

1) The flight is performed within the airspace of classes C and D;

2) The aircraft is part of aerodrome traffic at a controlled aerodrome;

3) A special flight under VFR is being performed.

4) During flight under VFR in the airspace of classes C and D, as well as in class G within the zone with a special mode of use of the airspace of Ukraine and within the aerodrome flight information zone (AFIZ), the aircraft crew must constantly listen to the corresponding channel of communication "air-land" connection and, if necessary, provide information on their location to the ATS authority.[1]

When flying under VFR within the ATC zones and areas of state aviation airfields, the aircraft crew must listen to the appropriate "air-to-ground" communication channel and, if necessary, provide the ATC departmental body with information about their location.[1]

The crew of an aircraft flying under VFR and intending to switch to flight under VFR must:

1) If the flight plan has been submitted, notify the relevant ATS body (departmental ATC body) about the necessary changes to be made to the current flight plan;

2) Submit a flight plan to the relevant ATS body (departmental ATC body) and obtain a permit to fly under IRR in controlled airspace (within air traffic control zones and areas of state aviation airfields).[1]

1.2. Peculiarities of flying in class “G” of Ukraine airspace

The airspace of Ukraine's ATS class “G” is organized in accordance with ICAO standards and recommended practice within the limits from the earth's surface to an absolute height of 1500 m inclusive. In an area where the height of the relief is 900 m above mean sea level (AMSL) and higher, the upper limit of the airspace of class G will be 600 m higher than the relief of the area (see Fig. 2. Class G of the airspace of the ATS of Ukraine). [5]

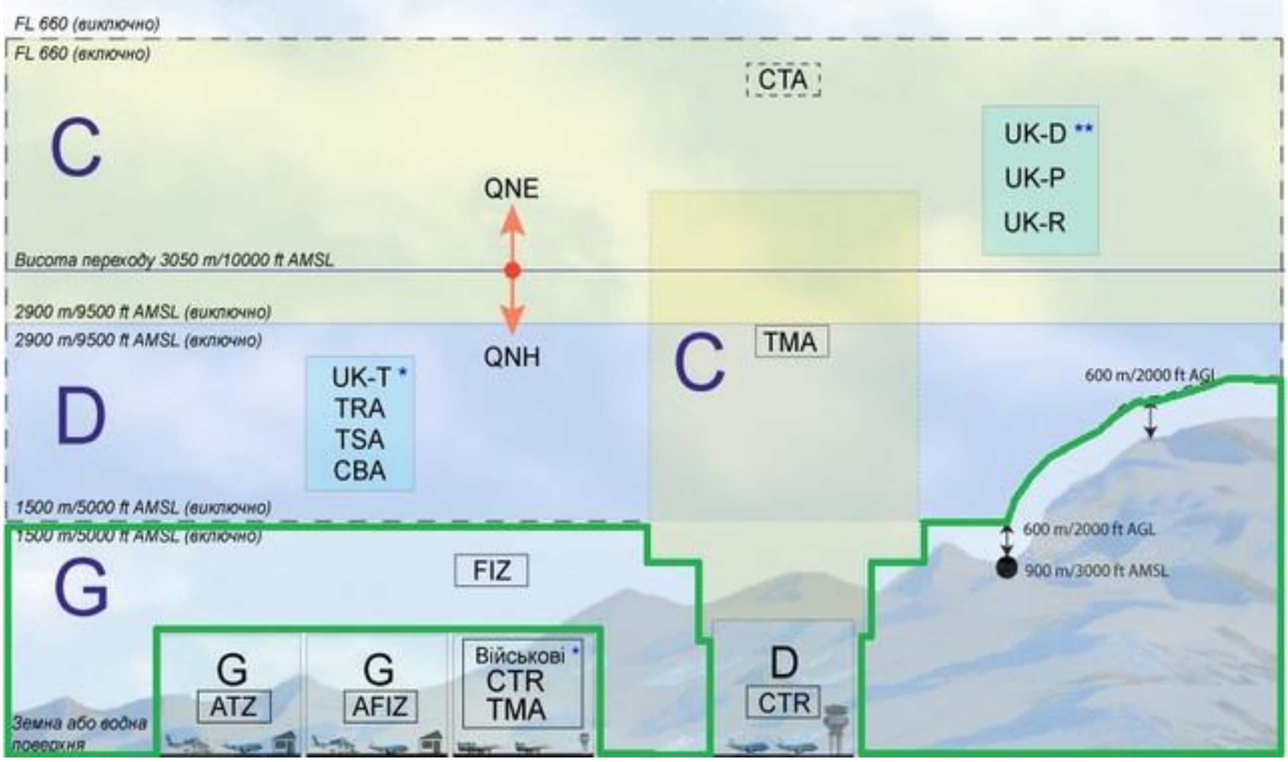


Figure 1.2. Class G of the airspace of the ATS of Ukraine

Class G airspace does not include such airspace elements as the airport traffic zone (ATZ), control zones (CTRs), terminal maneuvering area (TMA) and regulated prohibited, dangerous zones, flight restriction zones, temporarily reserved airspace (P, R, D, UK-T).[5]

Only flight information service and emergency notification (service) are provided in the airspace of ATS class G. Air traffic control services are not provided in this class of airspace. The requirements for flights in the air space of the ATS class G are established by the Order on the approval of the Aviation Rules of Ukraine "Air Traffic Services" dated 04/16/2019 No. 475.[5]

Users of the airspace of Ukraine should know the specifics of flying in the airspace of the ATS class G, namely:

1. Flights are performed only according to visual flight rules (VFR). Instrument flight rules (IFR) do not apply in this airspace.

2. When flying in this airspace, there is no need to have permanent two-way radiotelephone communication with the authorities (ATS (flight information service sectors of area control center (ACC) except for flights in the zone with a special mode of airspace use, except for its part, bordering the prohibited area If a pilot flying in this airspace wishes to receive flight information and emergency service, he can receive it in Russian or English using the operating frequencies of the flight information service sectors of the ACC.**[**6]

The responsibility for preventing collisions with other aircraft and physical objects in the air in Class G airspace rests with the captain of the aircraft.[5]

1.3. Meteorological service of flights

Meteorological service of flights at uncontrolled airfields is carried out in accordance with the Aviation Rules of Ukraine "Meteorological service of civil aviation" (order of the State Aviation Service of Ukraine dated 09.03.2017 No. 166). Airport Meteorological Service. The airport meteorological service issues:

- 9-hour forecast for the airport in TAF code form if there are flights every 3 hours;
- adjustments to previously compiled TAF forecasts, if necessary;
- forecasts of wind direction and speed at the height of the airfield flight circle;
- airfield warnings and wind shear warnings are prepared in accordance with the "Instructions for meteorological service of aircraft flights at the airfield in open text in russian;

The beginning of the period of the first forecast for the airport is the scheduled start time of the flights, the end of the validity of the last forecast is the scheduled time of the end of the flights. During flights, the staff of the AMS interacts with the weather services of other airfields.

Observations of wind, cloud ceiling, and atmospheric pressure are carried out remotely using meteorological instruments installed at the workplace of the AMS staff on duty. Observations of air temperature and humidity are carried out with the help of a station psychrometer, which is installed in a psychrometric booth at the meteorological site. Observations of atmospheric phenomena, the amount and form of cloudiness are carried out by the observer visually from the observation deck.

Observations of visibility are carried out visually according to selected daytime landmarks. According to the results of observations, if there are flights at the airport, regular reports on the actual weather are issued after 30 minutes (at 00 and 30 minutes of every hour). Between the periods of regular observations, the staff of the AMS conducts continuous observations of weather changes and issues special SPECI summaries when dangerous weather phenomena occur, intensify or weaken.

Special SPECI reports are issued in the following cases:

- the maximum wind speed reached or exceeded 15 m/s or more every 5 m/s regardless of direction;

- when the average surface wind direction has changed by 60° (or more) compared to the direction indicated in the last weather report, and the average speed before/or after the change is 5 m/s or more;

- when the average speed of the surface wind has changed by 5 m/s or more compared to the speed indicated in the last weather report;

- when the deviation from the average surface wind speed (gust) has increased by 5 m/s or more compared to the speed indicated in the latest weather report. At the same time, the average wind speed before/or after the change is 7 m/s or more;

- when the visibility exceeded the established criteria:

when worsened	**when improving**
less than 5000 m	more than 5000 m

- when the ceiling (vertical visibility) has exceeded the established criteria, provided that the number of clouds of this layer corresponds to the definition of BKN or OVC:

when decreasing	**when increasing**
below 450 m	above 450 m

- in the event of the beginning, termination or change in intensity of any of the following weather phenomena or their combinations:

- precipitation that freezes (supercooled);
- moderate (visibility 1-2 km) or heavy (visibility less than 1 km) precipitation (including showers), rain, drizzle, snow, rain with snow, freezing rain, hail, ice or snow flakes, snow grains;
- dust storm;
- sand storm.

In the event of the onset or termination of any of the following weather phenomena or combinations thereof:

- freezing fog (supercooled);
- dusty, sandy or snowy land;
- dust, sand or snow bottom blizzard;
- thunderstorm (with or without precipitation);
- squall;
- tornado

Local special reports are also issued under the following conditions:

- obtaining information about the presence of wind shear;
- obtaining additional information according to the data of the AC (weak, moderate or strong icing, moderate or strong turbulence and other special phenomena according to the data of the AC;
- drawing up a wind shear warning;
- receiving information about thunderstorms;
- in cases of change of forecast for landing type;
- "Alarm" signal.

Special and local special reports are transmitted by AMS personnel to the AFIS controller/flight coordinator in area UKT852 by telephone in open text.

1.4. Provision of meteorological information to flight crews

The following meteorological information is provided to aircraft crews:

a) summary of METAR and SPECI for the airfield, landing and alternate airfields;

b) TAF forecasts and their corrections for the airfield, landing and alternate airfields;

c) airfield warning and wind shear warning;

d) forecasts of wind and air temperature at altitudes;

e) forecast of special weather phenomena (conditions) along the flight route or zonal GAMET forecasts;

e) AIRMET information;

f) SIGMET information along the entire flight route, as well as special messages from AIREP SPECIAL (if available);

g) information of the Ministry of Internal Affairs and Communications (if available);

h) data from meteorological satellites of the Earth;

i) advisory information about volcanic ash, regarding the flight route.

Meteorological consultation is carried out at the request of aircraft crews, airlines or other authorized by them personnel, related to the execution of flights. The information specified in the previous paragraph is used for consultation. Meteorological consultation can be carried out by the forecaster of the AMS by phone or using other means of communication. After receiving the meteorological information before the departure, the flight crew member signs in the Logbook of weather consultations of the flight crew at the AFIS airfield to provide him with meteorological information for preparation for the flight. At the same time, the logbook indicates the flight number, time of weather consultation, time of departure, number of flight meteorological documentation, which the crew (personnel related to the execution of flights) read or received. When the departure is delayed for more than an hour, the crew must clarify the meteorological conditions, if necessary, obtain updated flight documentation and make a new entry in the logbook.

Flight documentation includes:

a) TAF weather forecasts for the aerodrome, landing aerodrome and alternate aerodromes;

b) compilation of METAR and SPESI (if available) for the Borodyanka airfield, landing and reserve airfields;

c) SIGMET information, special messages from AIREP SPECIAL on the flight route (if available);

d) SIGMET information on volcanic ash clouds and tropical cyclones along the flight route (if available);

e) GAMET zonal forecasts;

f) high-altitude wind/air temperature forecast maps and SIGWX special weather forecast maps;

f) AIRMET information (if available).

For flights lasting 2 hours or less, by agreement with the operators, the documentation for the flight is provided in a limited amount, which provides, at a minimum, weather forecasts and weather reports on landing and alternate airfields, as well as SIGMET information (if available) along the flight route .

When flying at low levels, crews are usually provided with GAMET zonal forecasts and SIGMET, AIRMET information (if available). At the request of the crew, the flight documentation is supplemented with other types of information.

Flight documentation is provided in the form of maps, alphanumeric OPMET messages. When the AMC has actual information or forecasts a synoptic situation, in which the meteorological conditions in the area of the destination aerodrome differ significantly from the forecast for the destination aerodrome, which was provided as part of the flight documentation, it draws the attention of the crew members to the existing discrepancies. At the same time, they are recorded on a copy of the flight documentation, which is archived.

1.5. Peculiarities of the activity of an air traffic controller

The peculiarities of the operation of the ATC dispatcher should include:

- *Polyergacity and monofunctionality of activity.*During the entire flight, the flight control process is carried out by many controllers, in turn, at different control points. However, on a certain section of the flight, in a certain zone, direct control is carried out by one controller.

- *Informational nature of activity.* Interaction of dispatchers of various control points, including points of support services, takes place at the informational level of interaction by means of communication between them, in the categories: "input", "output", "information", exactly the same as with objects of management.

- *Mediated nature of management,* that is, controlled objects are out of sight of the dispatcher. Only the dispatchers of ATC and AFIS stations can visually observe the movement of aircraft, and even then, for various reasons, not always (relief of the area, weather conditions).

- *Remote nature of management.* The controller receives information from the instruments and the crew in the form of coded messages (azimuth, range, altitude, flight mode, etc.), and influences the aircraft by sending commands to the crew.

- *Figurative nature of activity.* The mediated and remote nature of management forces the dispatcher to interact in the process of his activity with images that replace objects and the environment in which they function with the information model of objects and the environment.

The information model in the dispatcher's mind is reflected in the form of an image, an adequate task, which is set before him, and together with the knowledge he previously acquired in the educational institution, work experience, a broad understanding of tasks and goals, serves as the basis for the formation of a conceptual model that conditions the activity of the dispatcher in the process ATS.

- *Predictability of activity.* The peculiarity of forming an operative image for the dispatcher is that the information about the aircraft moving continuously comes to him discretely and he is forced to resort to extrapolation of this movement. This feature of the dispatcher's activity puts forward special requirements for the means of displaying information at the workplaces of the OPR, which should contribute to the creation of the dispatcher's necessary operational image.

- *Dynamism.* The dispatcher often controls several AC at the same time. He constantly and in a concrete form reflects in his consciousness both the entire air situation as a whole and its individual details. At the same time, the dispatcher's views are systematic and dynamic.

The systematicity of the ideas is revealed in the fact that the movement of one or another aircraft is not perceived by the controller in isolation, but only in connection with the movement of other aircraft. The movement of the aircraft is carried out within certain limits of the air zone, according to the established flight routes.

The dynamism of the representation is associated not only with high flight speeds, but also, more significantly, with constant changes in the air environment, flight parameters (speed, mode, altitude) and meteorological conditions.

- *Operativeness.*The dispatcher operates under a time limit. An increase in flight speed and intensity of movement requires a quick reaction, heightened attention, and plasticity of thinking from the dispatcher.

- *The complex nature of the management process.*The complexity of the processes of the operation of the ATS system, susceptibility to the influence of the environment and its dynamism require the dispatcher to simultaneously solve several independent tasks, different in their importance and nature.

At the same time, there are cases when the method of action for solving these problems is either completely absent (there is no established algorithm), or, despite the unusualness of the situation, the dispatcher has separate methods at his disposal, the combination of which in new combinations leads to solving the problems. This type of situation, typical for the dispatcher's work, can be characterized as problematic. That is why the professional level of the dispatcher's training, his work experience, and the quality of his training are of such great importance.

- *Emotional tension.* The occurrence of recoverable and non-recoverable equipment failures during the operation of the ATS system, as well as dispatcher errors, which sometimes lead to undesirable consequences, require him to be in a constant state of readiness and mobilization. The air traffic control operator must always be ready to make the necessary decisions to eliminate the emergency situation.

CHAPTER 1 CONCLUSION

The airspace of ATS of Ukraine class G is organized in accordance with ICAO standards and recommended practice within the limits from the earth's surface to an absolute height of 1500 m inclusive. In terrain where the terrain is 900 m above mean sea level (AMSL) and above, the upper limit of Class G airspace will be 600 m above the terrain.[5] but with the constant growth of air transportation, there is a need to adjust the processes of air traffic maintenance in order to maintain the level of flight safety at the appropriate level. After all, if the system is safe, the growth of flights will continue.

CHAPTER 2

THREATS IN AIR TRAFFIC CONTROL AND BASICS OF FLIGHT SAFFETY MANAGEMENT

Threads are defined as events or errors occurring outside the air traffic control controller's sphere of influence that complicate operational conditions and must be controlled in order to maintain the threshold level of flight safety. When performing routine ATC operations, air traffic control operators have to take into account various contextual complexities in order to cope with the control task. Such difficulties include, for example, adverse meteorological conditions, high mountains surrounding the airport, congested airspace, aircraft malfunctions or errors made by other people outside the air traffic control premises. Such complexities are considered threats because they can lower the threshold level of flight safety.

Occurrence of some threats are predictable because the air traffic controller knows about them and waits for them to appear. For example, in order to predict the possibility of changing the runway or the direction of its use, the air traffic controller can use the information contained in weather forecasts. Another example is unreliable communication in the high-frequency (HF) range, which necessitates the use of alternative options.[2]

Some threats can arise completely unexpectedly, such as the pilots of an airship carrying out instructions related to another PC as a result of confusion with the call sign. In this case, in order to cope with such a situation, air traffic controllers must be able to apply their skills and knowledge, which they have acquired during training, and use the accumulated work experience.

