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
(ПОЯСНЮВАЛЬНА ЗАПИСКА)

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

Тема: «Запобігання конфліктних ситуацій в повітряному просторі вільних маршрутів на етапі планування польотів»

Виконав:____ Нечеса Р. О.
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Київ 2023

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

PERMISSION FOR DEFENCE
Head of the Department
Doctor of Sciences (Engineering), prof.
__________________V.Y. Larin
"_____" ___________ 2023

MASTER'S THESIS
ON THE EDUCATIONAL PROFESSIONAL PROGRAM
"AIR TRAFFIC SERVICE"
(EXPLANOTARY NOTE)

Theme: "Preventing of conflict situations in free route airspace on flight planning phase"

Performed by: ____ Nechesa R.O.
Supervisor: ____ Luppo O. E.
Standard inspector: ______________________________________ Argunov G. 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.т.н., професор

____________В. Ларін

« ___ »________2023 р.

ЗАВДАННЯ

на виконання дипломної роботи

_______________Нечеси Романа Олеговича______________

(прізвище, ім'я, по батькові випускника в родовому відмінку)

1. Тема дипломної роботи: **«Запобігання конфліктних ситуацій в повітряному просторі вільних маршрутів на етапі планування польотів»** затверджена наказом ректора від 28 серпня 2023 № 1443/ст.
2. Термін виконання роботи: з 23.10.2023 по 31.12.2023.
3. Вихідні дані до роботи: теоретичні дані керівних документів ІСАО та національних документів України у сфері забезпечення та виконання польотів цивільних повітряних суден.
4. Зміст пояснювальної записки: аналіз сучасного стану авіаційної безпеки та розробці системи запобігання конфліктам у повітряному просторі. Дослідження включає в себе аналіз існуючих систем, моделювання конфліктних ситуацій та розробку нових методів для підвищення безпеки в авіації. Результати роботи

важливі для поліпшення авіаційної безпеки та можуть бути використані як рекомендації для практичної реалізації та регулювання в авіаційній сфері.

5. Перелік обов’язкового графічного (ілюстративного) матеріалу:

6. Календарний план-графік:

№ пор.	Завдання	Термін виконання	Відмітка про виконання
1.	Підготовка та написання 1 розділу: "Конфліктні ситуації в повітряному русі"	25.10.2023 – 02.11.2023	Виконано
2.	Підготовка та написання 2 розділу: “Існуючі методи запобігання конфліктним ситуаціям”	03.11.2023 – 10.11.2023	Виконано
3.	Підготовка та написання 3 розділу: “Розробка інформаційно-допоміжної системи управління польотами”	11.11.2023 – 18.11.2023	Виконано
4.	Підготовка та написання 4 розділу: “Автоматизована обробка великих даних в аеронавігації”	19.11.2023 – 25.11.2023	Виконано
5.	Підготовка та написання 5 розділу: “Охорона праці та навколишнього середовища”	26.11.2023 – 30.11.2023	Виконано
6.	Розробка та друк пояснювальної записки	01.12.2023 – 03.12.2023	Виконано
7.	Підготовка звіту та графічних матеріалів	04.12.2023 – 07.12.2023	Виконано
8.	Попередній захист дипломної роботи	13.12.2021	Виконано

7. Дата видачі завдання: «23» жовтня 2023 р.

Керівник дипломної роботи __________________ Луппо О.Є.
(підпис керівника) (П.І.Б.)

Завдання прийняв до виконання ______________ Нечеса Р.О.
(підпис випускника) (П.І.Б.)

РЕФЕРАТ

Пояснювальна записка до дипломної роботи «Запобігання конфліктних ситуацій в повітряному просторі вільних маршрутів на етапі планування польотів», а також сторінок, рисунків, таблиць, використаних джерел.

Ключові слова - FREE ROUTE AIRSPACE, AIR TRAFFIC MANAGEMENT, AIR TRAFFIC SEPARATION, SAFETY, SYSTEM, AIR TRAFFIC OPERATOR, AIR NAVIGATION SYSTEM

Об'єкт дослідження – система авіаційної безпеки та процеси пов'язані з плануванням та забезпеченням безпеки в повітряному просторі.

Предмет розробки – система та алгоритми, спрямованих на запобігання конфліктам в повітряному просторі вільних маршрутів на етапі планування польотів.

Мета роботи – метою даної дипломної роботи є розробка та дослідження системи, яка б забезпечувала підвищення рівня авіаційної безпеки шляхом запобігання конфліктам та небезпекам в повітряному просторі.

Методи дослідження – методологія дослідження цієї дипломної роботи передбачає використання різноманітних методів та підходів для досягнення поставлених цілей та вирішення завдань дослідження. Основні етапи методології включають в себе наступне:

- Аналіз літератури та вивчення існуючих підходів
- Збір та аналіз даних
- Моделювання конфліктних ситуацій
- Розробка системи запобігання конфліктам

Авіаційна безпека є однією з ключових складових сучасної цивілізації, оскільки вона безпосередньо впливає на життя та благополуччя людей. В контексті росту авіаційного транспорту та збільшення обсягу пасажирських та вантажних перевезень, проблеми, пов'язані з авіаційною безпекою, стають надзвичайно важливими. Ця дипломна робота присвячена дослідженню та розробці системи запобігання конфліктам у повітряному просторі з метою підвищення рівня безпеки в авіації.

PAGE OF REMARKS

Faculty of Air Navigation, Electronics and Telecommunications
Air Navigation Systems Department
Specialty: 272 “Aviation Transport”
Educational Professional Program: “Air Traffic Service”

APPROVED BY
Head of the Department
_____________ V.Y. Larin
«__»___________________2023

Graduate Student’s Degree Thesis Assignment

________________Nechesa Roman Olegovych______________

1. The work subject: **Preventing of conflict situations in free route airspace on flight planning phase** approved by the Rector’s order of № 1443/st from 28.09.2023.
2. The work (Thesis) to be completed between from 23.10.2023 to 31.12.2023.
3. Initial data to the work: theoretical data of ICAO guiding documents and national documents of Ukraine in the field of ensuring and performing flights of civil aircraft.
4. The contents of the explanatory note: analysis of the current state of aviation security and development of a system for preventing conflicts in airspace. The research includes analysis of existing systems, modeling of conflict situations and development of new methods to improve aviation safety. The results are important for improving aviation security and can be used as recommendations for practical implementation and regulation in the aviation sector.
5. The list of mandatory graphic (illustrated) materials
6. Calendar schedule:

№	Completion Stages of Degree Thesis	Stage Completion Dates	Completion Mark
1.	Preparation of Charter 1: “Conflict Situations in Air Traffic”	25.10.2023 – 02.11.2023	Completed
2.	Preparation of Chapter 2: “Existing Methods of Preventing Conflict Situations”	03.11.2023 – 10.11.2023	Completed
3.	Preparation of Chapter 3: “Development of An Information and Assistance System for Flight Control”	11.11.2023 – 18.11.2023	Completed
4.	Preparation of Chapter 4: “Automated Big Data Processing in Air Navigation”	19.11.2023 – 25.11.2023	Completed
5.	Preparation of Chapter 5: “Labor and Environmental Protection”	26.11.2023 – 30.11.2023	Completed
6.	Designing and printing of the explanatory note	01.12.2023 – 03.12.2023	Completed
7.	Preparation of report and graphic materials	04.12.2023 – 07.12.2023	Completed
8.	Preliminary presentation of the graduate work	13.12.2021	Completed

7. Assignment accepted for completion: “29” September 2023

Supervisor ________________________ Luppo O.E.
(signature) (Full Name)

Assignment Accepted for Completion ___________________ Nechesa R.O.
(signature) (Full Name)

ABSTRACT

Explanatory note to the thesis "Prevention of conflict situations in the airspace of free routes at the stage of flight planning", as well as pages, figures, tables, and references.

Key words: FREE ROUTE AIRSPACE, AIR TRAFFIC MANAGEMENT, AIR TRAFFIC SEPARATION, SAFETY, SYSTEM, AIR TRAFFIC OPERATOR, AIR NAVIGATION SYSTEM

The object of research is the aviation security system and processes related to planning and ensuring security in the airspace.

The subject of development is a system and algorithms aimed at preventing conflicts in the airspace of free routes at the stage of flight planning and improving aviation safety.

Purpose of the work - to develop and research a system that would ensure an increase in the level of aviation safety by preventing conflicts and hazards in airspace. In addition, the work is aimed at analyzing the causes of conflict situations and their impact on aviation safety. The results of the study can be used to further improve aviation security systems and develop recommendations for the practical implementation of conflict prevention in aviation.

Research Methods - the research methodology of this thesis involves the use of various methods and approaches to achieve the goals and objectives of the study. The main stages of the methodology include the following:

- Literature review and study of existing approaches
- Data collection and analysis
- Modeling of conflict situations
- Development of a conflict prevention system

Aviation security is one of the key components of modern life, it directly affects the lives of people. In the context of the growth of air transport and the increase in the volume of passenger and cargo transportation, the problems associated with aviation security are becoming extremely important. This thesis is devoted to research and development of a system for preventing conflicts in airspace to improve the safety.

CONTENTS

LIST OF ABBREVIATIONS

A/C - Aircraft

AIP – Aeronautical Information Publication

ANS – Air Navigation System

ANSP – Air Navigation Service Provider

ATC – Air Traffic Control

ATCO – Air Traffic Control Operator

ATCS – Air Traffic Control System

ATM – Air Traffic Management

ATS – Air Traffic Service

CAA – Civil Aviation Authority

DSS – Decision Support System

DM – Decision Making

EMS – Environmental Management System

ES – Emergency Situation

EUROCONTROL – European Organization for the Safety of Air Navigation

FIR – Flight Information Region

FIS – Flight Information Service

FAA – Federal Aviation Administration

FE – Flight Emergency

FPL – Flight Plan

FMS – Flight Management System

IATA – International Air Transport Association

ICAO – International Civil Aviation Organization

ICDMS – Intelligent Collaborative Decision-Making System

IDSS – Intelligent Decision-Making System

IFR – Instrument Flight Rules

HF – Human Factor

KPA – Key Performance Area

SARPs – Standards and Recommended Practices

SD – Stochastic Dominance

SESAR – Single European Sky ATM Research

SHEL – Software, Hardware, Environment, Liveware

SMAA – Stochastic Multiobjective Acceptability Analysis

SMCDM – Stochastic Multiple Criteria Decision Making

SMS – Safety Management System

UAV – Unmanned Aerial Vehicle

VFR – Visual Flight Rules

INTRODUCTION

In the ever-evolving realm of aviation, the safety and efficiency of air traffic management stand as paramount concerns. As the skies become increasingly crowded with a growing number of flights, addressing the complexities of conflict situations becomes imperative. This comprehensive exploration embarks on a journey through the multifaceted challenges and solutions within the aviation safety framework.

Aviation safety encompasses a myriad of factors, from intricate flight dynamics to the well-being of the professionals responsible for orchestrating the skies. As the industry faces unprecedented growth, so too do the challenges associated with ensuring safe and sustainable air travel. This exploration delves into the nuances of conflict situations in air traffic, existing methods of conflict prevention, and the development of innovative systems to assist in flight control.

The dynamics of conflict situations in air traffic are influenced by various factors, including the intricate interplay of flight routes, navigation systems, and the decisions made by air traffic controllers. Understanding these complexities is crucial for devising effective strategies to enhance safety and mitigate potential conflicts. This exploration seeks not only to identify challenges but also to propose innovative solutions that align with the evolving landscape of aviation.

As we navigate through the various facets of air traffic management, from the identification of conflict situations to the development of advanced assistance systems, we aim to contribute to the ongoing discourse on the future of aviation. The integration of intelligent decision-making systems and considerations for labor and environmental protection further underscores our commitment to fostering a safer, more efficient, and sustainable airspace.

Through this comprehensive exploration, we strive to provide insights that transcend individual challenges, offering a holistic perspective on the intricate dynamics that define the modern airspace. Our journey seeks to contribute to the continual improvement of air traffic management, advocating for safety, efficiency, and sustainability in the skies.

CHAPTER 1
CONFLICT SITUATIONS IN AIR TRAFFIC

1.1 Overview of the current state of flight safety

Flight safety is the state of an aviation system or organization in which the risks associated with aviation activities related to the operation of aircraft or directly supporting such operation are reduced to an acceptable level and controlled.

Depending on the context, the concept of flight safety can have different interpretations, for example:

a) no airline accidents - a viewpoint common among passengers;
b) absence of risks, i.e. factors that may lead to losses or their acceptable amount;
c) employees' attitude to hazardous actions and conditions, i.e. corporate safety culture with the accompanying processes of identifying sources of danger and risk management, including the prevention of losses due to aviation accidents (human casualties, property and environmental damage).

Aviation is characterized by the giant technological leaps it has made over the past century. This progress would not have been possible without parallel advances in the control and reduction of aviation hazards. Given the many ways in which aviation can cause injury or damage, since the earliest days of flight, industry professionals have been working to prevent aviation accidents. Thanks to the consistent application of best practices in aviation safety management, the frequency and severity of aviation accidents have been significantly reduced [1].

To understand the essence of flight safety management, it is necessary to clarify what is meant by the term "safety". According to Doc. 9859, "Depending on the aspect under consideration, the concept of aviation safety may have different interpretations, such as:

a) the absence of danger or risk; i.e., factors that cause or may cause harm;
b) the degree to which the inherent risk of aviation is "acceptable";
c) zero aviation accidents (or serious incidents) - a viewpoint widely shared by passengers;

d) preventing losses as a result of air accidents (human casualties, as well as damage to property and the environment);
e) the process of identifying hazard sources and controlling risk factors;
f) employees' attitude to dangerous actions and conditions (reflects a "safe" corporate culture)."

While avoiding accidents (or serious incidents) would be a desirable outcome, a 100 percent safety record is an unattainable goal. Despite the best efforts to prevent failures and errors, they will nevertheless occur. No human activity and no artificial system can be guaranteed to be completely safe. Safety is a relative concept, implying that in a "safe" system, the presence of natural risk factors is considered an acceptable situation.

Security is increasingly seen as the control of risk factors. Thus, Doc 9859 defines safety as follows: "Safety is a state in which the risk of injury to persons or damage to property is reduced to an acceptable level and maintained at that level or lower through a continuous process of hazard identification and risk factor control." Although major accidents are rare events, aviation accidents with less catastrophic consequences, as well as a wide variety of incidents, occur quite frequently. These less significant safety incidents can be harbingers of hidden safety problems. Ignoring such hidden sources of safety hazards can contribute to an increase in the number of more serious events.

A major role in ensuring the safety and efficiency of civil aviation (CA) flights around the world is played by the thorough preparation of the aircraft crew for the flight, which results in the decision to take off or not to take off by the aircraft commander (AC)[2].

Investigating aviation accidents (AAs), it turned out that many of them were caused by unsatisfactory pre-flight training, intentional and deliberate violation of existing aviation laws by aircraft crews during the performance of ordered and charter flights to the regions of Africa, Middle East, Asia (violation of the recommended flight and landing patterns), exceeding the maximum takeoff weight, centering violations, flights to airfields not included in the JEPPESEN air navigation information collections, etc.[3]. Some accidents are caused by the collision of serviceable aircraft with the ground in mountainous terrain, the reason for such accidents is insufficient training of crews for such flights; some incidents are related to violations of meteorological minimums [3].

Based on the analysis of the 2000-2013 accident reports, it was found that the general causes of air traffic accidents involving violations of the airspace use procedure are as follows:

a) departures without applications and flight plans, departures earlier than the time specified in the application, lack of notification by air defense authorities, landings at an unplanned airfield (40%);
b) unauthorized flights of private aircraft, home-made aircraft, etc. under the direction of persons not authorized to fly, flights without appropriate certificates and certificates (23%);
c) unsatisfactory flight planning, its non-compliance with flight standards and procedures, insufficient assessment of weather conditions, flying with overload, violation of weather minimums, flying without pre-flight training (studying instructions, ordering meteorological information in the flight plan) (17%);
d) Poor planning and maintenance by the aviation personnel of the relevant services, lack of regulatory documents in the required volume, violation of the rules for maintaining documentation, lack of clear organization and interaction of flight planning services (20%). A graphical representation of the causes of violations is shown in Figure 1.1.

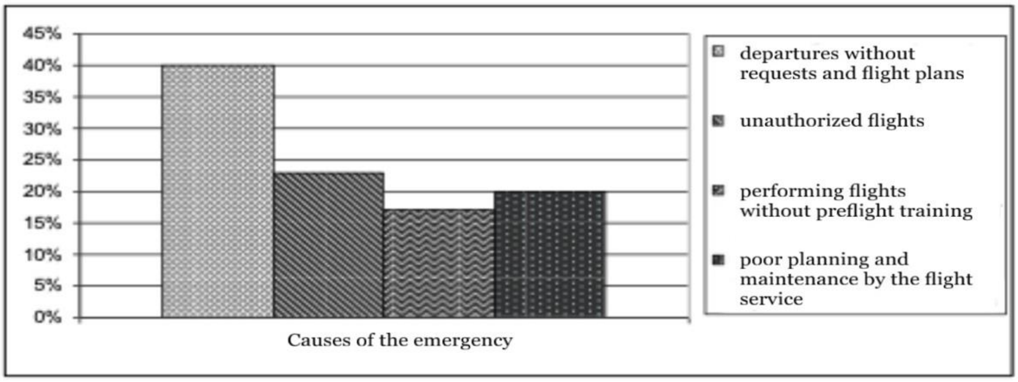

Figure 1.1 - Analysis of the causes of the conflict in 2000-2013.

It has also been established that overestimation of the professional abilities of the ATC, combined with underestimation of the active influence of the environment under extreme meteorological conditions in the course of making a decision to perform flights, in most cases results in emergency and catastrophic consequences.

The analysis of operational experience and the results of accident and crash investigations [4] over 43 years (1958-2000) showed that two hundred and fifty-two civilian aircraft crashes occurred in the USSR-CIS. The most accidental stages of flight (Fig. 1.2) are: landing, descent, takeoff and climb.

The main culprits in these accidents are: the crew (56% of the total number of accidents); the crew and air traffic control (ATC) (28%); and ATC (14%).

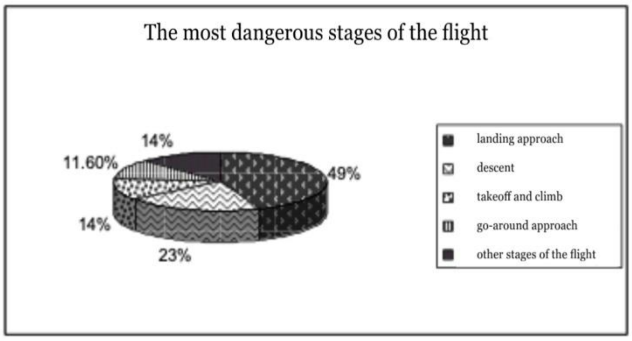

Figure 1.2 - The most dangerous stages of flight

The ATC on the ground is responsible for making the decision to start the flight, taking into account the safety of the flight, and the outcome of the flight depends on the correctness of his decision. An incorrect decision by the pilot can lead to an accident. The human factor still accounts for 80% of the causes of accidents worldwide for all types of aircraft [5]. Timely assistance from the EPS in making a decision to take off can prevent accidents, so there is a need to improve the professional training of future flight support specialists.

The majority of civil aviation flights in the world are commercial civil aircraft. In Ukraine, the National Bureau for the Investigation of Aviation Accidents and Incidents with Civil Aircraft (NBAAI) annually issues reports on civil aviation safety.

In order to prevent aviation accidents, the existing concept of aviation safety management requires aviation entities to constantly identify, search for and eliminate hazards that may cause an aviation accident. All aviation accidents are the result of the impact of hazards that were not timely identified within the aviation safety management system. Therefore, the task of the NBAAI during a technical investigation is to identify all hazards, regardless of whether they caused the accident or not.

The distribution of accidents that occurred with aircraft listed in the State Register in the period from 2015-2019 is shown in Figure 1.3 [5].

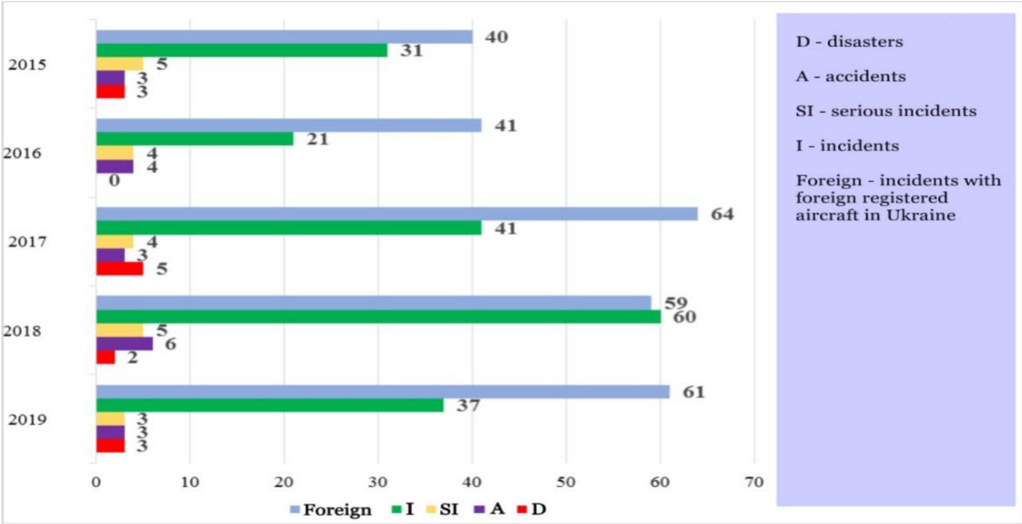

Figure 1.3 - Distribution of accidents with aircraft listed in the State Register that occurred in 2015-2019 by class

1.2 Main problems of flight safety

As part of the data analysis and with due regard to the number of event notifications and the classification of their significance, the State Aviation Administration identified flight safety issues in various key risk areas of civil aviation in 2021, which were carefully analyzed as they could have led to or resulted in aviation accidents [6].

The identified safety issues may change over the next few years depending on changes and trends. These flight safety issues have been categorized into the following categories, each of which is described separately, namely:

a) Operator of an airfield and ground handling organization, air traffic service provider
b) Operators engaged in transportation (Aircraft)
c) Operators engaged in transportation (Helicopters)

d) Maintenance organizations

e) General aviation

f) Airworthiness maintenance organizations

g) Aerostatic devices

h) Developers of the SAR

i) Aircraft manufacturers

j) Gliders

Here is an example of a description of the problems that occurred when events occurred at the airfield operators and ground handling facilities:

Decision-making and planning - Improper planning and decision-making by personnel can lead to dangerous situations on the airfield and in the ground handling work environment:

a) inadequate control by the traffic manager near the aircraft;
b) non-compliance with apron markings to facilitate aircraft taxiing to parking areas;
c) lack of aircraft type identification markings at parking areas;
d) there is no internal control on the part of the service organization;
e) The processes for ensuring the quality of operational activities and flight safety at the airfield are absent or in their infancy.

Runway pavement condition is the effective management of the condition and serviceability of the entire airfield operating environment. This issue covers all possible events that can occur due to poor airfield pavement conditions.

a) There is no special equipment or old special equipment is available.
b) There is no proper airport infrastructure.

Experience, training and individual competence - Aerodrome personnel do not have sufficient experience, training or competence to perform their duties and this can lead to unsafe situations in the work environment during takeoff or landing. In a well-functioning work environment and before performing any duties, all persons should receive appropriate training (initial and refresher training) and should be qualified and competent.

a) Low qualification level of management and production staff.

b) The service organization did not document how the relevant operations are carried out, and did not take into account the requirements of the airport.

c) Lack of awareness of the procedures for tie-down of aircraft in parking areas.

d) Insufficient management and security procedures at parking lots.

Collision with birds - A collision can cause damage and/or jeopardize flight safety. Inadequate control of birds and wildlife can result in either damage to the aircraft or loss of control during takeoff or landing. With a detailed understanding of the bird and wildlife habitat, airport operators should develop and implement management plans for bird and wildlife activity on and around the airfield, thereby minimizing the risk of collisions with birds and birds entering engines, which can lead to critical situations during takeoff/climb, approach and landing.

Convective meteorological phenomena (turbulence, hail, lightning, ice) inability of personnel to work due to the impact of weather on the airfield and in the context of ground handling.

Since the topic of our study is directly related to the organization and maintenance of air traffic, we will also describe the problems that occurred during the events in the organization of ATM/ANS air traffic:

Provision of information to the crew - not fully provided flight information services to the crew in the classified airspace of Ukraine, as required by the Aviation Rules of Ukraine "Air Traffic Services", approved by the Order of the State Aviation Service of Ukraine dated 16.04.2019 No. 475 [7]:

a) the crew did not receive information from the Dnipro RDC and Zaporizhzhia ATC and ADC authorities on the condition of the runway at Zaporizhzhia airfield, which was included in the updated METAR report;

b) the dispatcher did not verbally communicate important operational information about the condition of the runway at Zaporizhzhia airfield to the ATC [6].

Experience, training, and individual competence - the issue of insufficient experience, training, and individual competence relates to the ability of dispatchers to perform the required tasks and to respond to events that they may encounter in the course of their duties.

Management system effectiveness - ineffective implementation of safety management systems can lead to inefficient organization of air traffic and air navigation services with uncertain risks in service provider organizations. The complex nature of the concept of flight safety and the importance of addressing the human factor aspects justify the need for effective safety management by aviation organizations. This safety issue encompasses regulatory requirements and the promotion of management system principles for both aviation authorities and organizations, as well as the ability to identify and anticipate new threats and related issues.

The identified aspects of the human factor in air traffic services include: exceeding working hours; lack of records of medical examinations; insufficient control over dispatchers' fatigue.

One of the main causes of aviation accidents is the human factor, so we will also provide a description of the problems that occurred in the event of accidents involving Operators performing transportation by aircraft: commercial air operation (CAT), specialized operation (SPO).

Aircraft system failure. Any malfunction, failure or damage to the aircraft systems that renders the aircraft uncontrollable. Includes errors or failures in software and database systems. Also includes parts related to the powerplant or parts that are detachable from the aircraft.

Decision-making and planning - effective planning and preparation is achieved by ensuring that the flight crew uses the right processes, tools and information to plan and execute the flight. This includes the adequacy, accuracy and timeliness of the information used and how it is processed by the flight crew.

Effectiveness of the aviation safety management system - aviation organizations must implement aviation safety management systems and conduct appropriate training of relevant specialists in this area. Ineffective implementation of the aviation safety management system by aviation entities. Regulatory requirements and promotion of the SMS principles for aviation entities, as well as the ability to identify, anticipate and respond to new threats and related challenges.

Experience, training and individual competence - despite the obvious technological advances that have made the aviation industry safer and more efficient over the past few decades, the way in which aviation workers are trained has not changed significantly. Deviations from existing procedures or their complete non-compliance. Untimely actions by the crew due to insufficient training and experience. Ineffective actions by the flight crew to reduce risks.

Wind shear - encountering a wind shear during approach, landing, takeoff, and initial climb can result in an aircraft stalling, rolling off the runway, or colliding on the runway. Airlines should implement effective standard operating procedures and flight crew training to avoid and follow procedures in the event of such a situation. Such training should also be complemented by the detection of potential wind shear by third parties, such as Air Traffic Control, and the effective communication of this information to the flight crew.

Perception and situational awareness - covers the incorrect perception and inadequate awareness of the situation by the flight crew from the moment the flight begins. Persons acting on the basis of incorrect perception or inadequate situational awareness may cause damage to the aircraft and/or injure themselves or others.