Regardless depending on the type of threat (expected or sudden), one of the indicators of the air traffic control controller's ability to effectively control the threat factors is the ability to detect threats early enough and react to them by taking appropriate countermeasures.

2.1. Threats

Threats in ATC can be divided into the following four categories:

1. Internal threats to the air traffic service provider;

2. External threats to the air traffic service provider;

3. Threats in the air (on board);

4. Threats related to the environment.

These four categories can be divided into other categories as shown below as an example. Knowledge of these threats will contribute to the acceptance by both individuals and organizations of the limits of countermeasures aimed at maintaining the maximum level of flight safety during ATC.[2]

2.1.1. Internal threats

- *Equipment.* Equipment design is often a source of threats to ATC. Equipment malfunction and its design are one of the factors that dispatchers have to control to varying degrees during their day-to-day operations. Additional threats that belong to this category include poor quality radio communication and not always good telephone communication with other ATC centers. Entering data into an automated system can be a threat if the necessary data is rejected by the system and the dispatcher has to find out why these data were not accepted and how to correct this situation. On the face of it, sub-optimal equipment is a threat in many ATC centers around the world. Maintenance work (planned or performed without advance notice) performed during normal ATC operations poses a significant threat to ATC. In addition, maintenance work can present a threat that only becomes apparent when the relevant equipment is put into operation after such work.

- *Workplace factors.* This category of threats combines such factors as reflection, temperature in the room, a chair that cannot be adjusted, background noise, and others. The work of the dispatcher becomes difficult in those cases when the light from the lamps in the room is displayed on the monitor. The dispatcher, who is on the tower TWR, may experience difficulties in visual observation of traffic in night conditions in the case of reflection of internal light on the windows of the tower TWR. A high level of background noise (for example, from the operation of fans needed to cool the equipment) can make it even more difficult to accurately understand the messages that come over the radio communication channels.

- *Procedures* can also be a threat to ATC. This applies not only to air traffic control procedures, but also to internal and external communication or coordination procedures. Cumbersome or inappropriate procedures may lead to the introduction of simplifications intended to facilitate air traffic, but errors or undesirable conditions may occur.

- *Other ATC operators* from the same ATC body can also be a threat. Proposed solutions to ATC problems may not be accepted, intentions may not be properly understood or expressed, and internal coordination may not be sufficient. Other controllers may be busy with extraneous conversations, thereby diverting their attention from air traffic control, or substitute controllers arrive at the workplace late. Other controllers in a given ATC authority may manage air traffic less efficiently than necessary, and therefore they cannot accept the additional aircrafts that the controller wants to transfer to them for control.

2.1.2. External threats

- *Airport location plan*. The layout and configuration of the airport can serve as a source of threats to ATC, which equates to operating conditions at the tower TWR. At an average airport with only one short taxiway connecting the aircraft parking area with the middle of the runway, the air traffic control authority will need to organize taxiing of arriving and departing aircrafts in reverse directions on the runway. If the taxiway is located parallel to the runway and intersects it at both ends, as well as between them, then it will not be necessary to organize taxiing of the aircraft along the runway in the opposite direction. Some airports are designed or operated in such a way that aircrafts moving under the power of their engines, or aircrafts moving with the help of tugboats or other vehicles, have to cross the lane frequently. The solution in this case may be a taxiway around the runway, provided that the aircrafts and vehicles concerned use it properly.

- *Navigation aids*, that suddenly fail can pose an ATC threat by altering procedures or creating navigational inaccuracies and capturing aircraft echelons. Another example of threats in this category are instrument landing systems (ILS) installed on both sides of the same runway. Under normal conditions, only one ILS system is operating at any given time, so when the landing course of the runway is changed to reverse, the ILS system for that course may not be engaged yet, although the controllers already allow the aircraft to capture its course.

- *Infrastructure/Airspace Configuration.* The structure or classification of airspace is another potential source of threats to air traffic control. If there are restrictions in the airspace used, it will be more difficult to cope with a large volume of air traffic. Prohibited or dangerous zones, the use of which is not permanent, can be a threat in the case of sub-optimal procedures for transmitting information about the status of such zones to dispatchers. The provision of air traffic control services in Class A airspace is less prone to threats than, for example, in Class E airspace, where there may be unknown aircrafts that interfere with the air traffic controlled by the controller.

- *Adjacent bodies of ATC.* Dispatchers of adjacent ATC bodies may lose sight of traffic coordination. A transfer of control can be properly negotiated but not properly executed. They may not comply airspace boundaries. The dispatcher of the adjacent center may not agree with the proposed non-standard transfer of control, in connection with which there is a need to find another solution. Adjacent centers may not be able to manage the number of aircrafts that another body wants to transfer to them. Dispatchers from different countries may have language difficulties.

2.1.3. Threats in the air

- *Pilots,* who are unfamiliar with the airspace or airport may pose a threat to ATC. Pilots may not report to ATC authorities some of the maneuvers they may have to perform, which may pose a threat to ATC. Pilots may forget to report passing a control point or reaching altitude, or they may confirm some actions that they will not be able to perform later.

- *Flight and technical characteristics of the aircraft.* Air traffic control operators are familiar with the FTCs of most types of aircrafts category that they have to work with, but sometimes these characteristics may differ from what they expect. A “Boeing 747” flying to a destination that is close to the point of departure will gain altitude much faster and at a steeper angle than if the destination is far away. He will also need a shorter run. Some turboprop aircraft of the new generation demonstrate higher characteristics in the initial stages of flight after takeoff than jet aircraft of medium size. In the aircraft of the next series, the flight speed in the final stages of the approach to landing can be significantly higher than in the aircraft of the previous series.

All these aspects of the differences in characteristics, if they are not taken into account, can serve as threat factors for ATS.

- *Radiotelephone communication.* Threat factors for air traffic control are errors made by pilots when repeating messages transmitted to them (the same threat factor for pilots is the error of the ATCO when listening to the answer). The rules of radiotelephone communication are designed in such a way that it is possible to detect and correct such errors (and avoid the threat), but in practice not everything works perfectly. Communication between pilots and controllers can be complicated due to language differences. Conducting negotiations on the same frequency in different languages or the use of the same frequency by several ATC bodies is also considered a threat of this type.

- *Air traffic.* Air traffic control operators are familiar with the usual the flow of air traffic in their areas and the usual order of its maintenance. Threat factors in the management of ordinary air traffic means such non-scheduled flights as, for example, flights for the purpose of aerial photography, geodetic flights, calibration flights, parachute drop flights, traffic control flights and flights with the towing of advertising banners. The earlier the controller knows about additional flights, the more opportunities he will have full control of the factors of this threat.

2.1.4. Environmental threats

- *Weather.* Probably the most common source of threat to all types of aviation activities, including the work of air traffic control bodies, is weather. It is easier to control the threat factors if you know the current one weather and forecast, at least for the duration of the dispatcher shift. For example, a change in wind direction may make it necessary to change the runway. The more intense the traffic, the more important it is to choose the right moment to change the runway. The controller will plan the runway change in such a way that it takes place with minimal disruption to traffic flow. Control of air traffic on air routes, knowledge of special weather phenomena will help controllers to anticipate requests for deviations from the flight route. Adequate knowledge of local weather phenomena (eg, turbulence over mountainous terrain, fog formation areas, thunderstorm intensity) and sudden weather changes such as wind shear or micro-gusts helps to successfully control weather-related hazards.

- *Geographical conditions.* Threat factors of this category are associated with mountainous terrain or obstacles in the dispatcher's area of responsibility. Less obvious factors may be related, for example, to residential areas, over which flights should not be carried out below appropriate altitudes or at specified times. In some airports, according to the requirements of environmental protection, runway changes must be carried out in a mandatory manner at a certain time of the day.

2.2. The need for flight safety management

The flight safety management process is an integral part of the air traffic control system. A significant part of the activities of the ATC services is aimed at flight safety. To ensure effective, reliable and safe air traffic service, there is a need to manage flight safety.[1]

The need for flight safety management is justified based on the expected growth of the industry and the potential increase in the number of aviation events as a result of such growth. Although reducing the number of aviation incidents will always be a priority for aviation, there are more compelling reasons than statistical projections for the transition to international civil aviation safety management on a global basis.

You can to claim that aviation is the safest form of mass transportation and one of the safest socio-technical production systems in human history. This seems especially relevant given the age of aviation, which is measured in decades, while the history of other industries is measured in centuries. Thanks to the relentless efforts of the aviation community in the field of ensuring flight safety, in just a century aviation has gone from an unstable system to the first ultra-safe system in the history of transportation.

2.2.1. Flight safety management basics

In aviation organizations whose work is aimed at successful and efficient work, flight safety management is the main function. It is provided in each of the air traffic control processes.[1]

For example, when considering the monitoring process, it can be noted that it includes a forecast of the system state, a comparison of the actual state of the system with the predicted one. And, if there are even slight deviations from the normal state of the system, it is immediately reported for the purpose of ensuring safety.

If we take the management process, we can say that it is a process that is mostly related to security. This is the process of intervention in the air situation by the controller to control one or a group of airships. The controller begins to control air traffic first of all in order to ensure the safety of the flight of his sector and the safe entrance to adjacent sectors.

The verification process compares the correspondence between the actual state of the system and the expected one. But when inaccuracies are detected, the problem is sent to monitoring, and monitoring detects the problem and gives the dispatcher permission to perform actions aimed at flight safety.

The diagnostic process is directly aimed at identifying potentially conflict situations. When a conflict is detected, the controller intervenes in the air situation and the control process begins.

Therefore, it is safe to say that all air traffic control processes are closely related to flight safety.

Flight safety is one of the main factors of air traffic management. Effective flight safety management involves a realistic balance between safety objectives and production objectives. Thus, a coordinated approach that analyzes the organization's goals and resources helps ensure that flight safety decisions are realistic and complement the organization's operational needs.

It must be recognized that there are limits to financial and operational capabilities in any industry. Therefore, defining acceptable and unacceptable risks is important for cost-effective security management. With the proper implementation of security management measures, not only the level of security, but also the efficiency of the organization's work increases.

Experience gained in other industries and lessons learned from accident investigations emphasize the importance of a systematic, proactive and clear approach to safety issues.

- *Systematic* means that safety management measures will be implemented according to a pre-planned and consistently applied throughout the organization.
- *Proactive* means that an approach will be adopted in which the main emphasis is on prevention by identifying hazardous factors and taking measures to reduce the risk before any hazardous event occurs and has an adverse effect on the state of flight safety.
- *Clear* means that all safety management activities must be documented, visible and carried out separately from other types of management activities.

A systematic, proactive and clear approach to security ensures that in the long term, security will become an integral part of the organization's daily work and the security measures used by it will be directed to those areas where the benefits will be greatest.

A systematic approach

Modern approaches to safety management have been shaped by the concepts of flight safety, and in particular, the role of organizational problems as contributing factors to events and incidents. Safety cannot be ensured only through the introduction of rules or directives regarding the procedures to be followed by operating personnel.

The field of security management covers most types of activities of the organization. For this reason, safety management must start at the top, and safety performance must be analyzed at all levels of the organization.

System security

The subject of system security was developed in the 1950s as a technical discipline for aerospace and missile defense systems. In practice, it was applied by safety engineers, not by operational specialists. As a result, the focus of their attention, as a rule, was on issues of designing and creating fail-safe systems. On the other hand, in civil aviation, there was a tendency to focus on the production of flights, and the heads of flight safety units were often pilots. In order to ensure a higher level of flight safety, it became necessary to consider it in a broader context than just the plane and its pilot. Aviation is a complete system that covers everything necessary for the safe production of flights. This "system" includes the airport, air traffic control, maintenance, flight crew, ground maintenance service, air traffic control service, etc. Reliable flight safety management involves taking into account all components of this system.

Factors affecting flight safety

The factors that affect safety within a certain system can be approached from two points of view: firstly, to consider those factors that can create situations that threaten safety, and secondly, to analyze how the understanding of these factors can be used when designing systems in order to reduce the probability of occurrence of events capable of creating a security threat.

The search for factors that can endanger safety must be carried out at all levels of the organization responsible for operation and for the provision of support services.

Active defects and hidden conditions

The causes of active defects are usually equipment malfunctions or errors made by operating personnel. However, the human element is always present in hidden conditions. They may be the result of unnoticed structural defects. They may be associated with unrecognized consequences of officially approved procedures. A number of cases were also noted when the hidden conditions were a direct result of decisions made by the management apparatus of the organization. For example, hidden conditions exist in those organizations where the corporate culture encourages simplified methods, instead of always following officially approved rules. The direct consequences of this or that condition associated with simplified methods will manifest themselves at the operational level if correct procedures are not followed. However, if such behavior of the operating personnel is considered acceptable and the administration is either unaware of these facts or does not take any measures, then there is a hidden condition at the managerial level in this system.

Safety management process

Safety management is based on factual material in the sense that data analysis is required to identify sources of danger. Using the risk assessment methodology, priorities are set to mitigate the potential effects of existing hazardous factors. Then appropriate strategies designed to reduce or eliminate these factors are developed and implemented with a clear division of responsibility. The situation is reassessed on an ongoing basis, and additional measures are taken as necessary.

Below is a brief description of the steps in the security management process:

a) *Data collection.* The first step in the safety management process is the collection of safety-related data - the actual material needed to determine safety indicators or identify hidden dangerous factors. Said data can be obtained from any part of the system, namely: equipment in use, operating personnel, work procedures, human-equipment-procedure interaction, etc.

b) *Data analysis.* By analyzing all the information related to the problem, it is possible to identify dangerous factors. It is also possible to determine the conditions in which the factors constituting a real threat, their potential consequences and the probability of the occurrence of the event are indicated.

c) *Prioritization of hazardous conditions.* With the help of the risk assessment process, the degree of seriousness of the hazard factors is determined. Those of them, which pose the greatest risk, are considered for the purpose of taking measures to increase the level of security. A cost-benefit analysis may be required for these purposes.

d) *Development of strategies.* Starting with the risk factors that have the highest priority, several options for controlling these factors can be considered, for example:

1) distribution of risk among the maximum possible range of risk-takers. (This is the main principle of insurance.);

2) eliminating the risk (for example by ceasing these operations or practices);

3) acceptance of this risk factor and continuation of operational activities without changes;

4) risk reduction by taking measures designed to reduce its level or at least facilitate its control.

e) *Approval of strategies.* After conducting an analysis of risk factors and choosing an appropriate action plan, it is necessary to obtain the management's consent for its implementation. The challenge at this stage is to formulate a convincing argument in favor of making changes.

f) *Distribution of responsibilities and implementation of strategies.* After the decision to continue these efforts, it is necessary to develop "practical" aspects of the implementation of the plan. They include issues of resource allocation, division of responsibilities, scheduling, review of operating rules, etc.

g) *Reassessment of the situation.* The implementation of the plan rarely turns out to be as successful as originally intended. Feedback is required to obtain a closed circuit. What new problems could be introduced? To what extent is the agreed risk reduction strategy meeting the expected results? What system or process changes might be needed?

h) *Collection of additional data.* Depending on the results of the reassessment of the situation, there may be a need for additional information and a repetition of the full cycle in order to achieve a higher efficiency of the security measures taken.

Safety management requires analytical skills that management may not always have to apply in their day-to-day work. The more complex the analysis, the more pressing the need to use the most appropriate analytical methods becomes. The closed loop of the security management process also requires feedback, which allows the administration to check the correctness of its decisions and evaluate the effectiveness of their implementation.

2.3. State of flight safety from 2017 to 2021

In recent years, the problem of flight safety has become acute enough for Ukrainian aviation. This is related to the number and nature of accidents and disasters. According to information from the International Civil Aviation Organization, the relative indicators of the level of flight safety in the aviation industry of Ukraine are significantly worse compared to the global average. In addition, the problem of flight safety is also associated with significant social and economic losses.

The level of flight safety, among other things, characterizes the completeness of preventive work to prevent aviation incidents, carried out in the aviation division in conditions of increasing air traffic intensity.

In the following table 2.1. and diagram 2.1. it can be seen that in the conditions of the growing intensity of air traffic and the complexity of the tasks that civil aviation solves, flight safety indicators are also changing.

Table 2.1. The number of aviation events for 2017-2021.

Type of AP\year	2017	2018	2019	2020	2021
Disasters	2	1	1	1	0
accidents	2	1	1	0	0
Serious incidents	3	4	2	0	0
Incidents	37	52	25	17	57
Total AE	44	58	29	18	57

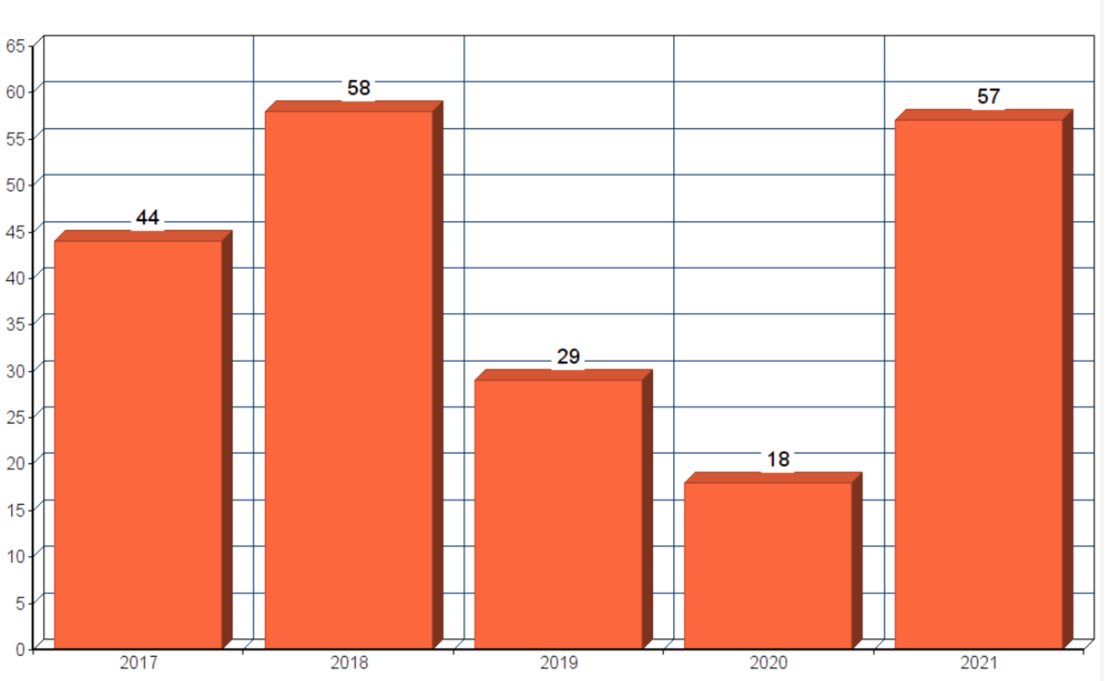


Diagram 2.1. The number of aviation events for 2017-2021.

So, as can be seen in diagram 1 and table. 4, in the conditions of the growing intensity of air traffic and the complexity of the tasks that civil aviation solves, flight safety indicators are also changing.

2.4. Example of a typical aviation event and airspace violation occurring in uncontrolled airspace of class “G”

2.4.1. Aviation event of the An-2 aircraft 09.12.2020.

Let's consider the investigation of the incident that happened 09.12.2020 an An-2 aircraft, which is excluded from the State Register of Civil Aviation of Ukraine, near Zolota Sloboda, Ternopil region

09.12.2020, at 17:04 Kyiv time (KT), at night, during the execution of unauthorized patflight and from "Pohorilivka", Zastavnytsky district, Chernivtsi region. within the borders of Khmelnytskyi and Ternopil regions, near the village of Zolota Sloboda, Ternopil region, when attempting to land on an unprepared plot of land, the An-2 aircraft collided with the earth's surface.

Figure 2.1. Aircraft An-2, flight number UR-33642 before the aviation event

7 minutes before sunset, the An-2 aircraft with the state and registration marks UR-33642 on the fuselage took off from the "Pohorilivka" airport, Zastavnytsky district, Chernivtsi region. The flight was performed within the boundaries of Chernivtsi, Khmelnytskyi, and Ternopil regions at altitudes of 800-1000 meters above ground level. At 17:01, at night, the plane flew to the village of Koziv, Ternopil region. Presumably for the purpose of landing.

Waspba, who was piloting the plane, turned on the landing lights and began to descend. At 17:04, the aircraft descended to minimum altitude and the left lower wing collided with the dirt embankment of the side of the dirt road. As a result of the collision, the lower wing of the aircraft was torn off, the aircraft turned upside down on its wheels and moved along the ground. The engine broke off from the engine frame of the plane's fuselage, which caused a short-term ignition. The person piloting the plane fell out of the cockpit and suffered life-threatening injuries.

As a result of the collision with the earth's surface, the plane was destroyed (Fig 2.2). The left landing gear and the left wing box were separated from the fuselage, the engine separated from the engine frame, the crew cabin is destroyed.

Figure 2.2. Aircraft An-2 win damage

Figure 2.3. Damage of the An-2 wing

According to the flight operational manual of the An-2 aircraft, the aircraft is not equipped with standard navigational aids. The pilot probably used a external GPS navigator that was found at the place of an aviation event (near the destroyed flight deck).

During the flight, the pilot did not communicate with the air traffic control authorities.

It should also be noted that at 18.00 (Kyiv Time) there was cloudiness with a ceiling of 200-300 meters, air temperature minus 3.8ºC, dew point minus 4.6ºC, humidity 94%. The Commission assume that under such conditions, fogging and icing may occur, which may lead to icing of the carburetor.

The commission considered the following reasons that could lead to the occurrence of this event:

1) human factor;
2) loss of aircraft controllability due to malfunction of control systems;
3) the influence of the external environment and the presence of dangerous meteorological phenomena.

Having analyzed all versions of the occurrence of the event, the commission came to the conclusion that the cause of the disaster is the collision of the An-2 plane, which is excluded from the state register of civil aircraft of Ukraine, with the earth's surface, which led to the destruction of the aircraft and the death of the person who piloted the plane, was the landing by an unprepared person at night on an unprepared and unequipped plot of land, which led to the loss by a person who piloted an aircraft in spatial position and collision with the earth's surface.

Contributing factors:

- failure to release the plane's mechanization into the landing position;
- landing at high speed;
- admission of a large left roll before landing.

2.4.2. Aircraft incident L-410UVP1 10.06.2020

The next incident occurred on June 10, 2012 at 10:40 a.m. with the crew of the

L-410UVP aircraft (registration number URSKD) in the Kyiv region near the Borodyanka airdrome.

The crew arrived at Borodyanka airfield at 04:55 (UTC). A pre-flight briefing was carried out, during which the crew was provided with information about the weather conditions at Kyiv (Zhulyany) airport and Kyiv FIR, as well as the actual weather at the Kyiv Antonov airfield.

According to the notes in the logbook, there were no comments on the operation of the aircraft's on-board equipment and engines.

At 06:46, the crew took off in visual meteoroical conditions (VMC) and, after completing the task of landing paratroopers at 07:10, landed and began preparations for the next flight.

The next take-off was carried out at 07:31 in normal visual metroroical conditions. The commission found that, according to the data of the Pulse Dopler Radar, thunderstorm centers were visible: at a distance of 15 km to the southwest of the Borodyanka airfield and to the southeast at a distance of 12 km. The fire was moved to the northeast at a speed of 50 km/h. Along the Teteriv-Fastiv-Skvira line, a powerful thunderstorm front with hail and thunderstorm centers arose.

Figure 2.4. The L-410UVP aircraft before the aviation event

The ATCO’s workplace at the airfield is not equipped with radar equipment. At approximately 07:40, the disoatcher visually noticed the approach of storm clouds and deteriorating meteoroical conditions and gave the fliht crew an instruction to gain an altitude of 3,000 m. The aircraft was at an altitude of 2,000 m at that time. After 15-20 seconds. the command was given to abort the mission and return to the airfield. Crew

confirmed the information and reported that they are located 10 kilometers north from the airfield. Air traffic control operator issued an instruction that it is necessary to contact with Kyiv-Radar on the frequency 127.725 in order to obtain permission to fly to the salternative (Zhulyany), after that he reported information about the actual weather at the Borodyanka airfield: wind 11 m/s , 270 ° gusts of approximately 15 m/s.

The crew accepted the information and reported that these conditions are good for landing at the Borodyanka airfield. The flight crew did not respond to further calls.

During the approach to land in the conditions of thunderstorm activity, the aircraft got into a downward gust of air, due to which it collided with the earth's surface in a wheat field at a distance of 900 m from the end of the runway. As a result of the collision, the aircraft was heavily damaged. The fuselage broke in half. The tail part stopped, with an inclination to the right. The front part of the fuselage, which has a pilot's cabin, was badly deformed. The right propeller separated as it moved through the ground. The left wing was broken. There was no fire. 13 paratroopers and 2 crew members were seriously injured.

Figure 2.5. Damage to the L-410UVP aircraft

Figure 2.6. Damage to the L-410UVP aircraft

Figure 2.7. Damage to the L-410UVP aircraft

2.4.3.Aviation event of Mi-8MTB-1 UR-CCM helicopter

On January 25, 2018, around 19:00 Kyiv time, after the completion of the training flights on the Mi-8MTV-1 UR-CCM helicopter of ‘’Ukrainian Helicopters’’, and during the return to the Kremenchuk (Velika Kohnivka) airfield, the aircraft collided with the elements of the television tower, located at a distance of about 3.5 km west of the Kremenchuk airfield, fell to the ground and caught fire. As a result of the accident, four crew members died, the aircraft was completely destroyed.

The investigation of the aviation incident is carried out by the National Buerau of

Air Accidents Investigation of (NBAAI). On-board recorders (black chests) were discovered and seized by NBAAI specialists in the presence of representatives of the National Police. Flight information is currently being deciphered and analyzed.

Figure 2.8. Airplane crashhelicopter Mi-8MTV-1

CHAPTER 2 CONCLUSION

Threats are events that occur outside the scope of activity of a given ATCO, they may occur in the sector of an adjacent dispatcher, these may be unfavorable weather conditions that may arise suddenly. Unauthorized actions of the pilot (execution of maneuvers without informing the ATC), improper conduct of radiotelephone communication, and so on, can also be considered threats.

There are many threats that affect the safety of air transportation. Flight safety is a system that is constantly developing in order to make aviation as a whole as safe as possible.

It is not possible to fully predict all threats that may occur during air traffic control, but it is necessary to constantly try to reduce them to the minimum.

CHAPTER 3

WAYS TO MINIMIZE RISKS WHEN FLYING IN CLASS "G" AIRSPACE OF UKRAINE

3.1. Development of a standard matrix of risks and hazards

The next step in risk management is the formation of a risk matrix. It has to be done only once, so it is not necessary to consider this activity as a process. The risk matrix is built on the basis of the selected risk model. The most common, as already indicated, is the two-factor model, in which the risk is calculated as the product of the probability of the occurrence of the hazard by the weight of the consequences of its implementation. This formulation can be applied only if both risk components are expressed numerically. To facilitate its use, in the case of qualitatively expressed components (one or both), an insufficiently flexible system of rank evaluations is used (more often they are integers), in which a corresponding risk number appears for each situation and a risk matrix is formed. It is with its help that classification of risks and completion of the register of risks is carried out in the future.

A significant problem that arises during the formation of the risk matrix is the expert assessment of elements of the risk matrix with the same risk value [63, 64, 76]. This is especially important when using rank scales. It is obvious that the same risk values can be obtained with a different combination of the probability of the occurrence of the event and the severity of the consequences. The rank assessments, due to their simplicity and integers, are not flexible enough to correctly reflect reality. Experts have to confirm that these different combinations really do represent the same risk. Otherwise, additional levels of gradation of probability or severity of consequences will have to be introduced.

Example. In the case of the presence of the risk matrix given in the table below for three-level scales, it is necessary to substantiate with the involvement of experts in each specific case that the risks with the same value at different combinations of the probability of danger and the severity of the consequences in a real meaningful sense really turn out to be the same. For example, it is necessary to confirm that the risks, level 2 will really be the same at the following levels of risk parameters: "Low probability - Medium severity" and "Medium probability - Low severity".

Table 2.1 Risk matrix

Severity of consequences, rank / Proba-bility of daner appearance, rank	Insignificant	Limited	Heavy	Very heavy	Catastrophic
Very low - 1	1	2	3	4	5
Low - 2	2	4	6	8	10
Average - 3	3	6	9	12	15
High - 4	4	8	12	16	20
Very high - 5	5	10	15	20	25

The most important element of risk assessment is the risk matrix, which allows you to evaluate them and determine the level of risk. The matrix shows: what combinations of the probability of the occurrence of hazards and the severity of their consequences give a certain level of risk, which is in the corresponding cell of the matrix. To use it, it is necessary to select zones with a certain level of risk in the matrix, corresponding to the understanding of the level of risk at the enterprise. This is done expertly. The formation of such a matrix is the main step in the assessment of the category of risks for the formation of ways to reduce them, and the matrix itself is the most important element of risk management along with the scales for measuring risk components. The peculiarity of the formation of such a matrix is the quantification of the probability of possible dangers and the severity of their consequences, which are carried out expertly, as well as the formation of zones of different levels of risks. There are no single levels of these risk characteristics suitable for any enterprise. In the work, all the given data were obtained during classes with specialists of a large chemical plant, taking into account their professional experience and the specifics of a chemical enterprise (the applicable method is mentioned on the previous page). The obtained values are agreed upon by all group members.

Another problem is the following: how and how many zones to allocate in the risk matrix? Is two enough? Or three? In this example, five risk zones are highlighted (highlighted with different levels of filling). In general, one should not forget that in the general case: "classification according to two directions - NOT a classification, but more like five - is practically not implemented"! (From scientific folklore) From what point of view should it be done? It can be defined in words (or substantiated by numbers): the zone ignores a small (acceptable) risk - in this case, a feature of no more than 2, the zone of acceptable risk (more than a small one can be ignored, we can no longer ignore it, but we accept it) - in this case from 3 to 5. Then the zone of significant risk that needs to be eliminated, to build long-term plans for this, to plan resources. In this example, from 6 to 10. The next one is a high-risk area. Urgent measures should be taken here, funds should be sought to reduce such risks. In this example, from 11 to 15. And, finally, extremely high risks: they require an almost operational response from the management. There are more than 15 risks. This is one point of view. Or maybe three zones are enough to assess compliance: acceptable risk, unacceptable risk and dangerous risk? This approach is more compact, practically more understandable and accessible. This is another point of view. In all cases, the solution to the problem of risk reduction should transfer a specific risk from one more dangerous zone to another less dangerous one with a lower risk value. For this, it is necessary to form a risk matrix when using ranking scales at each enterprise. The absence of a risk matrix (except in the case of quantitative assessment of probability and severity, which is discussed below, when the matrix is essentially replaced by the limit values of risks for individual zones) does not allow to classify risks and analyze them .

However, this {constructed} model, although simple for practical application, is not perfect because it is oriented towards the use of ranks or integer weights. Therefore, the author proposed a second model, which is based on an algorithm devoid of these shortcomings, which is oriented towards a fully quantitative assessment of risks. At the same time, the entered normalized value allows you to compare the level of its significance for different situations at the enterprise, for different enterprises, according to the value of the risk.

3.2 Quantitative scales of probability of occurrence of danger

Quantitative scales of the probability of hazard occurrence can be obtained by observing the frequency of hazard occurrence [61, 76]. At the first stage of the formation of quantitative scales, they usually rely on qualitative scales, only instead of ranks, certain intervals are assigned a numerical value of the frequency of occurrence of danger in certain conditions. An important requirement for forming a scale in this way is that the conditions for the appearance of the hazard must be approximately the same, otherwise the statistics will be incorrect. For example, the following scale may take place, where the quantification corresponds to the number of times a hazard has occurred over a certain period of time.

Table 2.3. Probability of hazard appearance

Qualitative assessment of probability	Very low	Low	Average	High	Very high
The frequency of occurrence of the hazard in the same conditions	1 time in 2 years	3 times in 2 years	5 times in 2 years	10 times in 2 years	20 times in 2 years
Quantification of probability	1/24 = 0.0427	3/24 = 0.1250	5/24 = 0.2083	10/24 = 0.4167	20/24 = 0.8333

Note: 24 is the number of months in two years. This time period is taken because all the occurrences of the analyzed events fall within this time interval. The probability values constructed in this way will vary in the range from 0 to 1. Using this scale, it is possible to find the probability of the occurrence of danger for others who did not fall into the zone of the scale values of the frequency of occurrence of danger, but if they do not go beyond certain limits. For example, if the event occurs 2 times every two years, then its probability will be 0.026 * 2 = 0.052, if the frequency of occurrence is 8 times every two years, then the probability can be found as 0.026 * 8 = 0.208. However, if the hazard frequency is, lets say, 50 times over two years, then using the transformation directly would give a value of 0.026 * 50 = 1.3 and quantify the initial opportunity as 50/24, which is also > 1, which is impossible because the value of the probability in this scale should not exceed 1. In this case, a large time base should be chosen, at which the most frequently occurring probability will be less than one. For example, in the given example 50 times in 2 years, instead of the base value of 24 months, take the base time interval of 1 week. Then the probability of the occurrence of an event in a week will be 50/112 (how many weeks in two years) For the following frequency values given in the table, new normalized values not exceeding 1 will be obtained.

Table 2.4. Hazard probability

The frequency of occurrence of the hazard in the same conditions	1 time in 2 years	5 times in 2 years	10 times in 2 years	20 times in 2 years	50 times in 2 years
Quantification of probability	1/24	5/24	10/24	20/24	50/24

Quantitative scales of the severity of the consequences of the manifestation of hazard. We can increase the accuracy of the risk calculation by introducing quantitative estimates and by the severity of the consequences, expressing it, for example, in rubles of costs [63, 64]. The easiest transition to quantitative estimates is to use the monetary equivalent of losses. It can be direct loss of income, damages, additional unforeseen expenses, etc. Expressed in rubles. In many cases, this approach can provide the necessary assessment of the severity of the consequences, because it is almost always possible to determine the losses more or less accurately, although in some cases it is quite difficult and time-consuming. Similarly, it is possible to introduce loss estimates to reduce production productivity in the event of danger, for losses in the quality of products, in terms of deliveries, to compensate for the loss of natural resources, to clean the environment, etc. In such cases, it is possible not to use the risk matrix itself. It is enough to enter the boundaries of risk levels for the borders of each zone. Therefore, the real severity of the consequences can be estimated by the relative losses. In particular, the severity of the consequences Z_{rel} can be considered as a share of losses V_{los} of a certain volume V_{av} of the total means.

$$Z_{rel} = \frac{V_{los}}{V_{av}}$$

For example, the value of the company, the amount of its annual turnover, the amount of funds allocated for carrying out a specific type of activity can be taken as V_{av} . Then "bankruptcy" for a certain type of activity can occur at losses $Z_{rel} = 1$, that is, when the losses are equal to the amount of funds used for this type of activity.