CRM and communications - the problem covers all aspects of communication that may affect crew situational awareness and/or flight performance, including the lack of a common action plan, inadequate segregation of duties, poor coordination between crew members, use of non-standard phraseology, sensory overload (loss of communication, numerous audio messages, etc.), etc. Good CRM can be achieved by implementing appropriate training for the flight crew [6].

The following problems arose during transportation.

Flight Preparation and Planning - this issue includes effective preflight planning, where preparation is achieved by ensuring the quality of the processes, tools and information used by the crew/operator to plan the flight. It includes the adequacy, accuracy and timeliness of the information used, how it is processed and assimilated by the flight crew and their training and special operating procedures. It includes the departure of the aircraft and the stages of flight preparation before the start of the flight. The following events were included in this problem:

a) The CPS does not take into account the fact that there may be sunlight, failure to use a light filter, and takeoff towards trees;

b) allowing a pilot to fly without a license;

c) Lack of control over the admission of ATCs to flights after drinking alcohol.

Perception and situational awareness - it is highly likely that the ATC was blinded by the sun during takeoff, which made it impossible to assess the distance to the trees.

Decision-making and planning - PIC, without a license, without a flight application, made the decision to fly. Drinking alcohol before the flight. Failure of the crew to make a decision to switch to instrument flight in the event of deteriorating weather conditions and deviation from the requirements of the Safe Flight Altitude Manual.

Management System Effectiveness - aviation organizations are required to implement a safety management system (SMS). This case examines the ineffective implementation of an organization's SMS. The complex nature of the concept of flight safety and the importance of considering human factors aspects show the need for effective safety management by aviation organizations. It encompasses regulatory requirements and the promotion of SMS principles for both aviation authorities and organizations, as well as the ability to identify, anticipate and respond to emerging threats and related issues. It also includes the establishment of a good safety culture in organizations and authorities. This issue has become more acute in the context of the COVID-19 pandemic. This problem includes the following:

The flight was scheduled to take place on a non-certified runway. The control system of the aircraft operator did not ensure proper implementation of the Guidelines and Rules, which led to the collision of the aircraft (the controller authorized the flight at an altitude of 300m, and the crew lowered to 150m without the permission of the controller, in difficult weather conditions (insufficient visibility)), the crew had to switch to the rules of flight by instruments, which they did not do. The flights were not suspended when weather conditions deteriorated. The aircraft operator did not ensure clear control over the temporary runway due to inadequate interaction with the agricultural company for perimeter protection [6].

Experience, training and individual competence - the lack of sufficient training and experience of the PIC in landing with hydraulic system failure due to pipeline failure (training on a complex simulator does not allow the pilot to gain sufficient skills to land with a failed hydraulic system in real conditions).

The human factor also plays a role in the organization of flight maintenance (FM). We will describe the main problems that have occurred in the event of accidents in maintenance organizations:

Experience, training, and individual competence - the problems of competence, training, and experience of maintenance personnel include the following: insufficiently trained personnel in terms of operational actions after the landing of the aircraft, incomplete implementation of aircraft maintenance procedures.

Aircraft Maintenance - aircraft maintenance issues include, but are not limited to: incorrect or incomplete maintenance tasks performed by personnel, foreign objects left in the aircraft after maintenance, planning and monitoring of maintenance activities, use of maintenance documentation, and compliance with maintenance procedures. Poor quality of maintenance, non-compliance or violation of procedures by maintenance personnel, failure to perform maintenance for the aircraft in accordance with the maintenance plan.

General aviation is one of the leading players in flight operations. We will describe the problems that occurred when events with general aviation occurred:

Fuel metering and control - the fuel tap in the Grumman AA-5 cockpit is located at the bottom of the central panel. Note: according to the design of the Grumman AA5 fuel system, the fuel tap switches the fuel supply to the engine fuel pumps from either the right or left fuel tank, there is no function to supply fuel to the engine from both tanks simultaneously. The pilots did not control the fuel consumption from different tanks, which led to the late switching of the fuel tap from the right to the left tank.

Decision-making and planning. After takeoff, at a true flight altitude of 30-40 meters, the engine probably shut down. The pilot decides to return to the departure airfield, despite the low altitude, instead of performing a forced landing in front of him. The result was a loss of speed after a sharp turn with a large roll and an uncontrolled collision with the ground. The ATC decided to enter the controlled area without the dispatcher's permission, crossing the runway, and did not check the frequency of contact with the dispatcher when planning the flight. No preflight preparation for the flight was carried out, as no documents or evidence were provided.

Experience, training, and individual competence - the ATC forgot to release the landing gear during landing. Failure of the crew (Beechcraft Model 76) to comply with the requirements of POH Section IV - Normal Procedures when flying on one engine: Section IV - Normal Procedures, Page 4-12. Wing Flaps - UP. Section III Emergency Procedures Propeller (inoperative engine) - FEATHER (propeller is flown).

Flight preparation and planning - the PIC should not have flown the flight with the deficiencies he had identified on the airplane during the previous flight. The crew did not take into account the inability of the airplane to take off with one engine running at its actual takeoff weight and outside air temperature. No pre-flight preparation was carried out, as no documents or evidence were provided (X-32-912 "Snipe"). The ATC, who decided to perform the flight without the appropriate documents, placed more passengers on the aircraft than provided for in the Flight Operations Manual.

The ATC did not thoroughly examine the terrain for obstacles, which resulted in the aircraft colliding with power lines. The aircrew did not inform the Armed Forces of Ukraine and the ATC authority about the flight. The aircrew did not submit a flight plan to the UkSATSE on the eve of the flight. The aircrew did not request conditions for the flight from the ATC authority. The aircraft did not have a permit for specialized work and the work was carried out. The CAA (owner of the aircraft), who flew the aircraft without having the right to pilot it (i.e., deliberately violated the processes and procedures).

Perception and situational awareness - the inability of the crew to calculate and execute an emergency landing on a restricted runway.

Landing approach trajectory control - non-compliance by the ATC with the requirements of the operating manual for the aircraft (A-22) in terms of approaching with a speed exceeding 30 km/h. When the aircraft suddenly threw up on the runway by about 3 meters. The ATC abruptly pulled the rudder away and landed on the front landing gear strut, which resulted in the aircraft cowling. The airplane did not set the flaps to the landing position. The AC did not start landing immediately after detecting the engine problem, but made a turn toward the runway, where it lost altitude and had to land immediately. Failure of the CSP to comply with the requirements for a stabilized approach, probably due to a wind shift.

Maintenance of the aircraft - the maintenance of the aircraft was performed incorrectly or not at all, which led to a technical malfunction or failure.

Monitoring of flight parameters and automation modes - due to low altitude flight with a high roll - when performing a descent of an aircraft with a roll of 450 or more, the NLPS X-32-912 may enter the stall mode.

Convection meteorological phenomena - loss of control over the helicopter by the pilot during a maneuver after getting into fog.

Knowledge of aircraft systems and procedures - ATC on a CESSNA-172M aircraft without carburetor heating, flew a flight that caused carburetor icing and caused the engine to shut down.

Analyzing the problems of flight safety, we can conclude that in order to avoid aviation accidents and conflicts, it is necessary to improve both the level of professional training of all entities of the aviation transport system and the means of maintenance, control, and flight planning.

1.3 Identification of typical conflict situations

A potentially conflicting situation (PCS) is defined as the relative positioning of aircraft when the dispatcher's failure to intervene will necessarily lead to a dangerous approach between them. A conflict situation is a foreseeable approach of aircraft in space and time when certain minimum echeloning levels are violated.

Search for a conflict situation - calculates and compares the estimated flight paths of two or more UAVs to determine the conflict situation. Conflict resolution - identifies possible flight paths that eliminate conflicts and selects one of these paths for use.

Detecting and resolving a CCS is one of the most important tasks during ATC, the essence of which is to ensure and maintain safe intervals between the PCs under control in the area. A conflict situation can be real or so close to real that the controller must immediately make a decision to prevent it. Conflict situations are one of the main criteria for air traffic controller workload.

Based on the experience of controllers, it should be noted that ACS are perceived by controllers as their spatial perception of the air situation. In this regard, the proposed classification makes it possible to cover all possible locations of conflicting ACs in space [8]. When classifying the types of ACS, the relative position, flight profile (modes) and course (flight direction) of the conflicting ACS are taken into account. Among the possible conflict situations that arise during ATC, the following can be distinguished:

a) the objects are moving in parallel toward each other. A collision can occur if they are at the same flight level and the distance between them is less than the established echeloning standards. Such a conflict situation of parallel objects is called a catch-up (Figure 1.4).

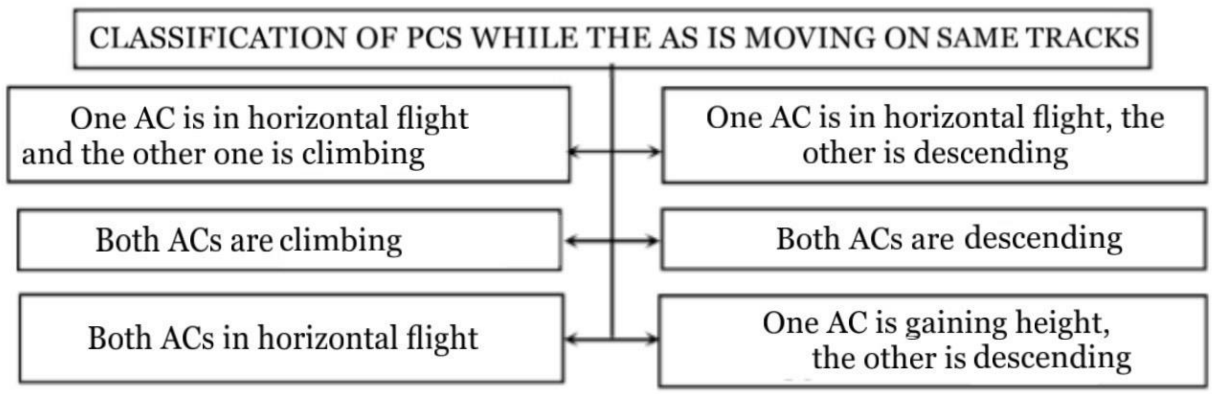

Figure 1.4 - Potential conflict situation when driving a PC on same tracks

b) the objects are moving toward each other along the same route. This is the situation of oncoming objects (Figure 1.5).

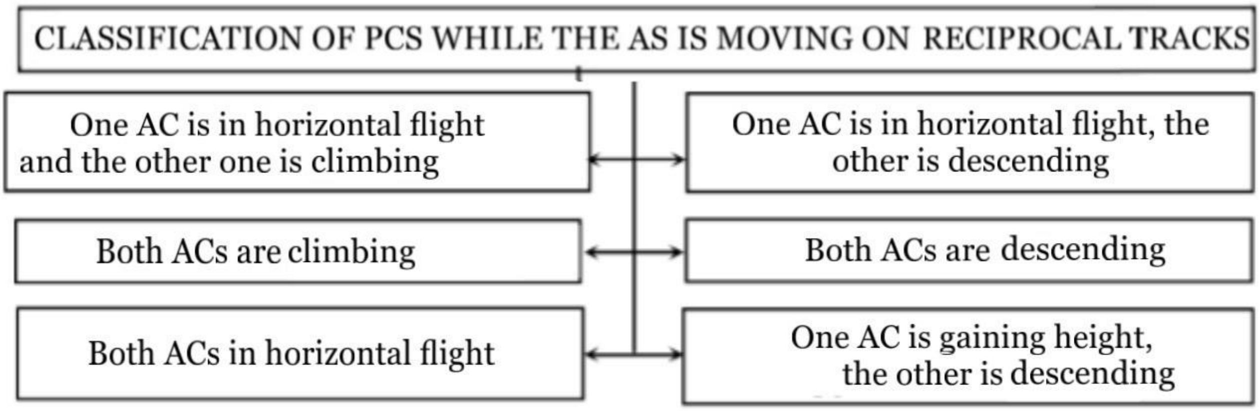

Figure 1.5 - Potential conflict situation when driving a PC on reciprocal tracks

The first, fourth and sixth situations are the most common in ATC practice. The third situation is almost never encountered and deserves attention only because the controller must know that if it occurs, it is necessary to immediately separate the PCs to different flight levels. The second and fifth situations occur less frequently. When each of these situations occurs, it is necessary to determine whether it is a conflict situation, and if it is, to separate the PCs.

c) The objects move along intersecting routes, and therefore there is a possibility of their collision at some height point. This is the situation of intersecting objects (Figure 1.6).

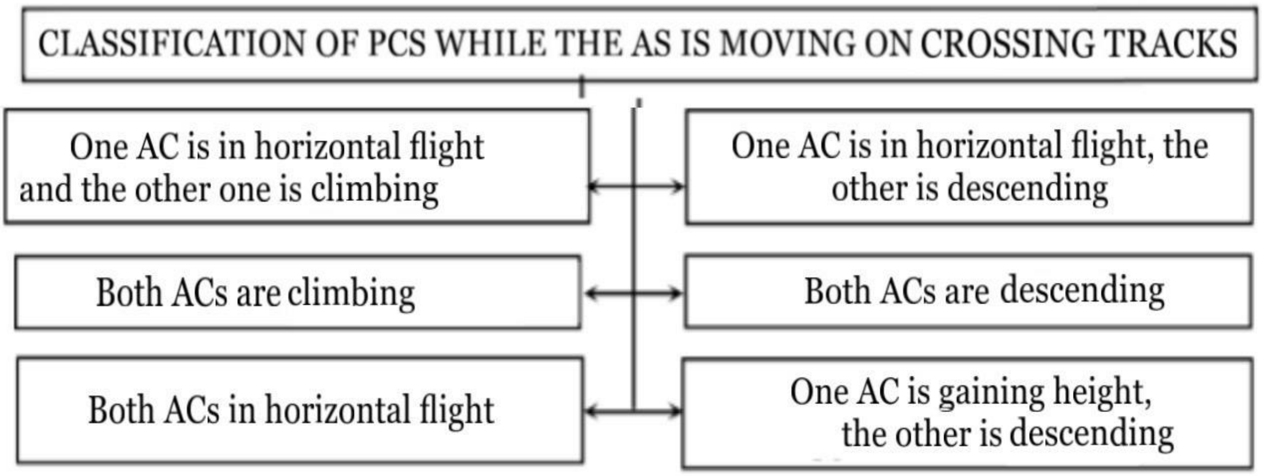

Figure 1.6 - Potential conflict situation when driving on intersecting PC tracks

All six situations arise in areas where routes intersect and are of practical importance to the dispatcher's work. The third situation is the simplest and most frequently encountered, when both PCs are flying horizontally. The other situations are less common, but they must be handled correctly.

d) the generalized situation involving more than two objects [8].

All types of conflict situations described in this paper require immediate and unmistakable intervention by the ATC dispatcher and calculation of options for diverging and avoiding a collision. The possible consequences of incorrect, untimely or erroneous operation of one of the links in the ATC system can lead to large losses.

1.4 Overview of typical conflict situations on free routes

An overview of typical conflict situations on free routes may include various scenarios that may arise in space not controlled by air traffic controllers or a control center. Free routes, also known as the uncontrolled area, can be particularly vulnerable to conflict, and it is important that pilots have a clear understanding of the rules and procedures in these situations. Below are some typical conflict situations:

a) Approaching aircraft

1) Scenario: two or more aircraft approach each other at a dangerous distance;
2) Possible causes: insufficient visual observation, incorrect position determination, insufficient use of radio or navigation systems.

b) Loss of connection:

1) Scenario: loss of communication between the aircraft and the control point or other aircraft;
2) Possible causes: technical malfunctions in radio equipment, incorrect equipment settings, interference with radio frequencies.

c) Incorrect height:

1) Scenario: The aircraft climbs or descends to the wrong altitude;
2) Possible causes: piloting error, incorrect altimeter setting, incorrect altimeter reading.

d) Incorrect course adjustment:

1) Scenario: An aircraft deviates from its route;
2) Possible causes: piloting error, incorrect autopilot setting, influence of atmospheric conditions.

e) Conflict with other PSs:

1) Scenario: An aircraft enters a conflict situation with another aircraft;
2) Possible causes: incorrect actions of the pilots, incorrect prioritization between vessels, small distance between them.

f) A large number of aircraft in a limited area.

1) Scenario: a large number of aircraft enter the designated area almost simultaneously;
2) Possible reasons: a short time interval between flights, insufficient coordination of flights in the area, and a large amount of air traffic.

g) Unauthorized entry into a restricted area:

1) Scenario: An aircraft enters an area controlled by an air traffic control center or other aviation service;
2) Possible causes: navigation error, misunderstanding of service boundaries, technical problems.

h) Violation of the established distances between the aircraft:

1) Scenario: two aircraft are not at a sufficient distance from each other;
2) Possible causes: incorrect distance determination, small discrepancy in radar readings, error in visual distance assessment.

i) Navigation error:

1) Scenario: The aircraft provides incorrect coordinates or navigation data;
2) Possible causes: technical problems with navigation equipment, insufficient knowledge of pilots on the use of navigation aids.

j) Problems with convergence in the vertical plane:

1) Scenario: two aircraft moving in the same vertical space.
2) Possible causes: piloting error, incorrect autopilot setting, incorrect altitude determination.

Resolving these situations requires the accurate use of all available surveillance tools and equipment, compliance with safety standards and procedures, and effective communication between pilots and ATC.

Conclusion to Chapter 1

Air Traffic Control (ATC) as a component of Air Traffic Services (ATC), which is a direct interaction between the air traffic controller and the crew of the aircraft, as well as other services (meteorological, technical and aerodrome).

The main tasks of the ODA are:

a) preventing aircraft from colliding with each other in the air, on the apron and on the runway, as well as preventing aircraft from colliding with obstacles;

b) accelerating and maintaining an orderly flow of air traffic;

c) providing the necessary information and assistance to the EPS in emergency situations;

d) ssuance of other necessary information (meteorological, radio engineering, etc.).

It is the first task that carries the greatest danger. After all, if all components of aircraft control, including electronics, are not coordinated and the technology is not properly understood, air crashes occur, which cause a large number of victims and irreparable damage to the environment. ATC controllers, using air traffic control equipment, radio equipment (radio stations, direction finders, etc.), continuously monitor the air situation and identify potentially conflicting situations (situations where there is a threat of aircraft crashing in the same place, at the same flight level, at the same time).

One of the most important reasons for dangerous collisions with aircraft is that the controller makes decisions about predicting and identifying conflicts based on incomplete information in a time-limited environment.

CHAPTER 2

EXISTING METHODS OF PREVENTING CONFLICT SITUATIONS

2.1 Analysis of causes and factors leading to conflict situations

The problem of mid-air collisions is as old as aviation itself. Despite the supposed boundlessness of the airspace, airplanes have always been cramped in the air. This narrowness was especially noticeable at the beginning of the rapid development of jet aviation, when the civilian air fleet began to grow at an accelerated pace. Even now, in an age of high technology and innovative progress, there is a real columnar formation in many parts of the world's airspace. It is quite clear that the greater the number of traffic participants, the more likely it is that an unpleasant encounter will occur at some point, and that this encounter may result in a conflict situation.

Let's look at the most common scenarios of conflict and the contributing factors that usually play a role in the accumulation of such events.

Conflicts with related sectors.

The loss of separation with related sectors usually means that standard procedures were not followed or something went wrong with the approval of a non-standard solution. The most common scenarios:

a) Correct coordination but wrong actions - a joint conflict resolution was agreed between the two controllers, but the transmitting controller could not guarantee that the aircraft would comply with it. Examples:

1) the clearance was issued too late - for example, the aircraft had to descend, but the clearance was issued when the aircraft could no longer reach the agreed level at the border, creating a conflict with another aircraft in the next sector;
2) inappropriate or unexpected performance of the ATC aircraft - for example, the aircraft was unable to reach the designated level before the boundary due to performance limitations, and the transmitting controller did not coordinate with the next sector. As a result, the aircraft was still gaining slow speed and collided with another aircraft shortly after the boundary.

b) Incomplete or misunderstood coordination - there was a miscommunication between the ATCs, resulting in each ATC having a different plan for the situation. Examples: ambiguity - a reference to "traffic on FL 380", although there are two or more aircraft that match the description.

c) Expectation bias - for example, the transmitting controller expects the conflict to be resolved by manipulating aircraft A, while the receiving controller requires that it be aircraft B.

d) Incorrect plan - all approval procedures were followed, the phraseology was clear and unambiguous, but the plan itself was flawed. Examples: as a result of the coordination, the aircraft crossed the airspace of a third party, and none of the controllers bothered to notify the third party; coordination resolved the conflict, but gave rise to another, even worse one.

e) No coordination - coordination should have been performed, but the transmitting ATC dispatcher either forgot or did not find it necessary to do so. Examples:

1) ATC did not recognize the need for coordination - for example, the upper sector had just been opened and an aircraft from the lower sector requested a climb. The controller (who had been in control of the entire airspace some time ago) allowed the aircraft to enter the upper sector without coordination;
2) the ATC dispatcher knew they should have started coordination early on, but forgot about it, for example because they were too busy;
3) the controller knew they should have coordinated but chose not to because the situation seemed safe (even though it was not) - e.g., the ATC controller scanned the traffic of the other sector and found no threats. The conflicting aircraft was not noticed because of its color representation (e.g., a dark gray label on a black screen);
4) dispatchers did not have time to coordinate due to the heavy workload. As result, the two sectors took uncoordinated actions to resolve the conflict, which led to the creation of a new conflict.

f) Improper application of standing agreements or procedures - the standard procedure set forth in the manual or agreement was not followed. Examples:

1) the transmitting controller did not notice the A380 overtaking the B733 and moved them both to the same echelon. Shortly thereafter, minimum echeloning was violated and the receiving controller was unable to respond due to poor radio coverage in the area;
2) two controllers moved the aircraft to their side too close to the border. Although each aircraft remained within the airspace of the respective controller, the minimum echeloning was violated;
3) the controller should have transferred the two aircraft at different levels (as stipulated in the letter of agreement, since the points of control transfer were too close to each other), but for some reason did not do so;
4) SAR without RVSM (civil) was transferred between FL 290 and FL 410.

Contributing factors.

A number of factors (which might otherwise be considered safe or insignificant) can contribute to an event if they are combined in a certain way. The most common ones are:

a) Too early handover of the aircraft - this results in the controller providing ATC in the airspace of another controller for a relatively long period of time without the necessary tools, competence or situational awareness. Possible consequences:

1) receiving an aircraft on a frequency gives the controller the ability to significantly change the crossing point. This can cause a conflict in the transmitting controller's airspace that the receiving controller does not even think is possible;
2) depending on the implementation of the system, it is possible that tools (e.g., MTCD) only work in the area of responsibility. Thus, system support for conflict detection before an aircraft crosses the border may be limited;
3) The receiving controller may not have the necessary competence to provide ATC in the airspace of the transmitting controller. They may not be familiar with the local conditions (e.g., hotspots);

4) The receiving controller may not be fully aware of the situation in the transmitting controller's sector (e.g., activated special use zones, aircraft without transponders, military aircraft, etc.).

b) too late handover of the aircraft - as a rule, the aircraft should be handed over 1-2 minutes before crossing the border. However, for various reasons, it is possible that the handover took place just across the border or even after it has passed. Possible consequences:

1) sometimes hotspots in the sector (especially in the [Free Route Airspace] environment) are too close to the border. Too late a handover may limit the ability of the receiving controller to resolve the conflict;
2) Handing over an aircraft after crossing the border is also a situation where the controller provides ATC in airspace where he should not do so, similar to the situation of too early handover;
3) in the event of poor radio coverage, it is possible that communication cannot be transmitted, resulting in loss of communication (and possible disruption of echeloning in RVSM airspace):

c) an incorrect frequency provided (or read) by the pilot can lead to various complications depending on the circumstances, for example:

1) controllers in the receiving sector are unaware of the flight crew's intentions (for example, if they received permission for a direct flight shortly before the transfer);
2) controllers in the receiving sector cannot issue urgent instructions to the crew;
3) prolonged loss of communication if the pilot is unable to switch to the correct frequency for a long time, for example, the pilot cannot establish communication on the previous frequency to get the correct frequency of the next sector.

d) Sector clipping (an aircraft flying through a sector in a very short period of time, usually less than a minute) usually results from controllers wanting to skip a "short" sector and avoid unnecessary frequency changes. However, sometimes the definition of "short" becomes too stretched and a sector is skipped when it should not have been (e.g., the controller does not notice the aircraft there because of its dull color representation).

e) Too much workload - this can lead to incomplete situational awareness or neglect of lower priority actions (e.g., handing over control), which in turn can lead to

1) transferring control too early or too late (not when it is appropriate, but when time allows);
2) Incorrect assessment of the situation (inability to notice a potential conflict);
3) is unable to find time for approval;
4) reduced quality of feedback (the controller hands over the aircraft and moves on to the next task without actually hearing the pilot's feedback).

f) Too low a workload can lead to distraction and negligence, which in turn can lead to the following consequences:

1) The aircraft may be handed over too early (so that the controller feels that his job is finally done);
2) The aircraft may be handed over too late (for example, the controller was engaged in other activities and did not pay due attention to one aircraft on the frequency);
3) neglect or failure to identify the need to coordinate with related sectors;
4) a false sense of security.

g) Hidden mark - a combination of different colors, overlapping marks, and a heavy workload can easily lead to the fact that the ATC dispatcher does not see the mark properly, which can lead to, for example:

1) inability to identify the conflict due to partially hidden information (speed, level);
2) Failure to identify the need for coordination (e.g., that the aircraft will not be able to reach its designated level before the border);

3) misinterpretation of points and velocity vector, especially in congested conditions, and transferring the aircraft back to the previous sector or failing to transfer an aircraft leaving the airspace.

h) Wrong/inadequate plan - the lack of an adequate plan can lead to last-minute mistakes, which can prevent timely decisions by the neighboring sector to resolve the situation, for example:

1) a sharp turn that creates a conflict with another aircraft;
2) permission for a direct route that, for example, violates a special use zone or airspace of a third party [9].

Here are the actions aimed at anticipating and preventing the emergence of these conflict situations.

Regular structured scanning is a major part of ATC's job. Bjyf involves repeated checks of the situational display and flight data to correctly identify conflicts.

System-supported coordination - System tools that support coordination (e.g., electronic offers and counter-offers, airline transfer assistance, etc.) can make the coordination process easier and more standardized.

Harmonization of phraseology and procedures - Strict adherence to standardized phraseology and procedures reduces the possibility of misunderstandings.

Medium-term conflict forecasting tools with route updates

Short-term conflict study - this method contains various tools to check whether the permit to be issued will cause a conflict.

The Predicted Gap Alert tool is an update to MTCD and STCA that includes enhancements such as updates in case of flight deviation from the expected trajectory or inclusion of flight crew intentions via a downlink.

Compliance monitoring tools - tools for monitoring the compliance of the planned and executed flight path and providing warnings in case of discrepancies.

Mitigation actions aim to reduce or eliminate the impact of a problem **once it has** occurred. These are general actions that do not relate to the identification of conflict with related sectors. Therefore, they will only be listed without detailed explanation:

Regular structured scanning - can potentially resolve the situation after, for example, a controversial permit has been issued.

Operational TRM - a colleague's warning can be a very effective way to identify and resolve a conflict situation.

Short-Term Conflict Alert (STCA) is a system tool that warns the dispatcher of an imminent loss of disconnection.

ACAS is an on-board equipment that warns pilots or advises them to take appropriate action to avoid a collision.

2.2 Study of means and methods of conflict prevention

Ensuring flight safety is largely related to the task of preventing aircraft collisions in the air. Currently, this task is assigned to the ATC system's dispatch service, the aircraft crew, and onboard collision avoidance systems. However, as air traffic volumes continue to grow, ATC and aircrews face increasing difficulties in preventing dangerous mid-air collisions. And the technical means and collision warning systems installed on board aircraft no longer meet modern requirements and do not provide the necessary level of flight safety.