For one type of activity, it may turn out to be 500,000, and for another - 50,000. But from the standpoint of the severity of the consequences in the given sense - these will be the same losses for the relevant organization, that is, lead to its bankruptcy. If $Z_{rel} = 1$, then it is obvious that the losses will amount to only 5% of the total amount of funds used in this activity.

It is often more convenient to express the severity of consequences in units of "value" of a particular activity managed by managers. Then it will be obvious losses due to insufficient competence of managers.

Let's explain it with examples.

Equipment modernization with investments is planned, which should last for 60 days. As a result of several skilled workers leaving the company (this was a hazard they knew about, but risked by doing nothing to reduce this hazard, without training other people), the modernization period was extended by 15 days. The severity of the consequences of the danger of the departure of qualified employees (or more precisely, the danger of not providing the necessary competencies) is a 15-day delay in project implementation.

All mentioned "values" in one way or another are related to the purpose of carrying out certain works, the effectiveness of the work should be determined by them, these indicators are the "value" of the effectiveness of this type of activity.

Therefore, any undesirable deviations due to the manifestation of danger from those indicators that determine the value (goal) of the activity can also be used as estimates of the severity of this or that danger. This is the meaning of the expression of the severity of consequences in units of the "value" of a particular activity when implementing managerial tasks, i.e. tasks of managing processes, productions, etc. it cannot be used to compare different risks in different types of activities, but for the operational assessment of specific risks, such an assessment of severity is very suitable.

The introduction of relative weights of consequences has a certain merit: they can be easily typified for all cases, for all hazards. And it is always easy to go to the absolute severity of the consequences using the formula:

$$Z = Z_{rel} * V_{av}$$

where V_{av} is the volume of the corresponding resource or value. For example, V_{av} can represent the amount of funds used in this type of activity (the cost of planned production, the amount of equipment, part of which may be lost in the event of danger) or the amount of value that is achieved in the process (the planned increase in production, part from which the planned amount of emissions into the atmosphere, the planned period of work performance, etc. may not be released in the event of danger).

It is clear that in the general case it is difficult to find a single risk assessment scale that can be used to compare completely different industries, their conditions of functioning. Only "absolute" characteristics can be attributed to such scales, for example, the number of deaths, the area of land, contaminated territory, etc. in the event of a specific danger. That is, indicators that, according to some generally accepted norms, are a measure of risk (from a social point of view, from an ecological, cultural point of view). In all other cases, the scales will have a private nature, a specific field of application.

In general, any scales can be used for risk assessment, but under one condition: they must be equally understood by all specialists at the enterprise, that is, the scales must be consistent.

3.4. Quantitative normalized assessment of risks

Using the two-factor risk model, taking into account the entered expressions, it is possible to write down [76]:

$$R = p^{norm} * Z = p^{norm} * (Z^{rel} * V_{av}) = (p^{norm} * (Z^{rel}) * V_{av} = R^{norm} * V_{av}$$

Obviously, R_{norm} varies from 0 to 1. Let's call it normalized risk. The real risk will be V_{av} times higher than normalized. It is obvious that the most successful (limiting) case is $R_{norm} = 0$, and the most unsuccessful – $R_{norm} = 1$.

To form the boundaries of risk zones, we will use one of the common psychophysical scales [31, 124] listed in the table.

Table 2.5 Quantitative assessment

Quantitative range of changes in the characteristics r	Quantitative assessment
0-0.2	Very bad
0.2-0.37	Bad
0.37-0.63	Satisfactorily
0.63-0.8	Good
0.8-1.0	Very good

To use the given psycho-physical scale, we express the risk as:

$$R^{normalized} = 1 - r$$

Then we get the following scale for R_{norm}:

Table 2.6 Scale of normalized risks

Quantitative range of change characteristics $R_{normalized}$	Quality assessment	Corresponding risk zone
0-0.2	Very good	Miserable
0.2-0.37	Good	Allowable
0.37-0.63	Satisfactorily	Dangerous
0.63-0.8	Bad	Very dangerous
0.8-1.0	Very bad	Catastrophical

In fact, the normalized risk shows the risk fraction of the total risk. The total risk can be found by multiplying the normalized risk by the total amount of resources involved in the activity, the share of which we risk.

That is, $R = R^{normalized} * V_{avarage}$

The merit of the risk normalization approach is that it makes it easy to compare risks across different conditions. This is due to the fact that with non-normalized risk, it is impossible to compare the risks that different enterprises are exposed to in different conditions, and even one enterprise in different conditions. This is determined by the subjective selection of risk zones, the subjective assessment of the levels of severity of the consequences of the realization of dangers and their probabilities. As mentioned above, real losses, and therefore risks in absolute terms, can be different even at the same level of their assessment, depending on the scale of the enterprise. Normative risks are also based on subjective assessments ("good", "satisfactory", etc.), but they are translated into the same quantitative form using a psycho-physical scale. Therefore, despite the different absolute level of risk in the system of scales of component risks and the risks themselves, chosen by the company, they will be the same in a normalized form, if they correspond to the concepts of "good", "satisfactory", etc., which are the same for a specific company. There are certain advantages when using a normalized risk , are most clearly manifested in the economic justification of risk reduction measures.

3.4. Ways to improve the safety level

1) Each aircraft flying in Class G airspace of Ukraine must be equipped with a dedicated navigator (GPS), with appropriate maps showing all applicable restrictions, temporary regimes, local regimes, restricted areas, range boundaries, etc., boundaries civil airfields, the boundaries of classes C and G, in order to avoid cases where the aircraft crew inadvertently deviates from the planned route or the place of work agreed with the ATS authority.

2) To equip all aircraft performing class G flights with GPS trackers to ensure monitoring of the actual location of such aircraft by the ATC authority

3) When flying in class G space, the airspace user must have a cell phone on board.
4) To strengthen penalties for violations of airspace use

Bring into conformity the regulatory and legal acts regulating the procedure for the use of Ukrainian airspace by users and oblige all air navigation service providers of Ukraine to establishmeans of displaying planned information or messages about ATC and means of receiving and transmitting messages about ATC, i.e. connecting to the AFTN network.

CHAPTER 3 CONCLUSION

In this chapter the aspects of probability determination and risk quantification are considered. We noted that the probability of occurrence of hazards can be based on the frequency of occurrence of events, and the numerical values of risks can be determined by costs in rubles. Considered methods of assessing the severity of consequences and entering estimates of losses for various aspects.

We also indicated the use of normalized risk to facilitate the comparison of risks in different conditions, which allows comparing their shares relative to the total risk.

Also, to improve safety in the airspace, specific measures can be applied, such as equipping aircraft with navigators, using GPS trackers and cell phones on board. It is also necessary to improve the regulatory and legal environment and establish means of displaying and transmitting information regarding airspace operations.

CHAPTER 4

SPECIAL CHAPTER

4. 1. Automated processing of large-scale aeronavigation data

Modern air navigation systems routinely handle automated data processing tasks. Air navigation data processing occurs both on aircraft, specifically within avionics units, and on the ground in dedicated data processing equipment. Contemporary systems measure navigation parameters using an array of sensors, contributing to a comprehensive data archive. The processing of this data necessitates specialized statistical algorithms. Since each sensor introduces some level of measurement error, which cannot be eliminated but can be mitigated, a holistic approach to data processing in aviation systems considers the error associated with each sensor. Confidence bands, ensuring a specific range within a given probability, are employed in this process. One widely used confidence band is the double root mean square deviation, offering a 95% localization of measured values, assuming a normal distribution of errors [1].

The structure of each unit of avionics is more similar to the architecture of a personal computer with the corresponding elements: processor, memory, and analog-to-digital / digital-to-analog converters, which allows processing of measured data at the software level [2]. The sensor’s data is converted to digital form by sampling analog values. Results of different value measurements are stored in appropriate registers, variables, matrices, or data archives.

Determining the precise location of an aircraft stands as a critical task in civil aviation [3-5]. With the continuous growth in air transportation, there's a constant need to reassess separation minimums to align with the demands of modern air transport. These minimums, governing the allowable spatial separation between airplanes on the vertical, lateral, and longitudinal axes, play a pivotal role. Addressing airspace congestion involves exploring strategies such as augmenting the capacity of specific airspace segments by reducing safe distances between airplanes. This is practically executed by imposing more stringent criteria for ascertaining airplane locations in airspace. However, the implementation of stricter positioning requirements relies on the availability of systems capable of meeting these demands. The operation of a civil airplane's on-board positioning sensors is facilitated by the aeronautical signals generated in space by various systems.

To illustrate big-data processing, we will utilize the trajectory of a specific aircraft and conduct calculations using MATLAB software.

4.1.1. Input data

The safety of air transportation relies significantly on the precision of the preplanned trajectory maintained by each user in the airspace. The flight technique and the performance of on-board positioning sensors dictate the extent of deviation of an airplane from its cleared trajectory. In modern civil aviation, the primary positioning sensor on board is the Global Navigation Satellite System (GNSS) receiver. The on-board positioning system's performance delineates a specific area of the airplane's location with a defined probability level. The operation of an airplane within a designated airspace volume is governed by navigation specifications that outline the requirements for on-board positioning system performance. To ensure a secure flight through a given airspace volume, each user must navigate with the stipulated performance levels.

The measured position of an airplane holds critical significance as it plays a key role in the overall safety of the air transport system. According to Automatic Dependent Surveillance-Broadcast (ADS-B), this position is shared with other airspace users to ensure surveillance and enhance aviation safety. Presently, the majority of airplanes are equipped with mode 1090 ES (extended squitter) transponders. These transponders periodically transmit a digital message that includes a position report [6, 7]. This data can be readily received and utilized on board other airplanes to enhance situational awareness or can be collected by ground receivers. National networks of ground ADS-B receivers, maintained by air navigation service providers, support surveillance and airspace user identification [8, 9]. Additionally, various commercial networks of ADS-B receivers process and collect all data transmitted via the 1090 MHz channel.

In particular, computation clusters of Flightradar24 and FlightAware companies provide simultaneous processing of data from more than 30,000 software-defined radios of ADS-B signals located all over the globe (Fig. 4.1).

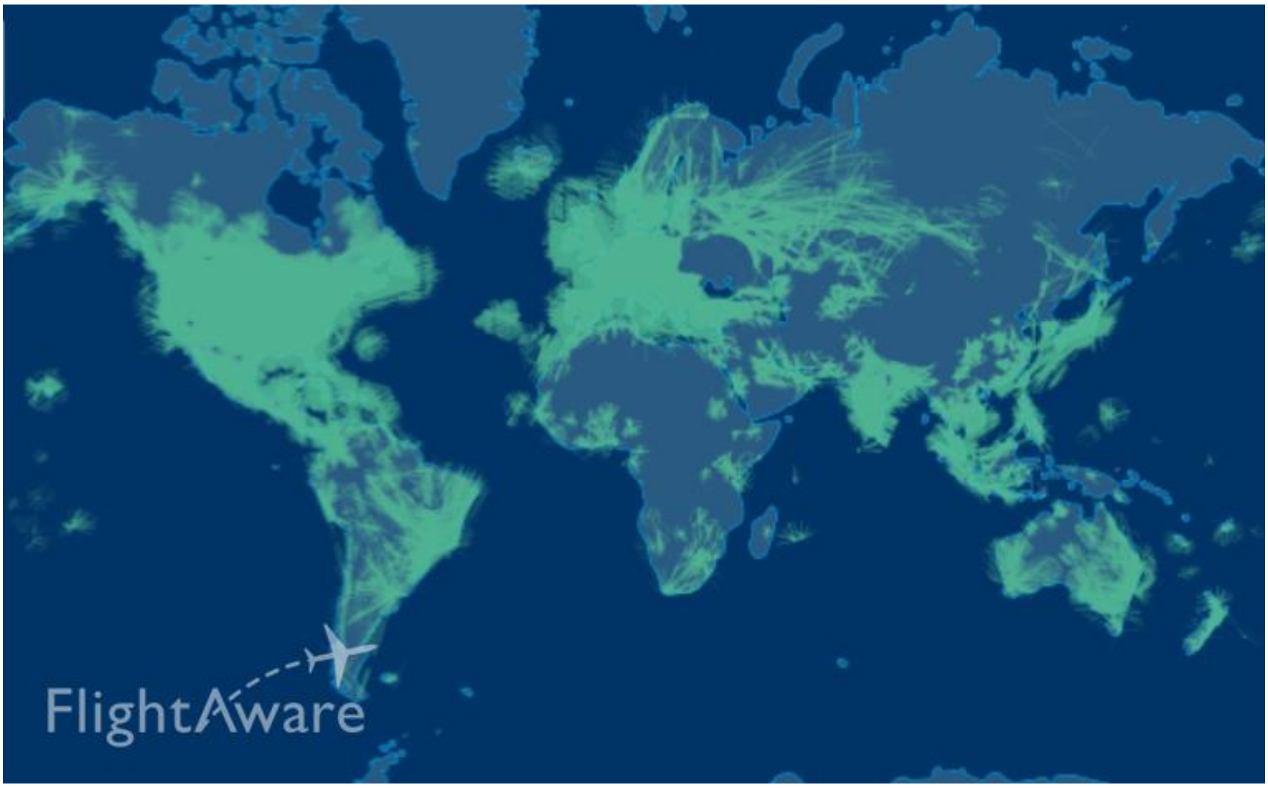


Figure 4.1 – Maps of global traffic [10]

Access to global databases of trajectory data is open and provided on a commercial basis. The application programming interface allows us to easily get any segment of trajectory data for analysis. As input, I use flight path data of CSA761 / OK761 (Czech Airlines 761) operated by Czech Airlines for connection between PARIS, FRANCE (LFPG) and PRAGUE, CZECH REPUBLIC (LKPR). Departure date is October 6, 2022 at 03:10PM (EST). Landing date is October 6 at 04:40PM (BST). The flight ended 5 minutes earlier than the scheduled landing time. This flight was performed by Airbus 319 (twin jat). Input data obtained from the archive athttps://flightaware.com/live/flight/CSA761/history/20221006/1310Z/LFPG/LKPR. Table 1.1 shows the first and final 10 rows of flight raw data.

Table 4.1. Trajectory data of CSA761 from October 6th 2022

Time (EEST)	**Latitude**	**Longitude**	**Heading angle**	**Ground speed (kts)**	**Ground speed (mph)**	**Barometric altitude (meters)**
15:20:43	49.0241	2.5195	← 264°	145	167	198
15:20:59	49.023	2.5033	← 264°	142	163	427
15:21:15	49.0217	2.4881	← 262°	148	170	587
15:21:31	49.0199	2.4703	← 261°	165	190	732
15:21:33	49.0196	2.4674	← 261°	168	193	891
15:22:07	49.0204	2.4226	← 290°	213	245	1,066
15:23:10	49.0763	2.4033	↗ 40°	242	278	2,316
15:23:29	49.0857	2.432	→ 81°	270	311	2,530
15:23:46	49.087	2.4657	→ 89°	290	334	2,728
15:24:30	49.0857	2.564	→ 91°	328	377	3,383
16:30:03	50.1906	14.5115	↙ 222°	176	203	1,236
16:31:13	50.1651	14.4377	↙ 245°	172	198	907
16:31:29	50.1596	14.4195	↙ 245°	168	193	831
16:31:45	50.1547	14.4029	↙ 245°	164	189	754
16:32:01	50.1495	14.3853	↙ 245°	158	182	686
16:32:29	50.1414	14.3584	↙ 245°	136	157	579
16:32:34	50.1402	14.3542	↙ 245°	131	151	710
16:33:49	50.1221	14.294	↙ 245°	124	143	312
16:34:05	50.1179	14.2801	↙ 245°	124	143	251
16:34:21	50.1144	14.2681	↙ 245°	124	143	198

4.1.2. Visualization of trajectory data at specific software

Let`s import trajectory data of CSA761 from October 6th 2022 into specialized software of MATLAB [10]. Results of trajectory data visualization for flight is represented in fig. 4.2. and vertical profile of flight is in fig.4.3.