Visual methods used during flights do not provide the necessary flight safety, because even with very good visibility, pilots in some cases detect an oncoming aircraft when there is not enough time to perform an evasive maneuver. In addition, visual methods are associated with subjective errors in determining the range to the aircraft, its speed, and assessing the degree of collision danger [10].

The existing ATC system, due to the overload of the control personnel arising in the process of control and some limitations of technical means, also does not fully ensure control over compliance with the specified navigation parameters by each aircraft flying according to the instruments. In addition, the ATC system does not allow for control of flights in the entire airspace, especially at low altitudes and in areas that are difficult to observe (mountains, tundra, poles, oceanic areas, etc.).

A very effective means of improving the reliability and efficiency of ground-based ATC services is the automation of flight control and management processes, the use of more advanced radar systems, computer systems, and information display systems. Automation of ATC systems is the basis for the development of ground-based air traffic control, and their implementation today significantly improves the efficiency and safety of air traffic, reducing the workload of controllers and pilots. At the same time, the automation of flight support processes and the improvement of radar equipment cannot sufficiently prevent dangerous convergences on highways with heavy traffic in remote areas, as well as during intercontinental flights [11].

When considering the problem of preventing aircraft collisions in the air, two concepts are distinguished: dangerous approach and collision.

Dangerous approach is defined as a situation where aircraft approach to a minimum distance when it is still possible to prevent a collision by evasive action.

A collision is defined as a situation in which aircraft have approached a distance equal to or less than the safe separation distance. There are several modern aircraft collision warning systems [12].

Today, to reduce the risk of aircraft collisions, a system for preventing dangerous airborne convergence of aircraft is used - TCAS (Traffic Collision Avoidance System). There are different versions of this system. ICAO recommends using the TCAS II system, as it fully complies with ACAS (Airborne Collision Avoidance System) standards and is installed on most commercial aircraft. The TCAS II system can detect aircraft at a distance of up to 40 miles, provides information about the air situation and direct recommendations for resolving a conflict situation. The system can simultaneously track up to 30 aircraft and issue conflict resolution commands for three of them at the same time.

TCAS has a number of significant limitations:

- the ATC system does not receive instructions issued by the aircraft's TCAS, so air traffic controllers may not have enough information and may give conflicting instructions, which causes uncertainty in the actions of the crews;

- For the TCAS system to work effectively, all aircraft must be equipped with this system, as they detect each other by the defendants;

- the system cannot detect aircraft that are not equipped with transponders. If the sensors of a conflicting aircraft do not provide altitude data for some reason, the TCAS may not identify it on the display;

- In order to resolve the conflict situation, the system issues commands for maneuvering only in the vertical plane, while horizontal maneuvers are still impossible for it.

Within the framework of the iFly project [13], Eurocontrol has attempted to develop a new onboard safe separation system ASAS (Airborne Separation Assurance (Assistance) System) is an onboard system that allows the crew to maintain safe aircraft separation and provides the necessary air traffic information. One of the basic functions of ASAS is to improve the crew's situational awareness by providing them with all the necessary information about the air traffic around their own aircraft to make correct and timely decisions on ensuring the formation with other aircraft.

The project envisages that the distance between aircraft will be reduced, which, in turn, requires the development of a system to prevent aircraft from entering the wake. ASAS algorithms have not yet been standardized in general. This is due to the complexity of the transition to new principles of distribution of responsibility between the controller and the pilot to support the safe echeloning of aircraft, which can be attributed to the main drawbacks of the system.

Let's also consider the technology of broadcasting automatic dependent surveillance ADS-B (Automatic Dependent Surveillance - Broadcast), which is an advanced method of ADS (Automatic Dependent Surveillance). ADS-B technology, which is currently being implemented in the United States and other countries, allows pilots in the cockpit and controllers at the ground station to see aircraft traffic with greater accuracy than previously available and to receive air navigation information [14].

ADS-B also provides real-time weather information to pilots. This information greatly enhances the pilot's situational awareness and increases flight safety. In addition, access to ADS-B information is free and open to all. Any user in the air or on the ground within the range of radio transmission can process and use this information for their own purposes. In addition, this information can be used not only by ground-based ATC services, but also by on-board ACAS (Airborne Collision Avoidance System) systems.

However, there are also disadvantages of ADS-B:

- the absence of any security features during data transmission;

- the ability to send fake data or replace information in data packets;

- The party receiving these packets cannot be sure of the authenticity of the packet or the sender's identity.

Currently, to solve the problem of collision prevention, it is considered technically and economically feasible to supplement the ATC system with a special onboard airborne collision prevention system capable of autonomously, independently of the ATC system, in real time, ensuring safe separation of aircraft in the event of a collision threat [15].

This was done for this purpose:

- measurement of location coordinates and motion parameters of objects;

- prediction by means of simulation modeling with a given discreteness of the possible position of objects after a certain time of detection of a collision threat;

- information exchange with objects to warn of danger and coordinate their maneuvers to avoid a collision;

- ensuring the implementation of an automated process for resolving a conflict situation.

These are the functional and programmatic tasks that underlie the new system for resolving dynamic aircraft conflicts to organize decentralized air traffic control in the current conditions of airspace security.

The basis of the developed method is the task of ensuring guaranteed prevention of aircraft collisions in a dynamic discharged (with a necessary and sufficient time margin) conflict in real time to improve flight safety in aviation and the efficiency of aviation equipment use.

The task is solved by the fact that the method of preventing collisions of aircraft in a dynamic conflict in real time provides the determination of the coordinates of movement of each of the aircraft in a given area of space. Each aircraft is assigned a conditional zone of uncertainty of its position to take into account possible deviations in location. With the help of network technologies, the data necessary for calculating the predicted (approximated) trajectories of the aircraft at each moment of time are transmitted from the aircraft, provided that the speed, altitude and course are maintained.

Then, the presence of intersection of these predicted trajectories of different aircraft in a given area of space at any given time is determined, which indicates a possible threat of collision (presence of a defused conflict), and if such a threat is detected, the controllability areas (based on all aircraft characteristics) for each of the aircraft are calculated. Based on their comparison, the aircraft or aircraft for which evasive maneuver trajectories are necessary and rational are determined, calculated taking into account the established database with a collection of general rules for evading aircraft in the event of a possible collision threat. In addition, the method is distinguished by taking into account the optimality criterion, namely the global optimum according to the criterion of the minimum deviation of the aircraft from the initial trajectories (the degree of deviation from the route).

After that, the predicted trajectories of the aircraft are calculated along the new trajectories of the evasive maneuver while maintaining a stable speed, altitude and heading to further check the possible intersection of the predicted trajectories of the aircraft and determine possible collision threats. During the evasive maneuver, if necessary, the trajectory of return to the initial trajectory is also calculated.

Let us note a new solution of the developed method:

a) calculation of predicted aircraft trajectories at each moment of time;

b) calculation and accounting of uncertainty zones and controllability areas of the aircraft;

c) taking into account the nonlinearity in the behavior of the PS and the conflict process in general;

d) availability of a database containing general rules for evading aircraft in the event of a possible collision threat;

e) determining the global optimum by the minimum deviation criterion.

This method will provide a guaranteed level of safety during the prevention of aircraft collisions in a dynamic conflict [15].

2.3 Analysis of existing air route planning systems

Systems for planning and using conventional air traffic services routes play a key role in organizing and ensuring airspace safety. These systems are used by ATC and air traffic control centers to efficiently manage air traffic and aircraft routes. The main functions of such systems include:

1. Route planning:

Automated planning systems take into account various factors such as weather conditions, aircraft weight and type, airspace restrictions, current air traffic, etc., and help determine the best routes to reduce fuel consumption and improve flight efficiency.

2. Manage conditional routes:

Systems can automatically identify and assign conditional routes that can be used by aircraft in certain conditions. This allows optimizing the use of airspace and avoiding conflicts between aircraft.

3. Monitoring and control:

The systems allow real-time tracking of aircraft movements, detecting possible conflicts and providing decision-making information to controllers. Automated systems can also delete or modify routes to avoid potential hazards.

4. Interaction with other systems:

ATC systems can interact with other air transport system systems, such as navigation, communications, and ground control, to provide an integrated approach to ATC.

5. Traffic forecasting:

The systems can use data analysis and forecasts to predict the volume of air traffic in different parts of the airspace and plan the work of air traffic control services.

These systems are aimed at improving the efficiency of air transportation, reducing fuel consumption and reducing the negative impact on the environment. They are important for the development of a modernized and safe air transportation system.

Let's take a look at some of the above systems and their key functions.

In the aviation context, a Conditional Route Management System is defined as a system that enables the dynamic assignment and control of flight routes depending on various circumstances, such as weather conditions, airspace restrictions, temporary changes in airport infrastructure, etc.

Key functions of this system:

a) Condition analysis - the system analyzes various conditions, such as weather conditions, airspace conditions, airfield repairs, etc;

b) modified route planning - the ability to generate new routes or modify existing ones in real time to avoid obstacles or optimize the flight plan;

c) Interaction with other systems - integration with meteorological monitoring systems, aircraft maintenance systems and other aspects of air traffic;

d) control over compliance with the rules - monitoring compliance with the rules and restrictions established by aviation authorities and air navigation services;

e) flight efficiency - maximizing flight efficiency by taking into account circumstances that may affect the route.

Examples of such a system are:

1. Flexible Airspace Management (FAM) - Eurocontrol:

Eurocontrol is implementing the FAM system, which allows for a dynamic response to changes in airspace and flight conditions.

2. NextGen - NAS (National Airspace System) - USA:

The NextGen system in the United States includes initiatives to manage conditional routes to optimize airspace and reduce delays.

Rather than slightly modernizing an outdated infrastructure, the FAA and its partners have introduced major new technologies and capabilities that have led to a new way of ATC known as trajectory-based operations (TBO). NextGen efforts ensure the safe introduction of non-traditional users to aviation, such as commercial space transportation and advanced air mobility. NextGen modernizes air traffic infrastructure in the areas of communications, navigation, surveillance, automation and information management. It includes improvements to airport infrastructure, new air traffic technologies and procedures, and enhanced security. NextGen will also help reduce harmful emissions [17].

3. Collaborative Decision Making (CDM) - IATA:

CDM initiatives facilitate interaction between airports, airlines and air traffic services to optimize flights.

Airport CDM (A-CDM) is about partners working together and making decisions based on more accurate and better information, where every bit of information is equally important to each partner. The targeted outcomes are more efficient use of resources and increased punctuality and predictability of events.

The A-CDM concept is divided into the following elements:

Airport CDM Information Sharing - defines the exchange of accurate and timely information between airport CDM partners to achieve common situational awareness and improve traffic predictability. It is the core element of A-CDM and the basis for other airport CDM elements.

The CDM turnaround process - the milestone approach - describes the progress of a flight from initial planning to takeoff with CDM-A by defining milestones to ensure that important events are closely monitored. The goal is to achieve shared situational awareness and anticipate future events for each flight. The CDM turnaround process in combination with the A-CDM information exchange element is the basis for the other A-CDM elements.

Variable time calculation is the calculation and distribution to airport CDM partners of accurate estimates of departure and arrival times to improve block and takeoff time estimates. The complexity of the calculation can vary depending on the needs and limitations of the A-CDM. The goal is to improve traffic predictability.

Joint Flight Update Management - consists of the exchange of Flight Update Messages (FUMs) and Departure Planning Messages (DPIs) between the network manager and CDM-A to provide estimates for the arrival of flights at CDM airports and to improve the ATFM slot management process for departing flights. The goal is to improve coordination between Air Traffic Flow and Capacity Management (ATFCM) and airport operations at CDM-A.

Shared pre-departure sequence - the order in which aircraft are scheduled to depart from their parking lots based on partner preferences. The goal is to increase flexibility, improve punctuality and improve slot compliance by allowing airport partners to express their preferences.

CDM in adverse conditions - joint management of CDM-A capacity during periods of predictable or unexpected capacity reduction. The goal is to achieve shared situational awareness among airport CDM partners, including better information for passengers, in anticipation of a disruption and rapid recovery from a disruption [18].

4. SESAR (Single European Sky ATM Research) - the European Commission. SESAR includes conditional route management to improve the efficiency of European airspace.

Conclusion to Chapter 2

When analyzing the causes and factors that lead to airspace conflicts, it becomes apparent that the development of aviation conflicts is associated with a variety of factors. These factors may include technical malfunctions, improper execution of crew commands, insufficient coordination between aircraft, and airspace restrictions. It is important to identify and resolve these issues to ensure the safety and efficiency of air traffic.

Research on means and methods of preventing conflicts in airspace points to the need for high-tech systems and improved methods of coordination between aircraft. The use of modern technologies, such as automated collision avoidance systems (ACAS), and the introduction of standards for crews can significantly reduce the risk of conflicts and improve overall aviation safety.

When analyzing existing air route planning systems, it becomes clear that they play an important role in ensuring efficient and safe air traffic. The use of modern technologies, such as Conditional Route Management systems, allows for optimized airspace allocation and avoidance of conflicts between aircraft. Continuous improvement of these systems is critical to ensuring the efficiency and safety of air traffic.

CHAPTER 3. PROTOTYPE OF AN INTELLIGENT DECISION SUPPORT SYSTEM

3.1 Objective of the program and its overall benefit

The purpose of the developed program is to create a tool for flight planning in free route airspace, catering to both individual pilots and aviation organizations. The primary goal of the program is to provide effective means for analyzing and optimizing flight plans to avoid conflicts and enhance interaction with air traffic controllers.

To develop an information and advice system designed to provide advice, the following tasks need to be solved:

- research and develop a mathematical model
- formulate the basic requirements for the IPS;
- to choose the tools for the IPS implementation;
- to design the IPS architecture;
- develop the IPS;
- edit and test the IPA;

The program extends capabilities for individual users by offering a range of features:

a) In-Depth Flight Plan Analysis: The system provides a detailed analysis of flight plans, taking into account potential conflicts with other aircraft.

b) Personalized Recommendations: Offering individualized advice on route changes, enabling users to avoid conflicts and ensure an optimal route for their flight.

For Aviation Organizations this program may become an essential tool offering a set of crucial functions:

a) Global Situation Analysis: The ability to analyze a large number of flight plans allows aviation organizations to obtain an objective overview of the overall situation in the airspace.

b) Optimizing Interaction with Controllers: The program highlights specific proposals for optimizing routes, simplifying interaction with air traffic controllers, and ensuring more efficient air traffic management.

This program is designed to enhance the safety of flights and provide optimal routes in free airspace, considering the individual needs of pilots and the requirements of aviation organizations. It becomes a critical tool for achieving high standards of safety and efficiency in the aviation industry.

3.2 Used Data and Program Algorithms

The functionality of the program is intricately woven into the fabric of geographical coordinates and diverse navigation systems, making it a comprehensive tool for flight planning and analysis. Here's a detailed exploration of the data utilized and the algorithms that drive the program:

a) Geographical Coordinates and Navigation Systems:

The program taps into the extensive network of geographical coordinates, leveraging the richness of navigation points. This includes Free Route Airspace (FRA) points and key coordinates from navigation systems such as Non-Directional Beacons (NDB), Very High-Frequency Omni-Directional Ranges (VOR), and Distance Measuring Equipment (DME). The utilization of these coordinates forms the fundamental framework for the program's analytical capabilities.

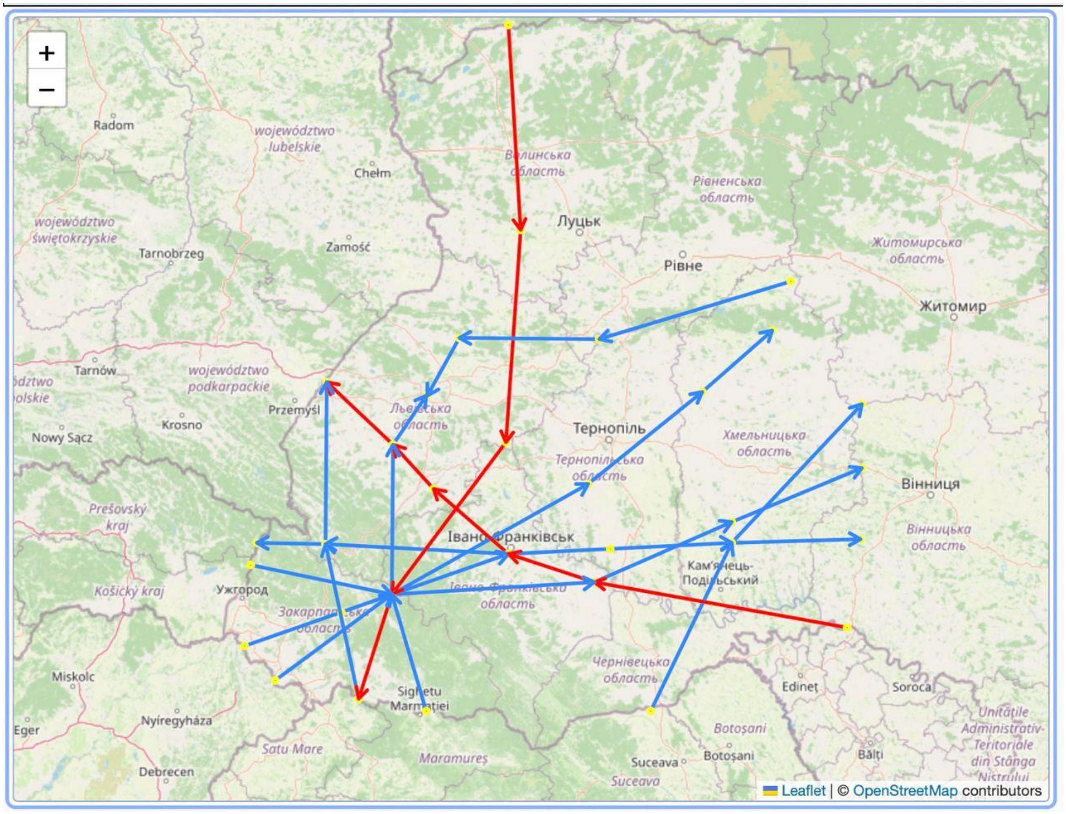

Fig. 3.1 - Route network

b) Input Data and User Interaction:

At its core, the program thrives on user-provided data, which serves as the catalyst for its calculations and assessments. Users input critical information, including departure and arrival times, departure and arrival points, and detailed route specifications in Flight Plan (FPL) format. This user interaction not only personalizes the analysis but also ensures that the program caters to the specific needs of each flight.

c) Predictive Modeling and Rule Compliance:

One of the program's standout features is its predictive modeling capability. It anticipates the potential location of the aircraft based on key parameters such as altitude, speed, and time. This predictive modeling is crucial for proactively assessing the flight's trajectory and identifying potential conflicts or rule violations.

d) Rule-Based Conclusions and Recommendations:

As the aircraft progresses through its trajectory, the program meticulously checks for compliance with aviation regulations. It considers the specific rules of the designated airspace and evaluates whether the flight plan aligns with these regulations. In instances where there is a potential deviation from the rules, the program draws insightful conclusions and formulates detailed recommendations.

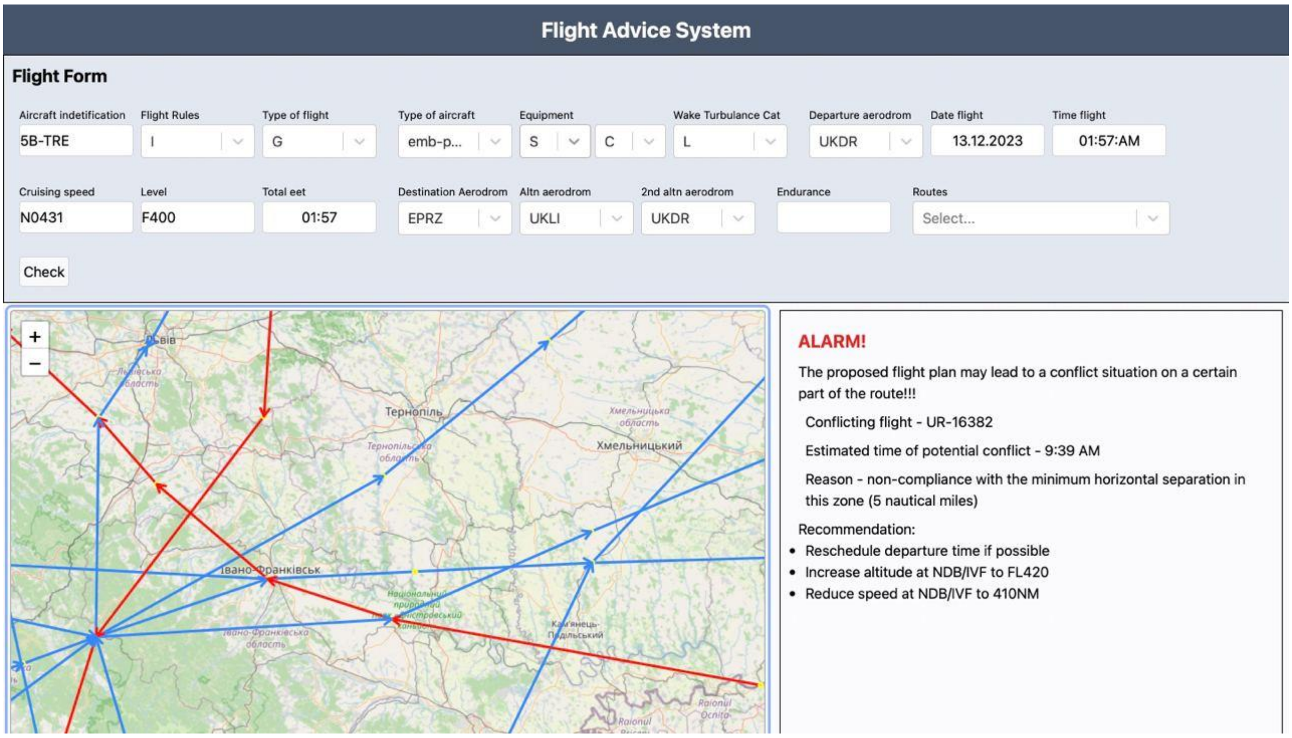

Fig. 3.2 - Example of program advice

e) Dynamic Analysis and Continuous Improvement:

The program doesn't operate in isolation; instead, it engages in dynamic analysis. It continuously monitors the evolving situation and, based on real-time inputs, refines its assessments. This adaptability ensures that the program remains responsive to changing conditions, upholding a high standard of accuracy and reliability.

In essence, this section underscores the program's reliance on geographical coordinates, the richness of user inputs, its advanced predictive modeling, and its commitment to rule-based decision-making. The combination of these elements empowers the program to provide comprehensive and personalized insights, making it an invaluable asset for flight planning and safety optimization.

3.3 Technical Description of the Program (Architecture and System Components)

Functional requirements

	Name	Description
1	Forming a flight plan	The user can view, create and edit a flight plan
2	Displaying an alternative view of the flight plan	The user can view the flight plan through an interactive map
3	Determining the availability of a flight plan	The user can get the result of the system analysis of the flight plan availability
4	Generating flight plan advice	The user can receive and view conflict avoidance advice for the current flight plan
5	Feedback	Users can fill out and send feedback forms

Table 3.1 Functional requirements

Non-functional requirements

№	Name	Description
	Localization of the interface	The system will be able to change the language to Ukrainian or English
2	Simple and clear design	The system will have an intuitive and simple design, simple structure, neutral color, pleasant font and consistency of information provided, etc.
3	System navigation	The graphical interface of the system should have navigation to assist the user
4	Scalability	The system will be adapted for all devices (smartphone, PC, tablet, etc.).
5	Accessibility	Users can use the system anywhere in the world with minimum requirements of their device

Table 3.2 Non-functional requirements

User scenarios:

a) Obtaining a flight plan analysis

1) Description: The user wants to be able to get a conflict analysis of his own flight plan
2) Participants: user
3) Prerequisite: the user has access to the web application
4) Post-condition: the result of the flight plan analysis.

b) Main scenario:

1) Opening the web application
2) Filling in the fields of the flight plan
3) Clicking the confirmation button
4) Notification of a positive analysis result

c) Alternative scenario - flight plan has conflicts with other air traffic

1) Notification of a negative analysis result
2) View flight plan advice
3) Edit the flight plan
4) Press the confirmation button
5) Notification of a positive analysis result

System Components

Component name	Description
Server side	Servers to which requests will be sent for processing
Processing services	Components for analyzing database data
Database	Database that stores the system's data models for processing and use
Database model	Model of tables for databases
Customer side	A website that allows users to send requests to servers
Hosting server	The server on which the system is located