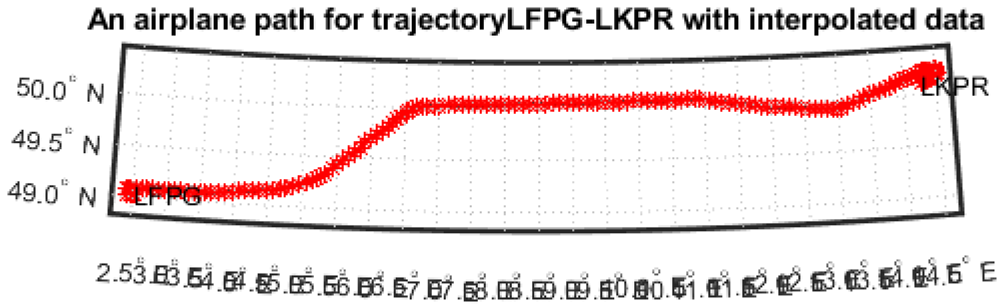


Figure 4.2 – Flight path of CSA761 (October 6th 2022)

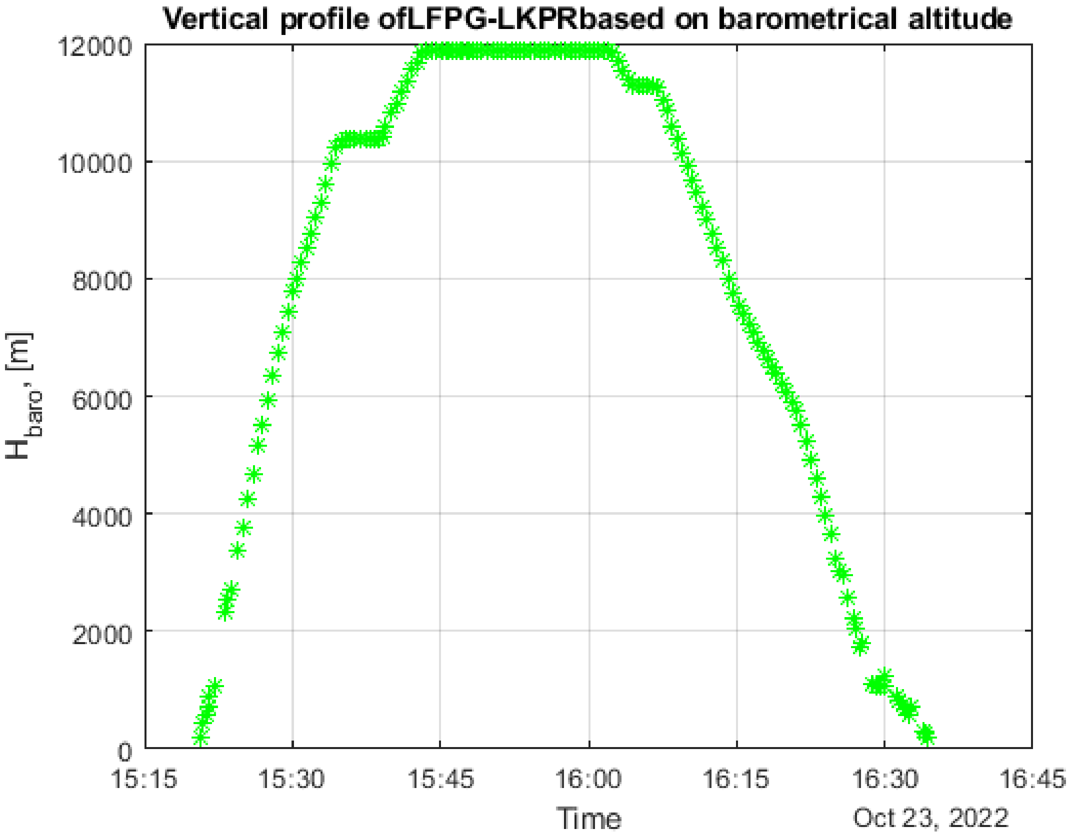


Figure 4.3 – Vertical profile CSA761 (October 6th 2022)

4.1.3. Trajectory data interpolation

The digital messages transmitted via ADS-B lack synchronization in time. Each airspace user's transmitter can be configured to its frequency for generating digital messages. It's important to note that the 1090 MHz frequency is quite congested, as it is utilized by secondary radars, airborne collision and avoidance systems, and ADS-B. Consequently, numerous digital messages may overlap, leading to the corruption of data transmitted within these messages. As a result, ADS-B trajectory data often contains gaps and fragmented messages. To address this issue during the data processing stage, interpolation methods are commonly employed. Interpolation functions, such as polynomials or spline functions, are utilized for this purpose. The outcomes of interpolating input data at a frequency of 1 Hz are depicted in Figures 5.4 to 5.6. All subsequent calculations will be based on interpolated data. Let's represent the data in the local NEU system, using the coordinates of the initial trajectory point as the system's center. The visualization results of the trajectory in the local system are presented in Figures 4.7 and 4.8.

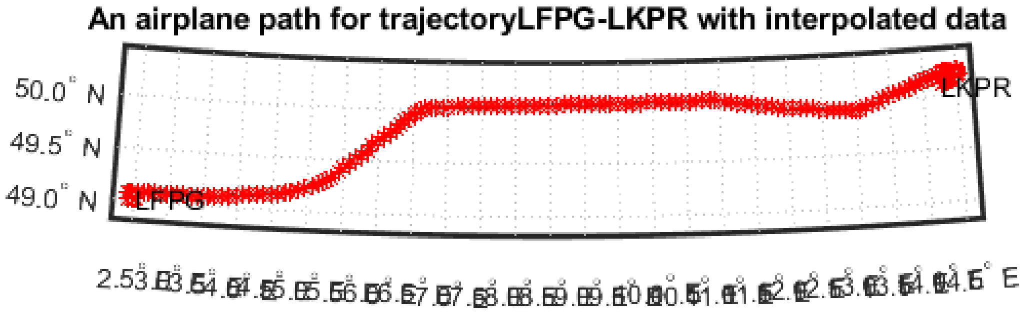


Figure 4.4 – Interpolated airplane trajectory of CSA761 (October 6th 2022)

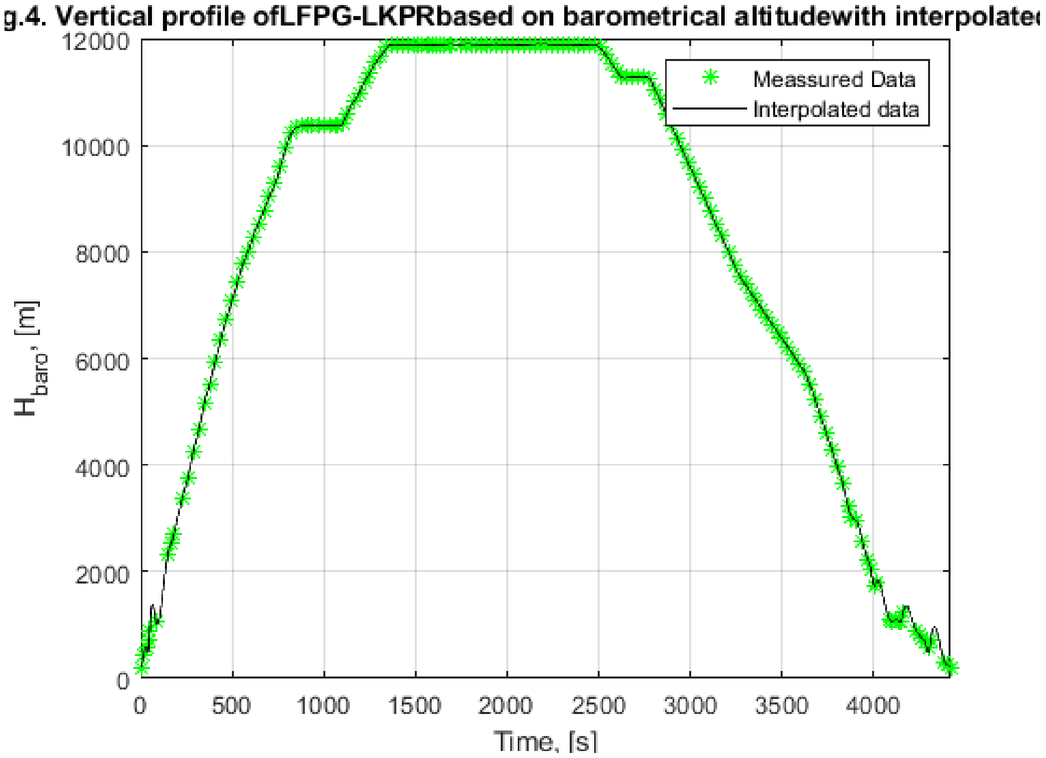


Figure 4.5 – Interpolated vertical profile of CSA761 (October 6th 2022)

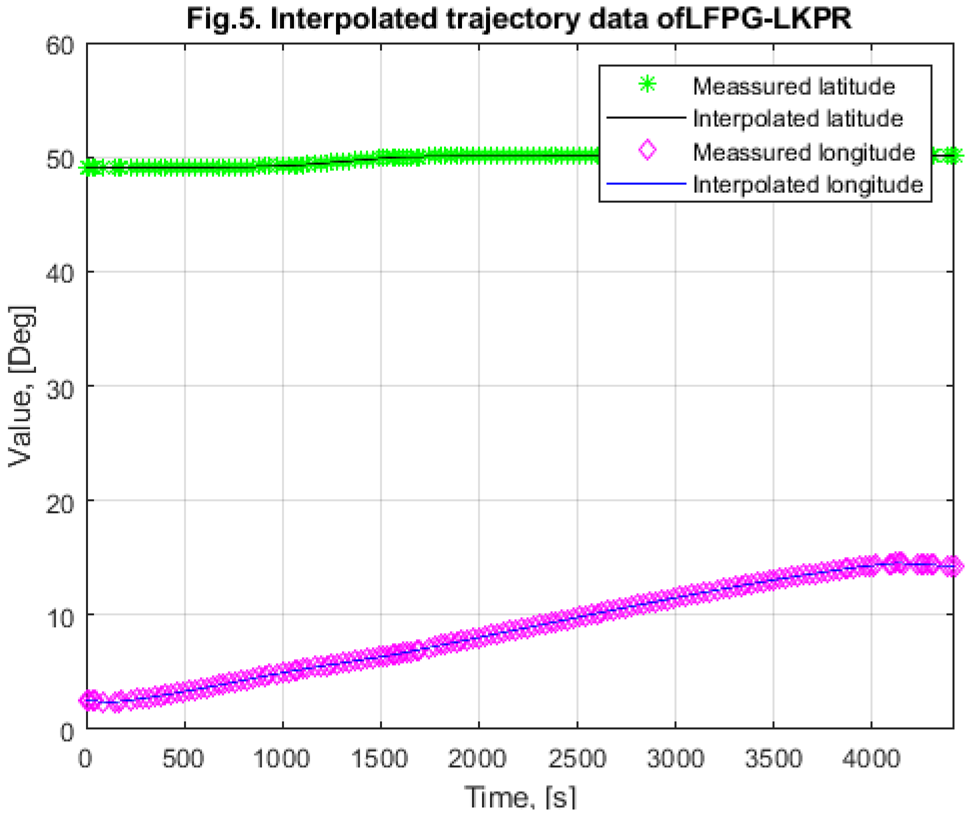


Figure 4.6 – Interpolated data for 1 Hz of CSA761 (October 6th 2022)

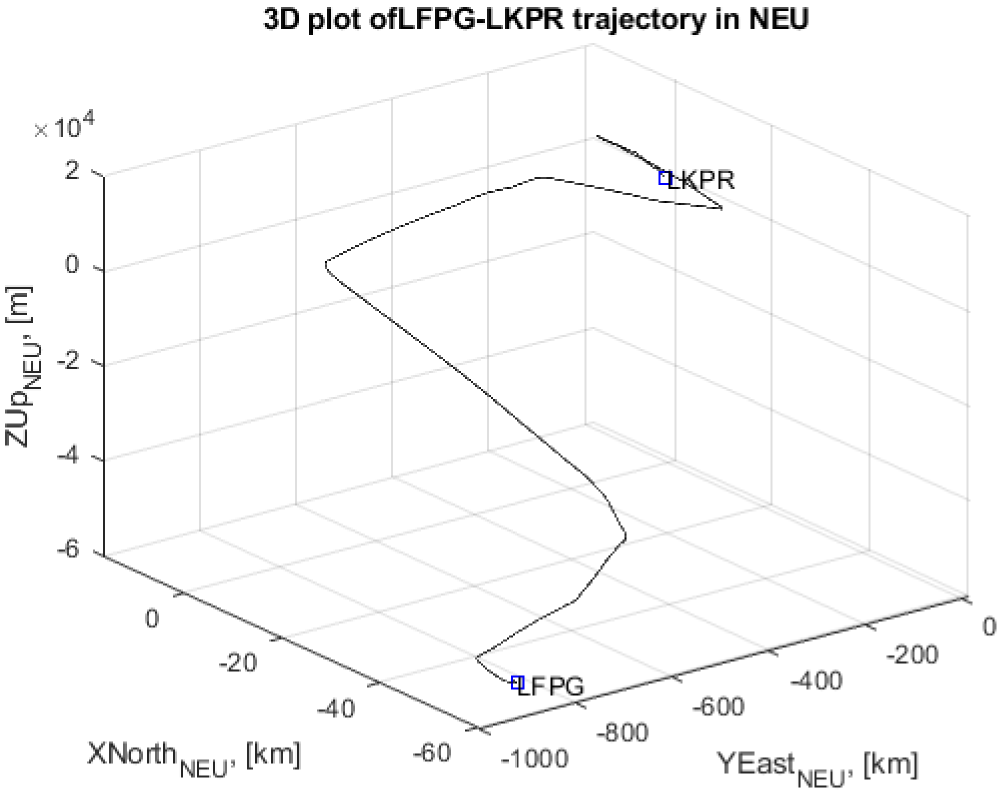


Figure 4.7 – 3D trajectory of CSA761 (October 6th 2022) in NED reference frame

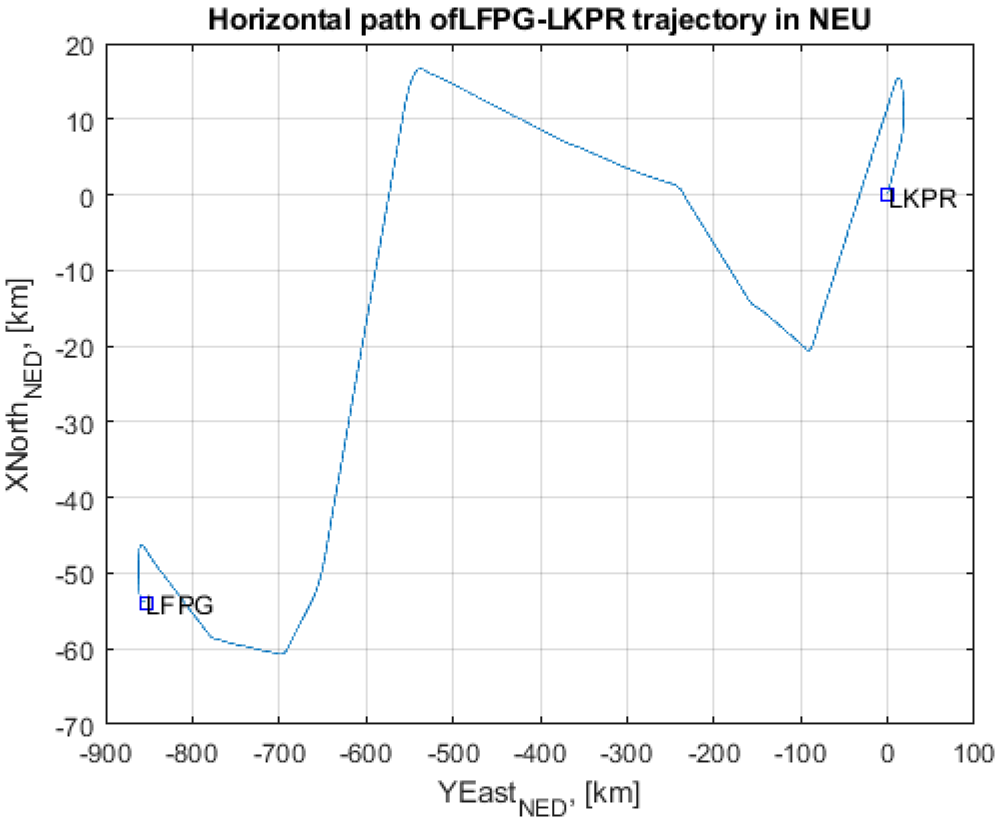


Figure 4.8 – Flight path of CSA761 (October 6th 2022) in local NED

4.1.4. Trajectory data calculation

Based on the data set of the three-dimensional movement trajectory, we will calculate the speed components. In particular, I calculate the full speed of an airplane, vertical, and horizontal components. The results of the speed calculation are shown in fig. 5.9., and the estimated course of the plane in fig. 4.10. Also, I calculate the total flight time and the length of the route and trajectory.