Table 3.3 System Components

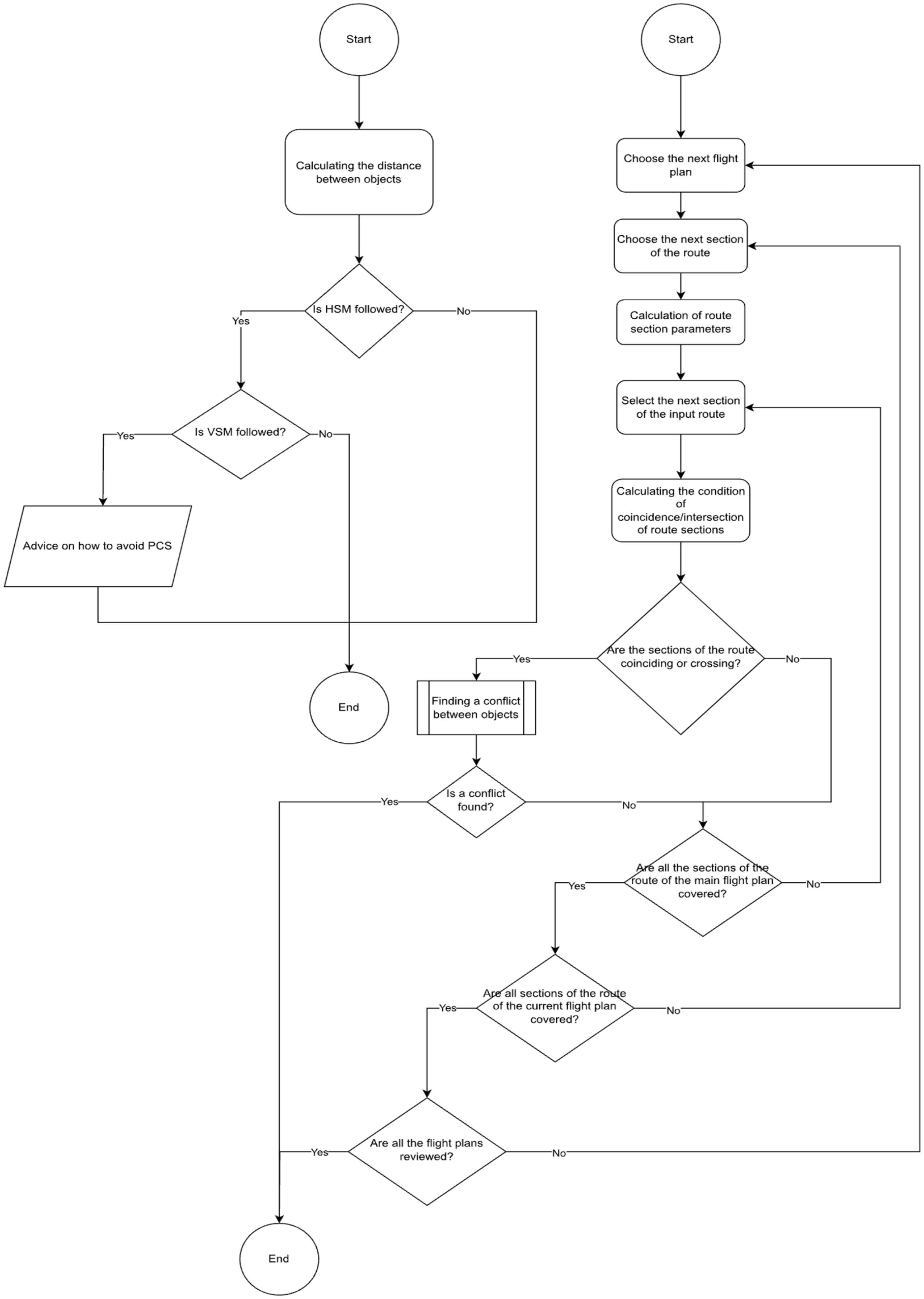

Fig. 3.1 - Algorithm of the system

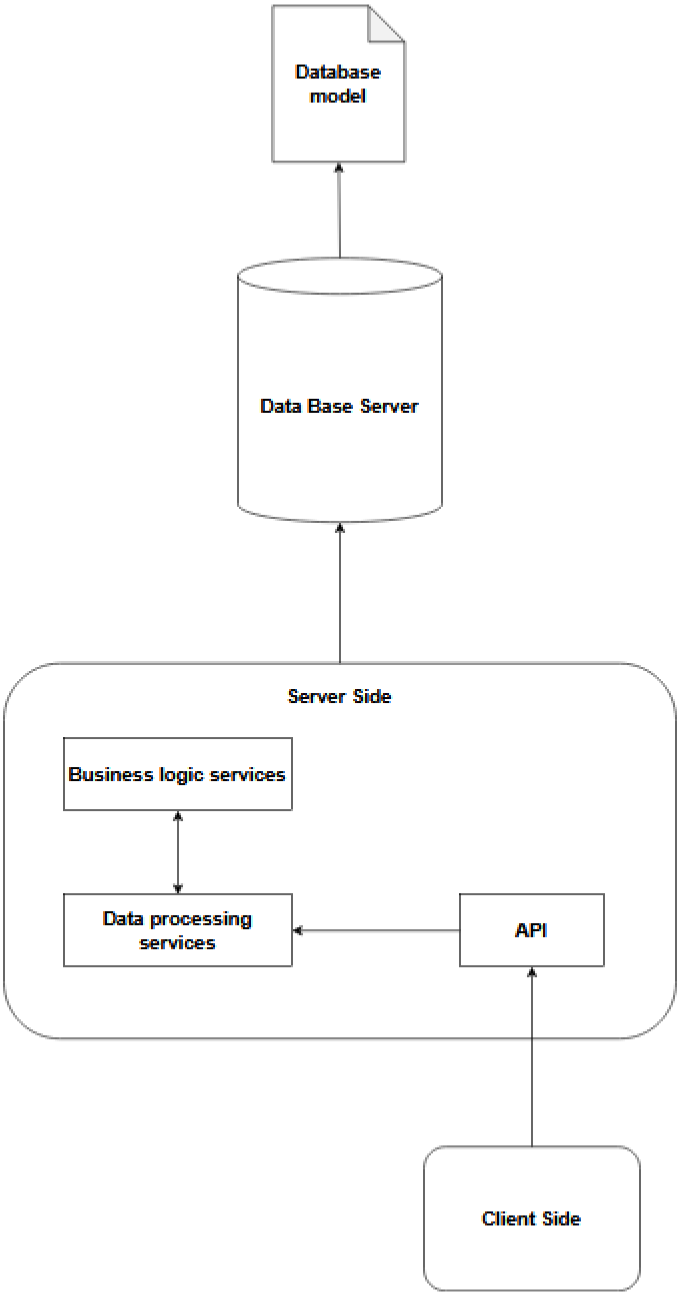

Fig. 3.2 - System architecture

Client-server communication

For this UIS, a client part (websites) and a server part (data processors and service contracts (APIs)) will be created. During user actions on the website, requests will be sent to the API, these requests will be processed, and database queries will be created. Then the necessary information will be transmitted to the user on the website.

The database system will be a relational SQL database, namely PostgresSQL. This DBMS has excellent performance and has a rich functionality.

Database tables can be divided into several groups:

a) Directories: airports, routes, beacons, points, tips;

b) Tables of flight plans;

c) Auxiliary tables;

Client side

For the client side, we will use a framework written in JavaScript - React.js. The Tailwind library will be used to write styles.

Use-case diagram

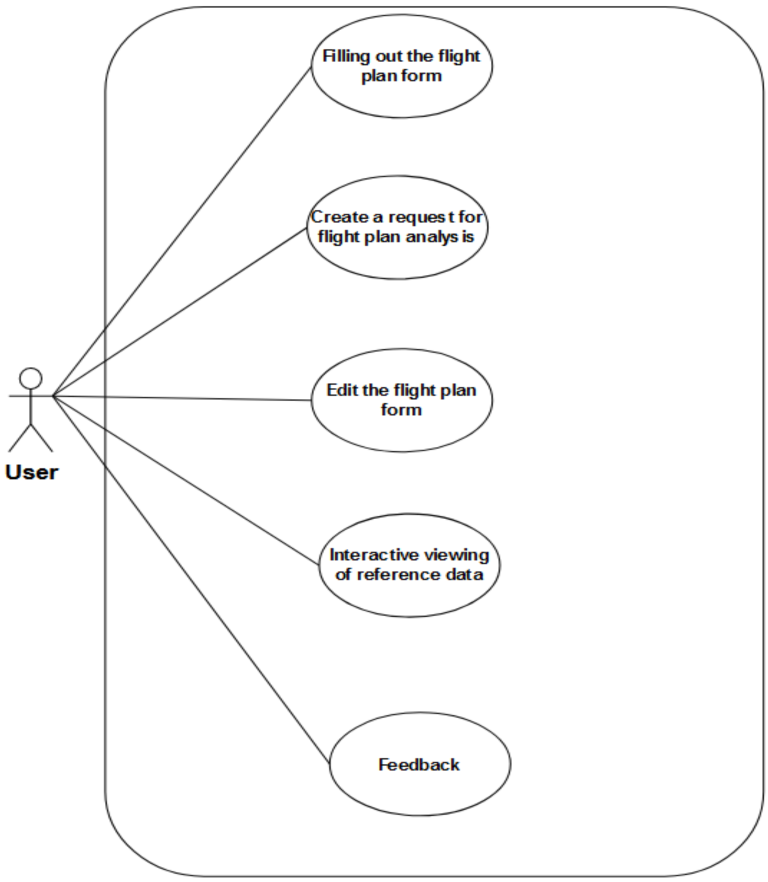

Fig. 3.3 - Use-case diagram

3.4 Expansion Perspectives

The program's potential for expansion goes beyond the realms of Free Route Airspace (FRA), extending its functionality to encompass a comprehensive array of flight stages and diverse data sources. This section elucidates the expansive capabilities and prospects for the program's growth:

a) Comprehensive Flight Stage Control

The program stands poised to evolve into a holistic solution, capable of overseeing all facets of a flight. From pre-flight planning to post-flight analysis, it aspires to provide a seamless and integrated experience for users.

b) Integration of Varied Data Sources

Beyond geographical coordinates and navigation systems, the program is designed to assimilate diverse data sources. Real-time weather conditions, dynamic parsing of online information pertaining to airspace restrictions, and other relevant data streams contribute to a richer, more nuanced analysis.

c) Enhanced Weather Considerations

The program's future iterations aim to incorporate advanced weather considerations. By integrating real-time meteorological data, it seeks to enhance flight planning accuracy by accounting for weather patterns, turbulence forecasts, and other atmospheric variables.

d) Online Information Parsing

A pivotal aspect of the program's expansion lies in its ability to dynamically parse online information. This includes retrieving and processing real-time data on airspace restrictions, regulatory updates, and any emerging factors that may impact flight planning decisions.

e) User-Centric Functionality

As the program matures, a user-centric approach becomes paramount. Future developments envision a highly intuitive and adaptive user interface, ensuring a seamless experience for both novice and experienced users.

f) Regulatory Compliance Enhancements

Continual refinement of the program involves staying attuned to evolving aviation regulations. The goal is to proactively implement updates, ensuring the program remains aligned with the latest standards and compliance requirements.

g) Machine Learning Integration

The program aspires to leverage machine learning capabilities to enhance its predictive modeling and decision-making processes. By continuously learning from patterns and user interactions, it aims to provide increasingly tailored and insightful recommendations.

h) Scalability for Future Needs

A critical aspect of expansion involves designing the program for scalability. This ensures that it can effortlessly accommodate additional features, data sources, and user demands as the aviation landscape evolves.

i) Future Perspectives

This section illuminates the program's potential for expansion, envisioning a future where it transcends its current capabilities to become a versatile, user-centric, and adaptive solution for comprehensive flight planning and analysis.

Conclusion to Chapter 3

In this exploration of the program's expansion perspectives, we envision a trajectory that goes beyond the current horizons, delving into a realm of comprehensive capabilities and enriched functionalities. The program's potential for growth unfolds across multiple dimensions, each contributing to a holistic and sophisticated aviation solution.

User-Centric Innovation:

The envisaged expansion recognizes the paramount importance of user experience. By embracing a user-centric design philosophy, the program aims not only to meet but to exceed user expectations. Intuitive interfaces, seamless interactions, and adaptive features will be pivotal in ensuring that the program becomes an indispensable tool for aviation professionals at every level.

Integration of Varied Data Sources:

Diversity in data is the cornerstone of the program's evolution. The vision includes an expanded repertoire of data sources, incorporating real-time weather data, dynamic parsing of online information, and a broader spectrum of navigational data. This approach empowers the program to provide more nuanced and insightful recommendations, enriching the flight planning process.

Technological Advancements:

The program's journey toward expansion is synonymous with technological advancement. Integration with machine learning, scalability for future needs, and the use of cutting-edge algorithms are integral components of this technological evolution. The program aspires not only to keep pace with technological advancements but to be a trailblazer in leveraging them for the benefit of aviation professionals.

Regulatory Compliance and Safety:

As the program expands its capabilities, ensuring adherence to regulatory standards remains a guiding principle. Enhanced features for regulatory compliance, coupled with a strong focus on safety optimization, are integral elements of the envisioned growth. The program aims to be a reliable ally for aviation professionals, offering not just convenience but also a heightened commitment to safety.

Future-Proof Scalability:

The concept of scalability is not merely about accommodating increased loads; it is about future-proofing the program. The design anticipates the evolving needs of the aviation industry and positions the program to seamlessly integrate new features, data sources, and functionalities. This forward-looking approach ensures that the program remains relevant and valuable in the long term.

In conclusion, the program's expansion perspectives represent a dynamic and ambitious vision for the future of aviation technology. By blending user-centric design, technological innovation, regulatory compliance, and scalability, the program aspires to redefine the landscape of flight planning and analysis. The envisioned growth is not just a progression of features; it is a strategic evolution that aims to empower aviation professionals with a tool that is not only sophisticated but also indispensable in navigating the complexities of modern airspace.

CHAPTER 4. AUTOMATED BIG DATA PROCESSING IN AIR NAVIGATION

4.1 Automation tools in the professional activity of flight controllers

In order to effectively perform the duties of the airport's production control service (PDSA) employees, the flight controller's workplace is equipped to varying degrees, depending on the size and volume of the airline's traffic, with SITA, AFTN, GABRIEL, ATC, Internet communication channels; flight planning systems; and aircraft location tracking programs.

Most aviation companies seek to automate the management of production processes and optimize the work of their structural units, including the FBO, relying on software developed by Western manufacturers. These enterprises face expensive and time-consuming implementation of such automated production management systems, as the purchase of a specialized software product often requires training in its operation. And while large air carriers are willing to bear the economic and time costs of optimizing and automating the workplaces of departments and, in particular, the ATC, small charter carriers, as a rule, do not allocate sufficient funds for the continuous updating of the ATC hardware and software base, investing only in absolutely necessary software products and systems, such as SITA, AFTN, JETCOM communication systems, flight planning systems such as JetPlanner, FlightStart (manufactured by Jeppesen), and modules that serve such tasks as maintaining the airline's daily flight plan and tracking airline flights, are currently not widely used by small air carriers in Ukraine. At the same time, the introduction of these modules would greatly simplify and optimize the work of the flight controller and the interaction of airline services, and would increase the level of productivity and safety. [20]

Currently, the daily plan and flight tracking of charter airlines involves filling out a standardized form, created using Microsoft Excel, by the FO dispatcher, which is filled in manually by FO dispatchers with data received from various competent sources (other departments, airport representatives, aircraft crews, ground handling agents) at different times. With the help of standard formulas, automatically calculated fields are filled in as soon as the dispatcher has filled in the corresponding cells. The remaining fields are filled in manually. This method of maintaining a daily plan is the simplest computerized method. The information for such a plan flows into the ATC from various sources through all available communication channels - AFTN, SITA, telefax, and oral reports. As a rule, in small charter airlines, the number of ATC controllers per shift ranges from one to two people, which requires the highest possible attention of the employee(s) to the entire range of tasks. The performance of the duties of the air traffic controller is even more complicated with a seasonal increase in the number of flights in the spring and summer, the presence of non-standard situations requiring special attention and prompt action, and thus the primitive computerization of the air traffic controller's activities serves as a prerequisite for the suboptimal use of human resources, the admission of mechanical errors and delays in the transfer of information to other interested services and departments of the airline, which in turn can lead to flight delays, and hence the formation of negative [20].

Today, there is a fairly wide range of systems that include a module for maintaining a daily flight plan and optimize the interaction of the services involved in flight operations. However, small charter carriers do not find them economically viable investments.