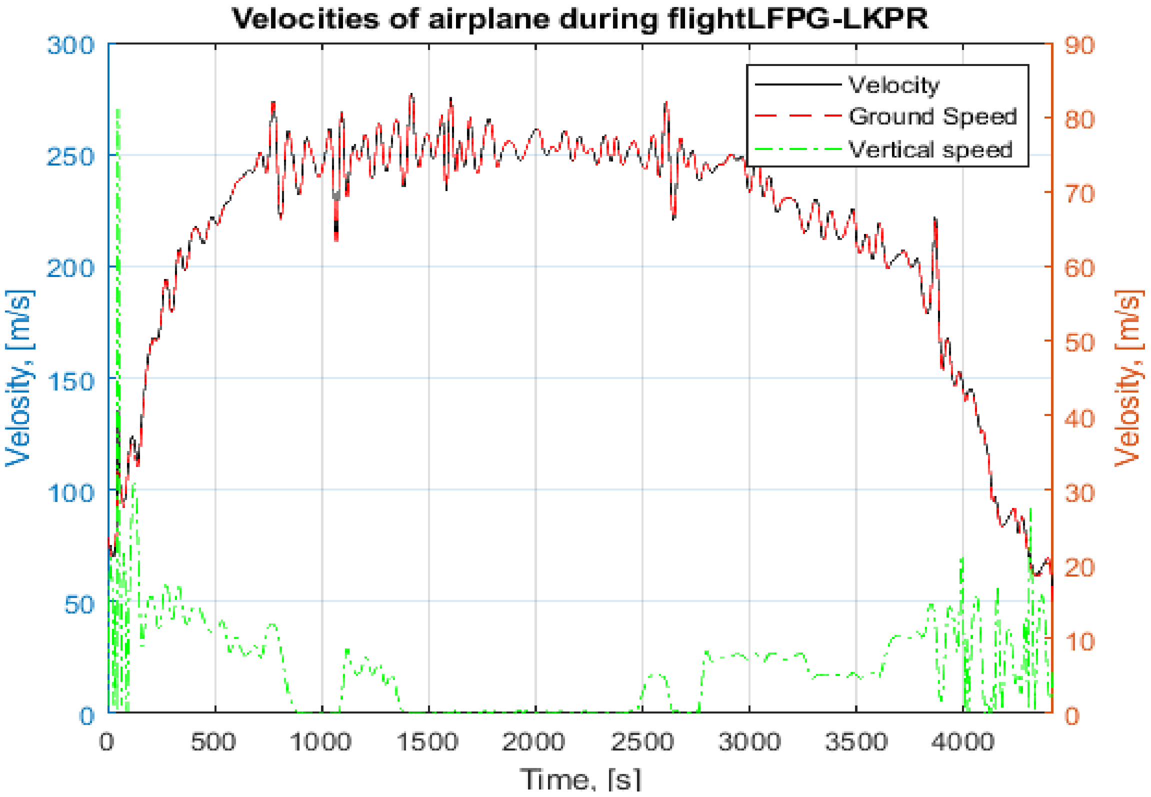


Figure 4.9 – Results of velocity estimation of CSA761 (October 6th 2022)

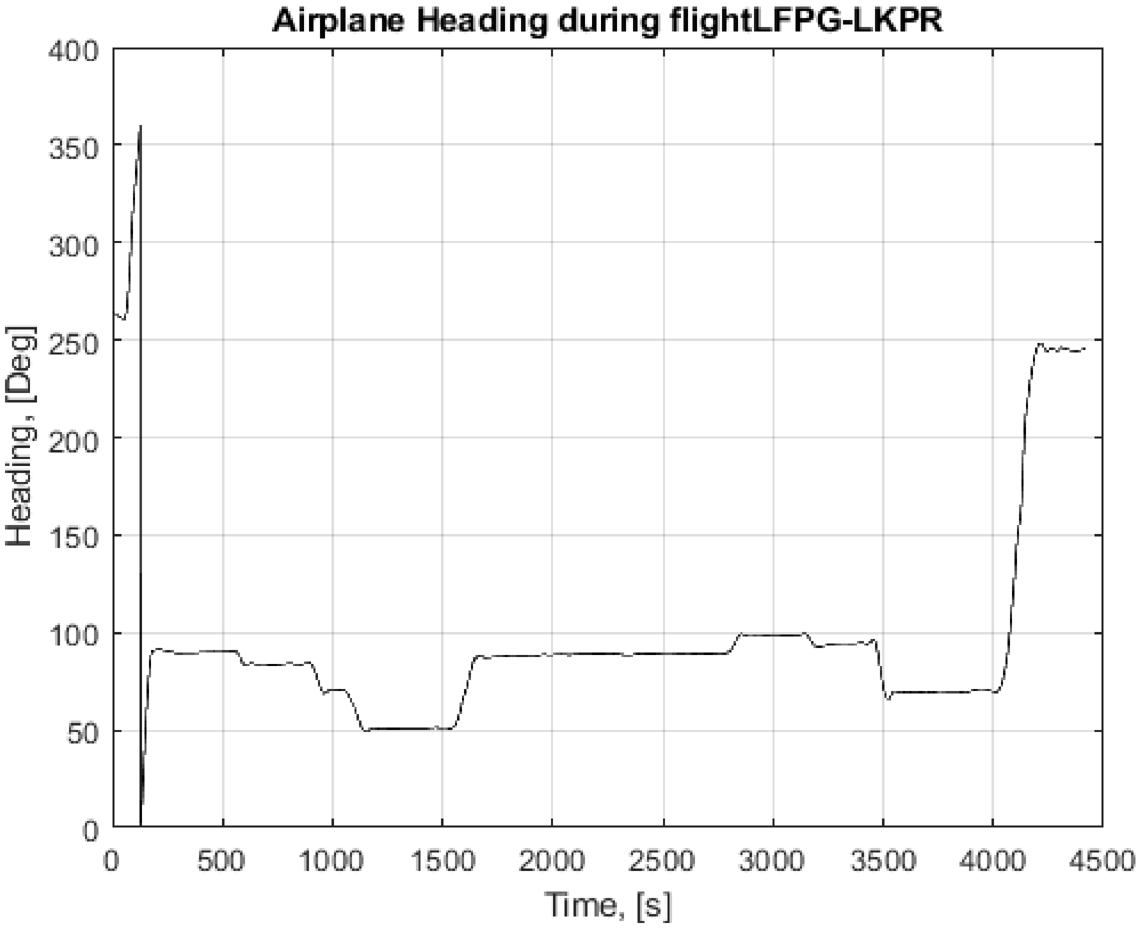


Figure 4.10 – Results of heading angle calculation of CSA761 (October 6th 2022)

The total flight time of CSA761 (October 6th 2022), was 1 hour 30 minutes 49 s. The length of the trajectory is 8277.2 km, and the length of the flight path (horizontal component) is 8276.7 km.

4.2. Statistical analysis. Correlation-regression analysis. Forecasting the efficiency of transportation

The global COVID-19 pandemic continued to exert a significant influence on aviation and air traffic management (ATM) throughout 2022. In 2021, there was a partial yet sustained recovery in European air traffic, starting at -64% in January compared to 2019 levels and concluding at -22% in December. The implementation of mass vaccinations and the EU Digital COVID certificate contributed to a robust summer recovery, and traffic has maintained relative stability, remaining over 70% since the summer. Despite this, the overall traffic for 2021 was -44% of 2019 levels, indicating 4.9 million fewer flights compared to 2019, and not markedly better than the situation in 2020 (with 6.1 million fewer flights).

The repercussions of reduced traffic continued to be distributed unevenly, with the five most affected countries, all in the northern region, experiencing a traffic decline ranging from -55% to -62%, while the five least affected countries, all in the southern region, faced a decrease between -8% and -27%. Although increased predictability and a return to travel have assisted airlines and airports in maintaining operations, their financial health has not fully recovered. Airline losses for 2021 amounted to €18.5 billion, with 1.4-1.5 billion fewer passengers. While these losses were substantial, they were not as severe as the disastrous losses experienced in 2020 (€22.2 billion and 1.7 billion fewer passengers). Profitability has been hampered by lower load factors (around 50-60%), and major airline groups operated 30-64% fewer flights.

In contrast, business aviation experienced a positive trend, recording a +3.5% growth in 2021. The sector significantly increased its market share to 12%, compared to 2019's 6.4%. Some business travelers shifted to this segment in response to the loss of previously available scheduled routes. However, the impact on aviation, while significant, is overshadowed by the unfolding humanitarian crisis. Despite our industry's role in promoting peace and freedom through bringing people together, the implications of the crisis need to be thoroughly evaluated and addressed.

The war in Ukraine has had a substantial impact on passenger traffic, leading to the closure of Ukrainian airspace by the end of 2022. This cessation of air movements affects approximately 3.3% of total air passenger traffic in Europe and 0.8% globally, based on 2021 figures. Belarus has also restricted flights over parts of its territory, and Moldova has fully closed its airspace, although these two countries contribute to minor shares of regional and global air passenger traffic.

4.2.1 Input data

Statistical data of air transportation from 2016 to 2021 years are presented in Table 4.2.

Table 4.2 - Statistical data of air transportation provided by IATA.

Year	x	Sched passenger numbers, millions
2014	14	3,328
2015	15	3,569
2016	16	3,817
2017	17	4,095
2018	18	4,378
2019	19	4,543
2020	20	1,807
2021	21	2,185

With the help of the method of correlation-regression analysis, an analysis of air transportation and forecasting of transportation for the following years was made.

4.2.2 Correlation-regression analysis

The method of correlation-regression analysis is used to make decisions about forecasting phenomena and in the case of determining interdependencies between multidimensional measurements. When conducting multidimensional measurements, it is very important to determine the interdependencies between the measured characteristics.

The main characteristics of the correlation-regression analysis are the *correlation coefficient r and the regression line. The correlation coefficient r lies within* $-1 \leq r \leq 1$. *If* $r = 0$, *then there is no connection between the characteristics of the object (phenomenon) being studied. If* $r = 1$, *then the connection is strong and direct. If* $r = 0.7...0.8$, *the connection is good. If* $r = -1$, *then this is an inverse strong relationship.*

The regression line determines the type of dependence and connects the average value of the response function f (x) with the values of the factor x.

Stages of correlation-regression analysis:

1. Collection of statistical data (conducting an experiment).

2. Correlation analysis. Using the correlation coefficient r, we determine the closeness of the relationship (strong, weak, etc.) and the nature of the relationship (direct, reverse).

3. Regression analysis. Definition of the type of dependence. The results of the experiment (statistical data) are applied to the correlation field and the type of dependence is visually determined. For example, for a straight line, we write down the analytical type of dependence

$y = b_0 + b_1 x,$

where b_0, $b_1$are regression coefficients

4. Determination of values of regression coefficients.

5. Determining the significance of the obtained values of correlation and regression coefficients using Student's and Fisher's tests.

6. Construction of the regression line.

7. Forecasting (extrapolation and interpolation).

Calculation of regression coefficients according to the formulas:

$$b_0 = (\sum y \sum x^2 - \sum xy \sum x)/(n\sum x^2 - (\sum x)^2);$$

$$b_1 = (n\sum xy - \sum x \sum y)/(n\sum x^2 - (\sum x)^2),$$

where *n* is the number of data.

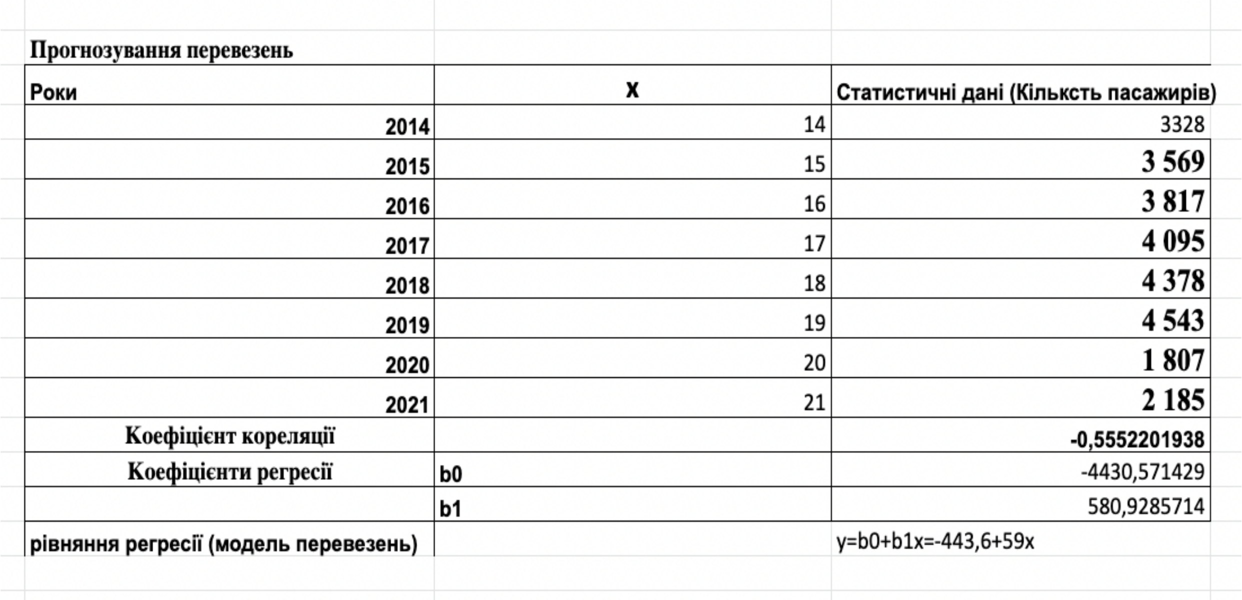
Calculation of the correlation coefficient according to the formula:

$$r = \frac{\sum xy - (1/n)(\sum x)(\sum y)}{\sqrt{\left[\sum x^2 - (1/n)(\sum x)^2\right]\left[\sum y^2 - (1/n)(\sum y)^2\right]}}.$$

$$-1 \leq r \leq 1$$

The value of the correlation coefficient shows how the variables x and y are related (inverse (as the value of r is negative) weak (as the value of r is closer to 0 than to -1) relationship). That is, over time, the number of transported passengers decreases.

A statistical analysis of transportation was made and, with the help of correlation-regression analysis, a forecast of passenger traffic until 2026 was made (Figure 1) using MS Excel.



Прогнозування перевезень

Роки	X	Статистичні дані (Кільксть пасажирів)
2014	14	3328
2015	15	3 569
2016	16	3 817
2017	17	4 095
2018	18	4 378
2019	19	4 543
2020	20	1 807
2021	21	2 185
Коефіцієнт кореляції		-0,5552201938
Коефіцієнти регресії	b0	-4430,571429
	b1	580,9285714
рівняння регресії (модель перевезень)		y=b0+b1x=-443,6+59x

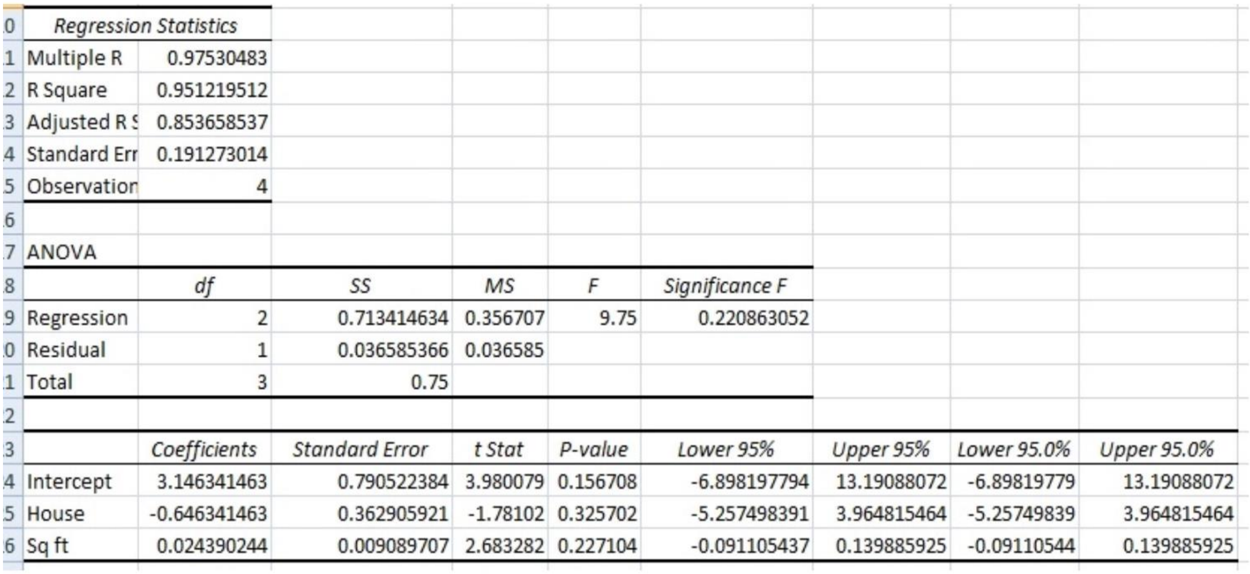
Figure 4.11. Calculation of correlation and regression coefficients.

In our calculation we use several variables:

1. Multiple R. This is the correlation coefficient. It shows how strong the linear relationship is. For example, a value of 1 means a perfect positive relationship and a value of zero means no relationship at all. It is the square root of r squared .
2. R squared. This is r2, the Coefficient of Determination. It shows us how many points fall on the regression line. For example, 80% means that 80% of the variation of y-values around the mean are explained by the x-values. In other words, 80% of the values fit the model.
3. Adjusted R square. The adjusted R-square adjusts for the number of terms in a model. You’ll want to use this instead of #2 if you have more than one x variable.
4. Standard Error of the regression: An estimate of the standard deviation of the error μ. The standard error of the regression is the precision that the regression

coefficient is measured; if the coefficient is large compared to the standard error, then the coefficient is probably different from 0.

5. Observations. Number of observations in the sample.



Regression Statistics	
Multiple R	0.97530483
R Square	0.951219512
Adjusted R S	0.853658537
Standard Err	0.191273014
Observation	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.713414634	0.356707	9.75	0.220863052
Residual	1	0.036585366	0.036585		
Total	3	0.75			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.146341463	0.790522384	3.980079	0.156708	-6.898197794	13.19088072	-6.89819779	13.19088072
House	-0.646341463	0.362905921	-1.78102	0.325702	-5.257498391	3.964815464	-5.25749839	3.964815464
Sq ft	0.024390244	0.009089707	2.683282	0.227104	-0.091105437	0.139885925	-0.09110544	0.139885925

Figure 4.12 - Excel regression analysis

Next step we run so caled Anova test to to see if there’s a difference between them testing groups.

In this test we use several variables:

1. SS = Sum of Squares.

Regression MS = Regression SS / Regression degrees of freedom.

2. Residual MS = mean squared error (Residual SS / Residual degrees of freedom).
3. F: Overall F test for the null hypothesis.
4. Significance F: The significance associated P-Value.

The last section of the table gives us information about the components we chose to put into your data analysis. The columns are:

1. Coefficient: Gives us the least squares estimate.
2. Standard Error: the least squares estimate of the standard error.
3. T Statistic: The T Statistic for the null hypothesis vs. the alternate hypothesis.
4. P Value: Gives us the p-value for the hypothesis test.
5. Lower 95%: The lower boundary for the confidence interval.
6. Upper 95%: The upper boundary for the confidence interval.

4.2.3 Forecast of passenger traffic

A forecast was made for passenger transportation volume (Figure 2). We received a transportation model for demand forecasting:

y=b0+b1x=-4430.6+590x

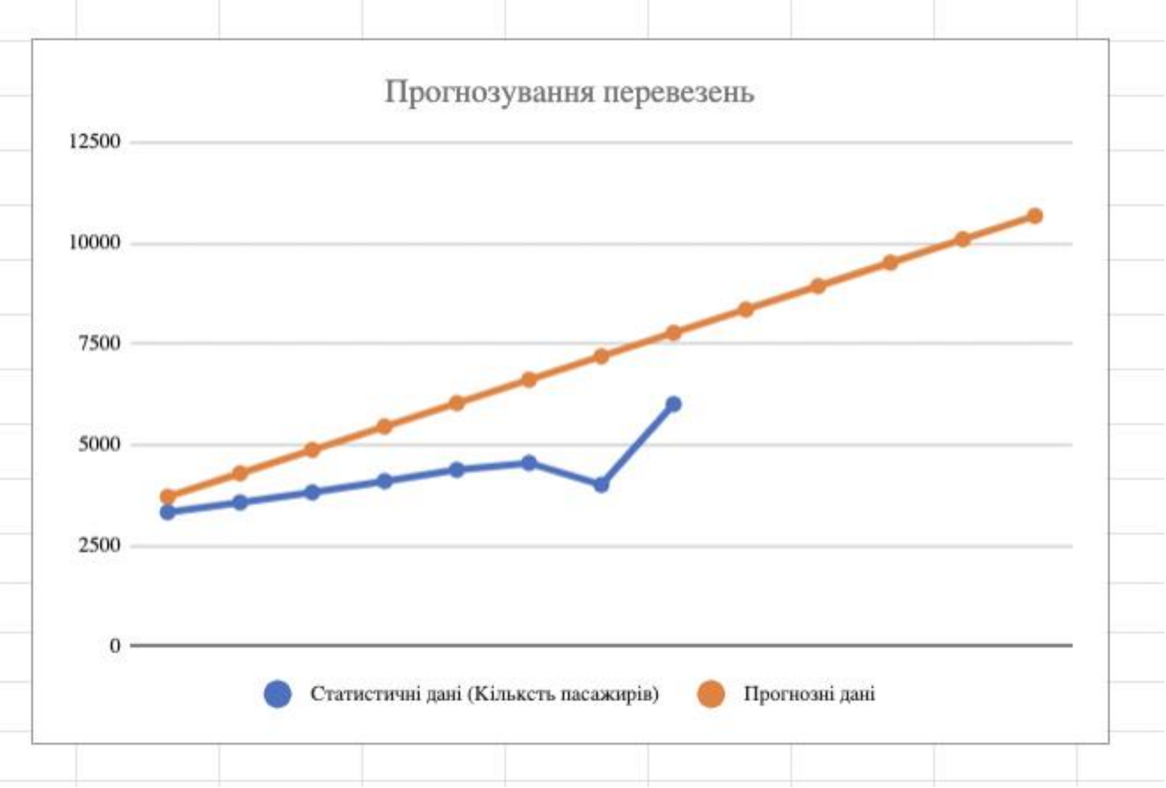


Figure 4.13. A comparison between estimated and actual passenger operations

Thus, according to statistical data, 3,817 million passengers (commercial flights) were served in 2016, and 9,511 million passengers are expected in 2024.

CHAPTER 5

LABOR PRECAUTION AND ENVIRONMENT SAFETY

5.1. Aviation occupational health and safety regulations

To minimize the time the crew dedicates to readying the aircraft for flight, the bulk of preparatory tasks, including checking the aircraft systems, is undertaken by specialized aircraft and ground services personnel before handing over to the crew.

Maintenance of aircraft equipment during pre-flight preparation and in-flight is the responsibility of the crew, starting from the aircraft's acceptance before departure and continuing until taxiing to the parking place (engine shutdown). Throughout these tasks, there exists a potential risk of encountering numerous dangerous and harmful production factors.

5.1.1 General Terms

The following factors cause the greatest number of injuries and diseases:

- aircraft, special vehicles and self-propelled mechanisms that are moving at the moment;

- unprotected by movement and elements of the aircraft (ailerons, shields, interceptors, trimmers, landing gear, rotating propellers, turbines, exiting ladders, etc.);

- jets of exhaust gases and objects that got into them;

- collapsible structures (board ladders, stepladders);

- highly placed parts of the Aircraft;

surfaces with increased slippage caused by icing, wetting of aircraft surfaces, ladders, ladders, attachment ladders and parking lot coverings, on which crew members move;

- increased or decreased temperature, humidity and air mobility in the aircraft parking area and in the crew cabin;

- increased level of noise, vibration, ultra- and infrasound in the parking area of the aircraft and in the crew cabin;

- insufficient illumination of the working area;

- chemicals that are included in the materials used for the manufacture of equipment and devices of crew cabins, as well as those that are used as poison chemicals;

- neuropsychological and emotional overloads, overstrain of analyzers and hypodynamia.

The requirements for the safety of the crew largely depend on the type of aircraft and its design features. For example, for special application aircraft crews, one of the main harmful production factors is toxic chemicals used in aviation chemical work.

In transport aircraft with high-placed wings and engines installed in the tail area, entrance and exit doors located at a significant height relative to the ground and requiring the use of airport passenger trawls, the effect of such a dangerous production factor as "highly located parts of the aircraft" is most often manifested .

5.1.2. Occupational safety of aircraft crews

Because of this, even now, crew members and service personnel fall from a height.

In the preparation of the aircraft crew for the flight, both when approaching and departing, it is essential to adhere to the designated route marked on the apron and exercise caution to prevent collisions with moving vehicles and other aircraft, including avoiding exposure to jet streams. Additionally, the crew must exercise care when traversing uneven sections of concrete surfaces where icing may occur and airfield equipment is positioned.

While in the parking lot and inside the aircraft, the crew and the aircraft must adhere to the safety instructions outlined in the current regulations for maintenance. Smoking is strictly prohibited in the aircraft parking area. Crew members are obligated to cease loading the aircraft with cargo that is either prohibited for carriage or has damaged packaging, posing potential harm to passengers and compromising the safe conduct of the flight. The initiation of the auxiliary power plant, engines, testing of mechanization means, and taxiing of the aircraft should exclusively occur through communication with the aircraft technician using an intercom system.

The sequence of technical processes must be carefully planned to prevent simultaneous execution of tasks that could heighten risks (such as refueling concurrently with passenger boarding or disembarkation, depleting oxygen from the system while working with electrical equipment, etc.). The aircraft parking area should be equipped with standard fire extinguishing equipment and a fire prevention system to eliminate the formation of a combustible environment and potential ignition sources.

Crew members bear the responsibility for passenger safety during boarding and disembarking. Therefore, they must ensure strict compliance with the prohibition on passengers being on board the aircraft during high-risk operations such as refueling, oxygen supply, de-icing, operation of thermal machines, etc.

In instances where ladders or car lifts are not available near the entrances and service doors, it is imperative to arrange and oversee the installation of safety belts. Crew members are expressly forbidden from opening entrance and service doors (after the aircraft has landed) without first securing safety belts to prevent them from falling overboard due to gusts of wind, excessive pressure, or other factors affecting the doors. The use of a thermal machine to remove ice from the aircraft is carried out only when all doors, hatches, and cabins are securely closed.

Prior to refueling,boarding, and cargo loading, it is imperative to clear all equipment positioned beneath the fuselage, wing, and open doors of the aircraft. Neglecting this precaution could result in potential injuries, aircraft damage, and harm to various equipment such as gangways, special vehicles, ladders, mechanisms, electric cars, cargo carts, etc. The responsibility for ensuring compliance with this protocol falls on the flight crew.

During aircraft towing activities, rocking it with tractors to shift its position is strictly prohibited. The angle of rotation should not exceed plus 55°. All crew members must exercise caution while driving within the bounds of visible limits. The use of aircraft wheel brakes is reserved for specific scenarios, such as towing device breakdown, receiving a ground command to stop, or after the aircraft has come to a complete halt. Towing with a malfunctioning brake system is strictly forbidden. When evacuating the aircraft from the runway, a speed of 3 km/h is permitted, accompanied by an aircraft technician maintaining a safe distance from the undercarriage and equipped with thrust pads.

While in flight, the crew is explicitly prohibited from smoking, troubleshooting pilotage and navigation systems, and manipulating electrical equipment by opening panels and replacing fuses. The use of an open flame when working with oxygen is strictly forbidden. Oxygen must not come into contact with oiled (greasy) objects. The crew is also prohibited from using oxygen in the event of a hydraulic mixture leak into the aircraft cabin. Avoiding the opening of the valve of the inflatable ladder's balloon inside the aircraft cabin prevents it from filling or jamming. Additionally, electronic heating devices are not to be repurposed for activities beyond their intended use, such as heating the interior or drying objects.Safety requirements can be adjusted over time, supplemented in connection with the entry into operation of new modification aircraft, modifications of existing aircraft, accumulating information (experience) on the prevention of injuries of modern aircraft crews.

5.1.3. Rendering First Aid in the Event of Flight Condition Violations

While contemporary passenger trains offer reliability in transportation, the operation of most high-speed aircraft at elevated altitudes introduces the potential for emergency situations. These scenarios might stem from a partial or complete breach of cabin sealing or an enforced landing on either land or water.

When a high-altitude aircraft cabin experiences a partial breach or complete depressurization, especially at altitudes exceeding 2500 meters, passengers and the crew may confront life-threatening conditions. Adhering to current instructions and flight protocols, the crew must expeditiously lower the aircraft to a safe altitude, staying within the reserve time. However, certain individuals may struggle with this descent, potentially experiencing unconsciousness, necessitating immediate first aid. In case of a forced landing, consider the following recommended first aid measures:

- Safely evacuate victims from the accident site, exercising extra caution with individuals displaying spinal damage or fractures.
- Initiate artificial respiration for an unconscious victim, continuing until signs of life emerge or it becomes evident that resuscitation efforts are futile.
- Apply a tight bandage above and below the wound in instances of bleeding; if bleeding persists, employ a tourniquet.

- Attend to victims in shock (pale complexion, rapid and irregular breathing, elevated pulse, moist skin) by placing them in a supine position, slightly elevating their legs, and providing warmth. For severe head injuries, slightly elevate the head and offer a few sips of hot sweet tea or any warm beverage.
- Apply a sterile dry or alcohol-soaked bandage on burns without opening blisters.
- In the case of fractures, immobilize the damaged limb with a splint.

For incidents of drowning resulting from a forced landing on water, the recommended first aid involves placing the victim face down on the bent knee of the rescuer's leg, applying pressure between the shoulder blades on the victim's back. This position facilitates water drainage from the victim's stomach, followed by the administration of artificial respiration.

5.1.4. Aircraft cleaning and disinfection

Aviation and chemical operations encompass a range of activities, including combating pests and agricultural diseases, mineral fertilizer application, weed control, preharvest leaf removal, and expedited opening of cotton bolls, along with snow blackening for accelerated melting. However, modern transport planes and helicopters lack full adaptation for such tasks. Constructive solutions to shield crews from poisonous chemicals are often ineffective, prompting the pressing need for specialized aircraft designed for aviation and chemical operations. Many countries are actively engaged in adapting existing and developing new aircraft for these specialized tasks.

The catalog of chemical and biological agents for pest control, plant diseases, and weed management in agriculture undergoes annual revisions, evolving with additions and changes. Currently, around 200 such agents are in use. The widespread application of poisonous chemicals during agricultural crop processing poses environmental risks, polluting plants, water, soil, and the air. This contamination can lead to drinking water poisoning and fish fatalities in reservoirs. Pesticides can infiltrate plants, persisting in derived products and accumulating in the bodies of animals and humans. Increasingly, reports in the media highlight the adverse effects of toxic chemicals on various life forms.

Aviation chemical operations must adhere to sanitary rules governing the storage, transportation, and pesticide use in agriculture, as well as comply with the current directives from civil aviation authorities. Following completion of work, transitioning between different tasks, or the need to eliminate residual toxic chemicals, aircraft used in aerochemical work undergo sanitary treatment according to prescribed instructions. This includes procedures after 100- and 300-hour routine operations, before aircraft repair, or in cases where aircraft repurposing is planned for non-aerochemical tasks.

The cleaning, washing, and degassing procedures for aircraft follow a systematic approach. Initially, pesticide residues are meticulously removed from internal surfaces using a vacuum cleaner, with special attention to cracks, grooves, nodes, dashboard, and specialized equipment. The cargo area floor is also subject to removal. Subsequently, a washing solution is uniformly applied to the inner surface of cargo and tail compartments' lining using a hydraulic remote control or a washing machine, ensuring the protection of special equipment and control systems from solution drops.

After 20-30 minutes, the solution is rinsed off the treated surfaces with hot water (50-60°C), followed by a rinse with cold water and thorough drying using a cloth.

The cockpit undergoes processing in the same sequence, followed by the external finishing of compartments with the closure of hatches and doors. The washing solution is applied to the outer surface, commencing from the power unit, using a hydraulic remote control or another appropriate unit. After 20-30 minutes, the solution is washed off first with hot water (50-60°C) and then with cold water.

Throughout the cleaning, washing, and degassing procedures, the aircraft must remain grounded. Following the completion of work, personnel remove their clothes, take showers, and apply specialized protective creams to their hands. Subsequently, the parking place of the aircraft undergoes degassing. Both the flight crew and technical staff are required to implement preventive disinfection measures. Adequate facilities for washing, changing clothes, and storing work attire should be available on-site. Overalls are subject to daily cleaning and periodic washing as they become soiled, at a minimum frequency of twice a month.

5.1.5. Safety Measures for Aircraft De-Icing/Anti-Icing Fluids

De-icing fluids commonly consist of ethylene glycol or propylene glycol, incorporating water, corrosion inhibitors, wetting agents, and dye.

Anti-icing fluids share a similar composition but include polymeric thickeners. They are designed to not only de-ice but also to prevent the formation of unabsorbed frozen contamination for an extended duration compared to de-icing fluids. It is essential to note that the protection period is still limited, and specific details on useful time availability can be found in the "Hold Over Time" guidelines.

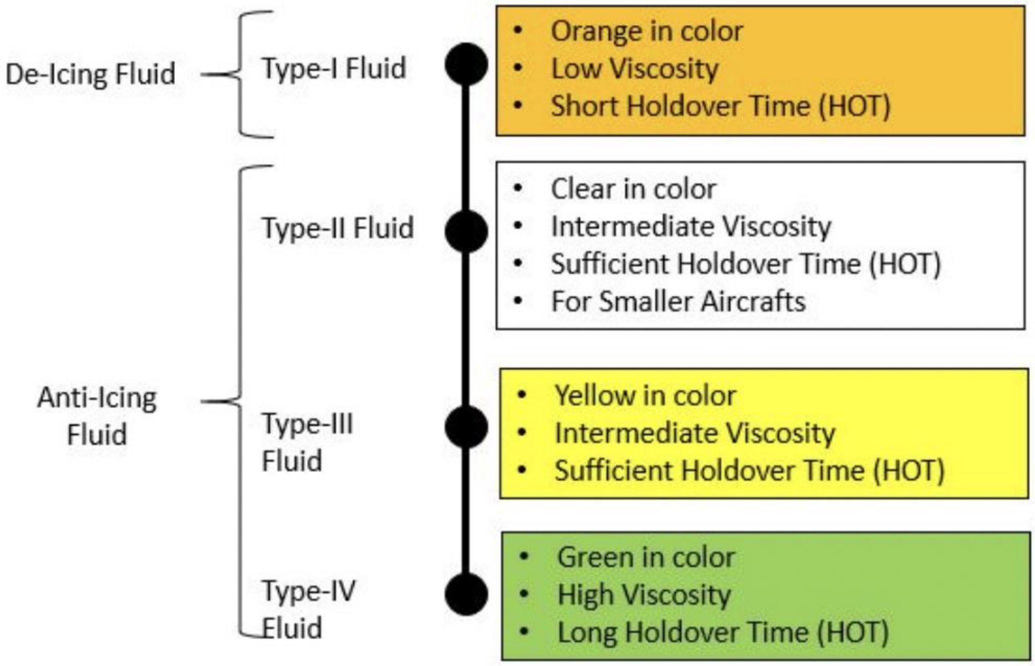


Figure 5.1 - Types of De-Icing/Anti-icing Fluids

Type I Fluids: These offer short-term protection as they quickly flow off surfaces after application. Typically sprayed at high pressure and high temperature (130-180 °F, 55-80 °C), they effectively remove snow, ice, and frost.

Type II Fluids: Characterized as pseudoplastic, these fluids contain polymeric thickening agents to prevent immediate runoff from aircraft surfaces. A Type II Fluid Film remains in place until the aircraft reaches approximately 100 knots, at which point viscosity breaks down due to shear stress.

Type III Fluids: Designed for slower aircraft with a rotation speed of fewer than 100 knots, Type III fluids are typically bright yellow in color.

Type IV Fluids: Serving the same purpose and meeting the same AMS standards as Type II fluids, they provide a longer holdover time. Dyed green for application consistency.

Storage Guidelines: The stored fluid must adhere to the manufacturer's recommended temperature limits. Routine checks should be conducted to ensure no degradation or contamination.

Pilot Responsibility during Acceptance Following De-Icing: Take-off should not be attempted until the Pilot in Command (PIC) verifies that critical surfaces are free of frost, ice, or snow contamination.

Operator Responsibility: The operator is responsible for ensuring the use of qualified fluids. If the applied fluid's color differs from expectations, the procedure should be halted, and an investigation conducted.

5.2. ICAO role in environmental protection

In the realm of environmental preservation, the International Civil Aviation Organization (ICAO) shoulders a range of obligations stemming from various conventions. While the Chicago Convention, in its original drafting, does not explicitly encompass environmental protection in its entirety, it delegates the responsibility of establishing provisions for the same to ICAO, as outlined in Article 44. This particular provision mandates ICAO with the development of principles and techniques for international air navigation, thereby necessitating its active engagement with environmental concerns within the aviation sector.

Additionally, the Kyoto Protocol places further obligations on ICAO. Under Article 2 of the Kyoto Protocol, ICAO is entrusted with the task of actively pursuing the limitation or reduction of greenhouse gas (GHG) emissions not regulated by the Montreal Protocol. This specifically pertains to emissions originating from aviation bunker fuels, and the responsibility involves collaborative efforts through ICAO's framework.

Evidently, ICAO holds significant responsibilities in addressing environmental considerations within the civil aviation sector. Over the decades, ICAO has formulated a series of legal instruments aimed at mitigating both aircraft noise and emissions. This proactive approach has played a pivotal role in enhancing the overall efficiency of the aviation sector since the 1970s.

5.2.1 Environmental Concerns in the Aviation Sector

In fulfillment of its environmental obligations, ICAO formulated three pivotal environmental objectives in 2004, aiming to (1) minimize or decrease the number of individuals affected by substantial aircraft noise; (2) mitigate the impact of aviation emissions on local air quality; and (3) curb the influence of aviation greenhouse gas emissions (GHG) on the global climate. To address these concerns, the ICAO Council's Committee on Aviation Environmental Protection (CAEP) established strategic priorities, prioritizing environmental protection. Comprising representatives from States, intergovernmental bodies, and NGOs representing both the aviation industry and environmental interests, CAEP serves as the driving force behind environmental initiatives within the aviation sector. The Council is obligated to review and update environmental policies and practices every three years, presenting them to the ICAO Assembly for adoption. Notably, Resolutions A39-1, A39-2, and A39-3 were adopted by the Assembly in 2016.

The ICAO Business Plan for 2017-2019 outlines the sector's commitment to environmental sustainability, focusing on two key facets: enhancing the environmental performance of aviation and diminishing its overall impact on the global climate. To achieve the former, ICAO will bolster states' capabilities in implementing integrated measures to address aircraft noise and engine emissions. This involves leveraging technological and operational advancements, embracing sustainable aviation alternative fuels, and implementing a global market-based measure for international aviation as deemed appropriate. In the latter scenario, ICAO aims to empower states in implementing measures to reduce CO2 emissions from international aviation. This entails adhering to a harmonized global regulatory framework consistent with UN system environmental protection policies.

The ICAO's 2020-2022 Business Plan underscores the enhancement of the international legal framework as a key priority, reinstating the importance of environmental protection. However, the 2016-2020 Business Plan encountered a gradual pace in implementing the Environment CO2 Reduction State Action Plans and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The successful realization of these frameworks hinges on international cooperation among States and the robust implementation of ICAO policies and standards.

5.2.2 Environmental Impact: Emissions and Noise

The environmental challenges within the aviation industry are characterized by two key aspects: emissions and noise. Both of these issues pose significant threats to human health and overall well-being. Emissions, in particular, play a crucial role in contributing to global warming, thereby inducing changes in the Earth's climate. On the other hand, aircraft noise, stemming from activities such as take-off, landing, or flight at low altitudes, constitutes another form of pollution. This noise pollution can have a profound impact on individuals residing in proximity to airports and other affected areas, affecting their quality of life.

5.2.3 Environmental Impact: Emissions

The growth of the aviation industry, while meeting essential human needs and fostering global integration, introduces significant challenges, particularly in the form of emissions from aircraft. These emissions, identified here as the release of greenhouse gases (GHG) during international aviation activities, raise concerns for human health and overall well-being. Greenhouse gases, characterized as compounds capable of absorbing infrared radiation and trapping heat in the atmosphere, find substantial contributions from aviation operations.

The emission of GHGs, a primary driver of global warming, has become a critical global issue. Notable greenhouse gases, as outlined by the Environmental Protection Agency (EPA), include water vapor (H2O), carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). Among these, CO2 emerges as a major cause for alarm, having experienced a significant surge since the industrial revolution. The National Oceanic and Atmospheric Administration (NOAA) reports a startling 38% increase in CO2 levels since the industrial revolution up to 2009, contributing to the record-breaking heat observed in 2014.

Additionally, fluorinated gases, categorized as greenhouse gases and generated by industrial processes, possess a high "global-warming potential" (GWP) due to their effective heat-trapping capabilities.

ICAO recognizes that aircraft engines generate emissions comparable to those resulting from fossil fuel combustion. Aircraft emissions encompass CO2, water vapor, hydrocarbons, carbon monoxide, nitrogen oxides, sulfoxides, and black carbon. While each emission type has varying atmospheric effects, CO2 remains the most perilous. NASA reports a 38% increase in CO2 levels since the industrial revolution up to 2009, contributing to the record-breaking heat observed in 2014.

In response to the potential impact of aviation emissions on climate and ozone, the ICAO Assembly in 2001 urged states to conduct scientific research to address uncertainties. The Fourth Assessment Report (IPCC AR4) in 2007 indicated a reduced climate impact from contrails, estimated at 3% of anthropogenic radiative forcing. Aviation's CO2 emissions were approximated at 2% of global GHG emissions. The report suggested that improved fuel efficiency could contribute to medium-term CO2 mitigation, but such improvements were expected to only partially offset the growth of CO2 aviation emissions.

Volume II of Annex 16 to the Chicago Convention, which focuses on environmental protection, specifically addresses the issue of aircraft emissions and their impact on air quality near airports. Within this volume, ICAO imposes certain obligations on its member states to restrict emissions of nitrogen oxides (NOx), carbon monoxide, and unburned hydrocarbons during reference landing and take-off (LTO) cycles below 915 meters (3,000 ft). The most recent update in 2016 introduced the emissions compliance demonstration reporting system, requiring specific technical details to ensure environmental compliance.

In addition to the ICAO's efforts, there is an ongoing project within the global chemical transport model (GEOS-Chem) that aims to minimize the impact of aviation emissions on air quality. Projects like the National Aerospace Standards (NAS) and Global Rapid Aviation Air Quality focus on the swift assessment of aviation emission impacts, intending to identify effective strategies for mitigating these impacts. The primary concerns of these initiatives revolve around the effects on air quality related to PM2.5 and ozone resulting from aviation emissions.

Aviation emissions play a substantial role in contributing to global warming and climate change, posing potential threats to human well-being. While ICAO has undertaken initiatives through policy and standard development, its Council faces challenges in effectively addressing environmental issues within the aviation sector. The increasing reliance on bilateral agreements and the referral of disputes to arbitration mechanisms have diverted the resolution of conflicts away from the Council. Furthermore, the Council's historical hesitancy to decide on environmental matters underscores its limitations in this domain.

The ICAO Council typically functions as a forum for settling disputes and interpreting the Chicago Convention. According to Article 66 of the Convention, the Council plays a role in resolving disputes related to the International Air Services Transit Agreement and the International Air Transport Agreement. Under bilateral agreements, parties can designate the ICAO Council to settle disputes concerning the interpretation and application of the Convention. However, despite its authority under Chapter XVIII of the Convention, the Council has never issued decisions on the merits, leading to questions about its effective exercise of power.

Out of the five cases handled by the ICAO Council under Article 84 of the Chicago Convention, only the 2000 'hush-kit case' specifically focused on environmental protection. This case involved a dispute between EU Member States and the United States regarding the application of the EU Directive, known as the 'hush-kit regulation,' aimed at reducing aircraft noise-related issues. The regulation would have prohibited US carriers from flying older aircraft to the EU. The case was submitted to the ICAO Council and ultimately settled by the Council'

President, acting as the Conciliator, who facilitated an agreement satisfactory to both parties.

5.2.4 Environmental Impact: Aviation Noise

The noise generated by aircraft during takeoff and landing has become a source of annoyance for communities living near airports. This aircraft noise has been linked to various health issues, including stress, hypertension, sleep disturbances, and impacts on work and academic performance. Professor Dr. Paul Stephen Dempsey has highlighted this connection over the last five decades. Additionally, airport noise has led to local protests, resulting in night curfews imposed by municipalities.

To address the potential harm caused by aviation noise, the ICAO General Assembly introduced the "balanced approach" through Annex 16 to the Chicago Convention on environmental protection (Volume I). The balanced approach involves assessing noise issues at specific airports and identifying the most cost-effective measures from four principal approaches: reducing noise at the source (quieter aircraft), land-use planning and management, noise abatement operational procedures, and operating restrictions.

Over a three-year period (2013-2016), ICAO conducted technical work on standards, guidance, and policies aimed at reducing aircraft noise. This included research on subsonic aircraft and technology for helicopter noise reduction, as well as efforts in airport land-use planning and community engagement in environmental management. However, despite these initiatives, the reduction of noise radiation has been slow, and the issue persists as the aviation sector continues to grow, leading to an increasing number of people experiencing problems related to aircraft noise.

CAO faces certain shortcomings and legal implications in addressing aviation emissions. Unlike the International Air Transport Association (IATA), ICAO lacks a long-term strategic plan for aviation emissions. While IATA aims for emission reduction by 2050, ICAO's goal is to stabilize emissions at 2020 levels.

The Global Market-Based Measure (GMBM), designed to tackle the growth of international aviation emissions, has progressed slowly. ICAO's environmental instruments, operating beyond sovereign airspace, are soft laws facing substantial violations by developed countries. The lack of an effective enforcement mechanism necessitates a stronger approach, holding states liable for violations of international environmental law.

Despite the significant use of Radio Spectrum (RF) resources in aviation activities, ICAO has not developed policies to address potential environmental issues related to RF use. This oversight poses risks to this scarce and vulnerable natural resource.

Challenges arise regarding emissions from national and international aviation, as IPCC and UNFCCC guidelines assign responsibilities only to nations, excluding emissions from international aviation in national totals for separate reporting. This exclusion makes such emissions exempt from limitations and reductions mandated by the UNFCCC and Kyoto Protocol for State Parties. To address this issue, the IPCC, as a source of scientific information, should collaborate with aviation industry entities globally to adequately handle the higher emissions from aircraft. An example in this context is illustrated by Indonesia's strategic cooperation.

In adherence to the United Nations Framework Convention on Climate Change (UNFCCC) established in 1992, Indonesia introduced Presidential Decree No. 61/2011, outlining the National Action Plan on Greenhouse Gas (GHG) Emission Reduction in 2011. This decree set a target for businesses, including the aviation sector, to reduce GHG emissions by 26% by 2020, aligning with Indonesia's commitment. Presidential Order No. 71/2011 on the implementation of the national GHG inventory in Indonesia mandates governmental and corporate entities to produce annual GHG inventories. The Ministry of Environment coordinates and submits the national inventory to the UNFCCC, facilitating the measurement of mitigation action effectiveness.

Indonesia collaborates with neighboring countries and international organizations to address climate change, involving various air transportation companies such as Garuda Indonesia, Sriwijaya Air, Lion Air, and airport operators like PT Angkasa Pura I and PT Angkasa Pura II. The government entity Badan Penanggulangan Bencana

National (BPBN)/ The National Agency for Disaster Countermeasure also plays a role in climate change initiatives.

Aircraft noise remains a unresolved issue inadequately addressed by ICAO, posing threats to the lives of those residing near airports. Initiatives and funding for innovative projects are needed to tackle this problem. For instance, the EU has invested in scientific and technological research projects aimed at reducing aircraft noise radiation and mitigating its impact on nearby communities. ICAO should adopt a comprehensive approach to minimize aircraft noise instead of relying on various city regulations that may impact international aviation development.

In meeting current aviation demands without compromising the future, the Intergovernmental Panel on Climate Change (IPCC) seeks technological innovations to reduce emissions. Striking a balance between potential drawbacks and long-term benefits is crucial for sustainability in the aviation sector. ICAO's mechanisms require a strong partnership with Member States for effective implementation of policies and standards in their territories. Adopting a conventional approach aligned with global sustainable development goals will enable ICAO to provide harmonized solutions, incorporating environmental concepts and international legal principles.

CHAPTER 5 CONCLUSION

In summary, this chapter has delved into crucial aspects of aviation safety, operational procedures, and environmental concerns. Emphasizing the paramount importance of safety protocols, it underscores the need for meticulous planning from pre-flight to post-flight stages. The discussion on aviation and chemical works stresses the significance of adherence to safety guidelines to prevent potential hazards.

The section on de-icing and anti-icing fluids highlights their crucial role in adverse weather conditions. Furthermore, the chapter addresses the environmental impact of aviation activities, emphasizing the role of international organizations like ICAO in developing policies and ensuring effective implementation.

As the aviation industry faces challenges in emissions, noise pollution, and sustainability, global cooperation and proactive measures are crucial. The identified shortcomings in current frameworks underscore the need for continued international efforts. Subsequent chapters will offer a detailed analysis of specific issues, providing insights into challenges and potential solutions in aviation safety and environmental protection.

SUMMARY

In the recent years a lot of difficulties faced by the Ukrainian aviation, even though the need to use the airspace taking into account the requirements of the appropriate level of security has not disappeared. The development and implementation of new international concepts in the field of air navigation also requires constant improvement.

In order to synchronize with standards our country has established "General rules for flights in the airspace of Ukraine", which establish three of the seven ICAO classes of airspace over the territory of Ukraine : C , D and G. According to the structure and classification of the airspace, depending on the type of ATS, controlled (C, D) or uncontrolled (G) airspace is established, the latter of which we worked on in this thesis work

Controlled airspace is introduced in classes C and D. Class C operates in the upper airspace from an altitude of 2900 m (exclusively) to FL 660, and class D below an altitude of 2900 m (inclusively) to an altitude of 1500 m (exclusively). In each of these classes, air traffic control service is conducted.

The uncontrolled use of airspace is valid only in the airspace of Class G - the space where classes C and D are not established, and which is located from the earth's surface up to a height of 1500 m (inclusive). Class G airspace users are provided with air traffic information service and emergency notification.[

During the performance of this work, the object of our research was the air traffic service system of Ukraine, we formulated problems during air traffic control in the uncontrolled airspace of class "G" and found ways to solve them using statistical and analytical methods, as well as methods of observation, generalization and forecasting.

We described the specifics of flights and ATC in class "G" airspace and highlighted the general provisions regarding the flight safety management system.

This work contains an analysis and accounting of aviation events such as the An-2 aircraft on 12/09/2020 in the Ternoil region, the L-410UVP aircraft on 06/10/2020 near the Borodyanka airfield in the Kyiv region, and the Mi-8MTV-1 helicopter of " Ukrainian helicopters" near the Kremenchuk airport, as well as flight safety statistics from 2017 to 2021.

At the end of the work, recommendations for improving the level of safety when flying in uncontrolled airspace are highlighted, such as, for example, equipping each aircraft flying in class G space with a specialized navigator (GPS) with appropriate maps showing all applicable restrictions, temporary regimes, local regimes, restricted areas, range boundaries, etc., boundaries civil airfields, the boundaries of classes C and G, in order to avoid cases where the aircraft crew inadvertently deviates from the planned route or the place of work agreed with the ATS authority , GPS trackers for monitoring the position of the aircraft by the ATC authority, an availability of cellular phone on board, and also introducing amplification punishment for violating the use of airspace.

The provisions set out in the work are proposed to be applied in the development of national documents on organizing and ensuring flight safety in class G airspace in terms of risk management. It is also proposed to use these developments in the educational process of training aviation operators on relevant topics related to risk assessment and decision-making in the process support of operational activities.

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