4.2 Overview of software modules for flight control

APM SmartOps Module

The SmartOps software module was developed by APM Technologies SA and is part of a system of modules for financial modeling and flight performance control. The SmartOps module has a wide range of functionality and is a high-graphic quality window that provides the user with extensive information about flight operations. The system is capable of transmitting and receiving standard IATA messages (SSM, ASM, MVT, LDM) via SITA and e-mail, and aircraft movement messages are transmitted via the SmartTelex application, which is part of the system. This ensures timely updating of information on actual departures, arrivals, and returns and generates clear color-coded alerts. The system imports flight schedules from the SchedulePlanner module. The graphical display also allows you to control the rotation of aircraft in the fleet. Another of the many features of SmartOps is the availability of an extensive airport database which, in addition to information about airports, contains information about handling agents and relevant contacts. And finally, SmartOps combines a number of reporting functions, including a flight time report based on actual and planned flight times. For users of Jeppesen flight planning software, there is a function to generate and view Jeppesen FPLs directly on the SmartOps display. Thus, the SmartOps module is a modern, multifunctional and relatively easy-to-use software application that, in combination with other modules of the system, allows for effective control of air carrier flights, ensuring their timely execution. [20]

Let's take a closer look at some of SmartOps' features and functions.

In SmartOps, users are given the opportunity to personalize settings such as the period of information update, automatic or manual update, automatic calculation of flight duration, calculation of aircraft structure wear, monitor settings, and display of graphic material

SmartOps has a search function by flight number according to the specified search criteria. The program allows you to edit the estimated flight time along the route. An example of the window is shown in Figure 4.1. [20]

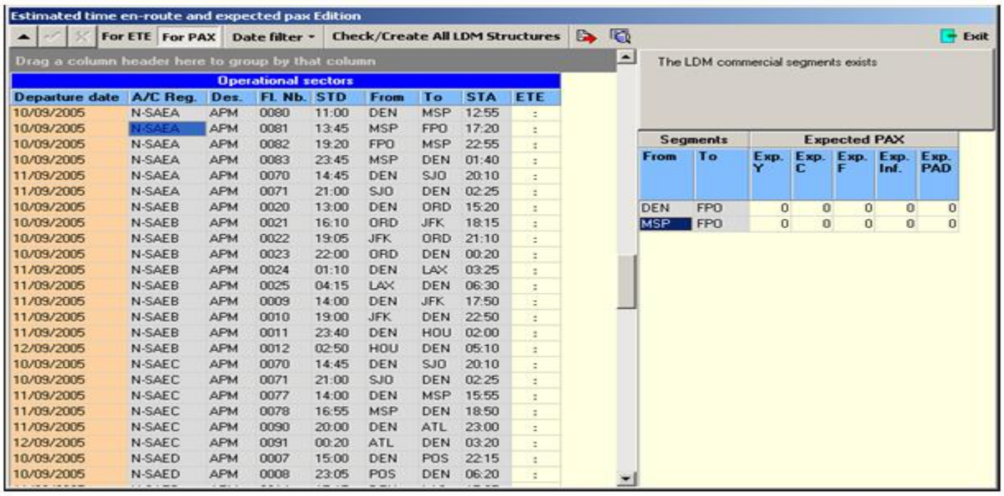

Fig. 4.1 - SmartOps window

To do this, click the "Edit" button →

→ Click on the ETE button → Insert the planned flight time for the route for the selected cities (pairs of cities served by the airline)

→ Click Passengers. Here you can generate an LDM (Load Distribution Message)

→ Click Create LDM

→ Insert the expected number of passengers for the flight sector

Note: There are Print and Export outgoing messages buttons,

The program also provides for the generation of ASM and AAS messages.

Messages are sent when the Send button is clicked and the Aviation and Information Technology (SITAtex) related file is sent to the recipients:

- Click Generate - Refresh AAS button

- Creating an AAS update - Date range

- Click Yes

The report is generated in the form of a Gantt chart (Figure 1.2).

- Click the Preview button

- Date range

- Select Time for Sector Information (default group or Local departure and destination airtime)

- Select the Time String view (Show in UTC or in a regular time zone)

- Click Yes. [20]

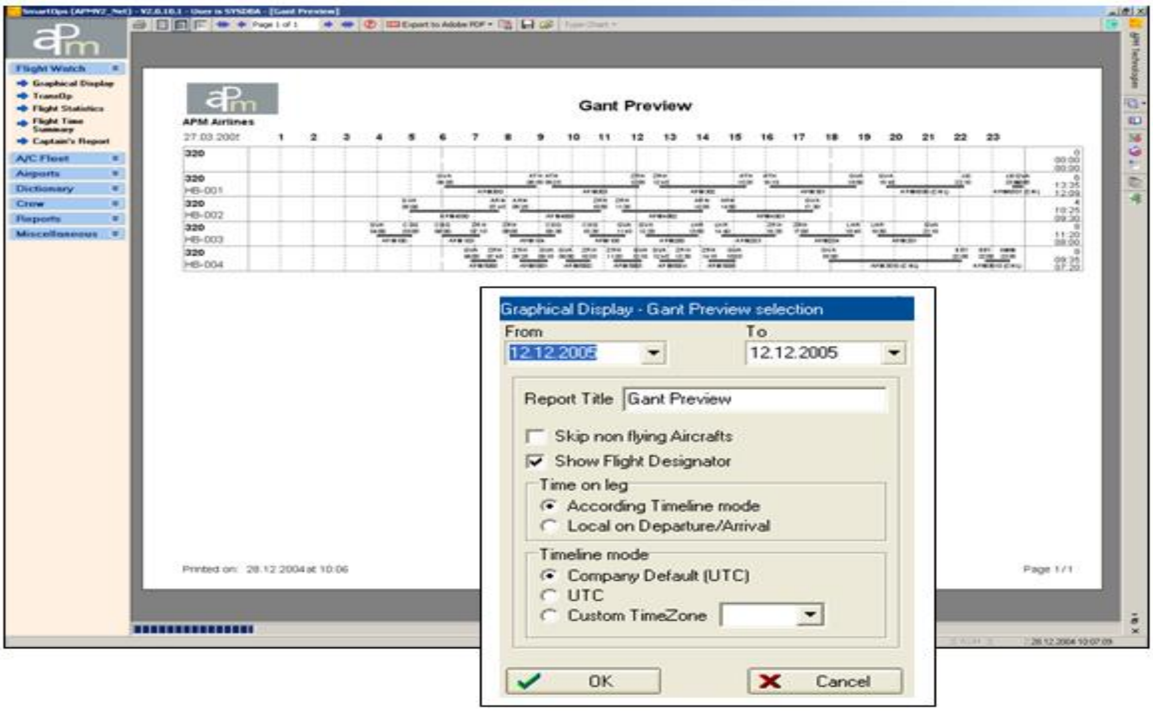

Fig. 4.2 - SmartOps window

The function of viewing the daily flight plan.

- Daily flight plan window (example window Figure 4.3)
- Click the Preview button
- Date range
- Click Yes. [20]

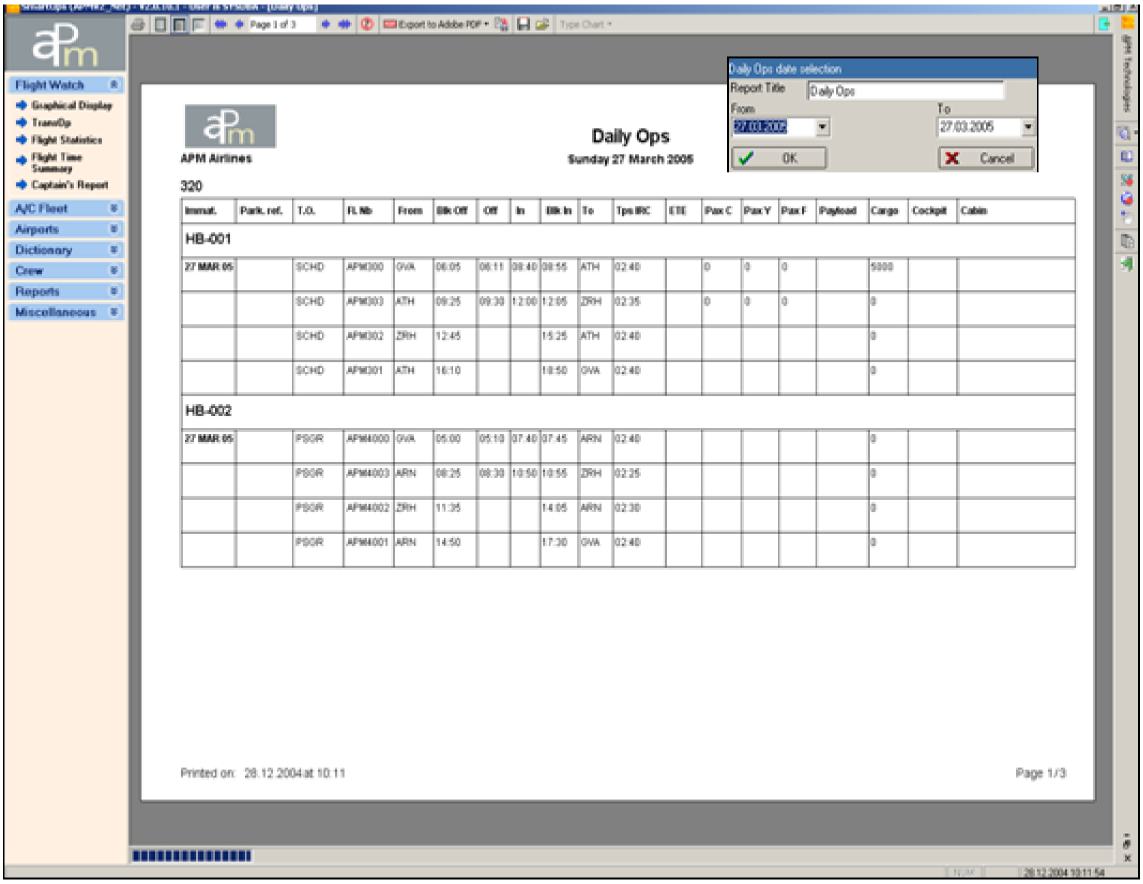

Fig. 4.3 - SmartOps window

The program provides for planning the rotation of troops.

To do this, after selecting the row of the planned BOP, click the "Create" button, then make corrections, if necessary, and confirm this BOP selection.

Enter the call sign, then the flight number, then the departure and destination airports, and the scheduled departure time.

The module also provides the ability to view information on flight sectors, including:

- Information about the flight
- General information about the SAR
- Passenger information
- Cargo

- Fuel
- Summary (short):
- Operational summary (at the sector level)
- Commercial summary (at the sector level)
- Summary of catering services (at the sector level)
- Passenger information (at the sector level)
- Summary of logistics (at the sector level)
- Commercial memo (at the series level)
- Operating instructions (at the series level)
- Memo on logistics (at the series level)
- Information about the crew:
- Displays the position, identification numbers, and names of the crew planned for the selected flight sector.

The program provides fuel calculation by sector. To do this, you need:

- Select a sector
- Press the right mouse button
- Select "Flight sector information"

Then, in the flight sector information window, click "+" to enter:

- Number of the payment document for fuel
- Fuel volume
- Unit of volume measurement
- Weight
- Units of weight measurement
- Name of the gas station

Passenger information - displays the number of passengers and a message about the distribution of passengers by category.

Telex

- Select a flight sector
- Click the right mouse button
- Click "Telex"

- Message log file - A list of all message exchanges for the flight (about the flight)

You can set a filter:

- Filter - All / Arriving / Departing

- Status - -1 = Not sent

The function of generating notifications:

- Select flight sector → "Telex" → "Create"

The module has the function of generating and sending messages about aircraft movement - MVT, automatic generation of requests for SCR airport slots (Figure 4.4).

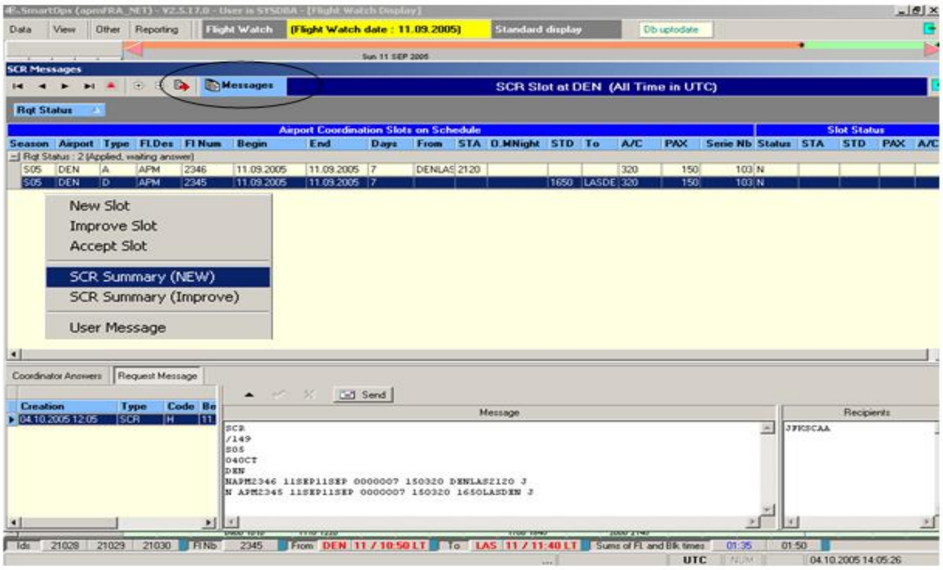

Fig. 4.4 - SmartOps window

You can enter and correct passenger data:

- Select the flight sector

- Press the right mouse button

- Click "Edit passenger data".

When you click the "Request filed FPL" button, the program finds a flight plan for the sector from Jeppesen - OpsControl (the User must be subscribed to these Jeppesen services)

When the user selects the aircraft rotation, the program highlights all sectors of the flight where the aircraft rotation is performed [20]

It is possible to view the flight sector of the same series:

- Select a flight sector

- Click the right mouse button
- Click Show flight sectors of the same Flight series.

The list of crew members on board is displayed.

In this case, all sectors with this crew will be highlighted. However, this feature is only available to APM customers using the CrewLogic APM module or who have purchased the Integration Services inc) package. [20]

It is possible to split the flight sector:

- Select a flight sector
- Click the right mouse button
- Tap Split Flight sector

Similarly, it is possible to combine flight sectors:

The function of delaying selected sectors of the flight is provided:

- Select flight sector (a);
- Right-click the mouse
- Click Delay selected flight sector(s). See the example window in Figure 4.5.

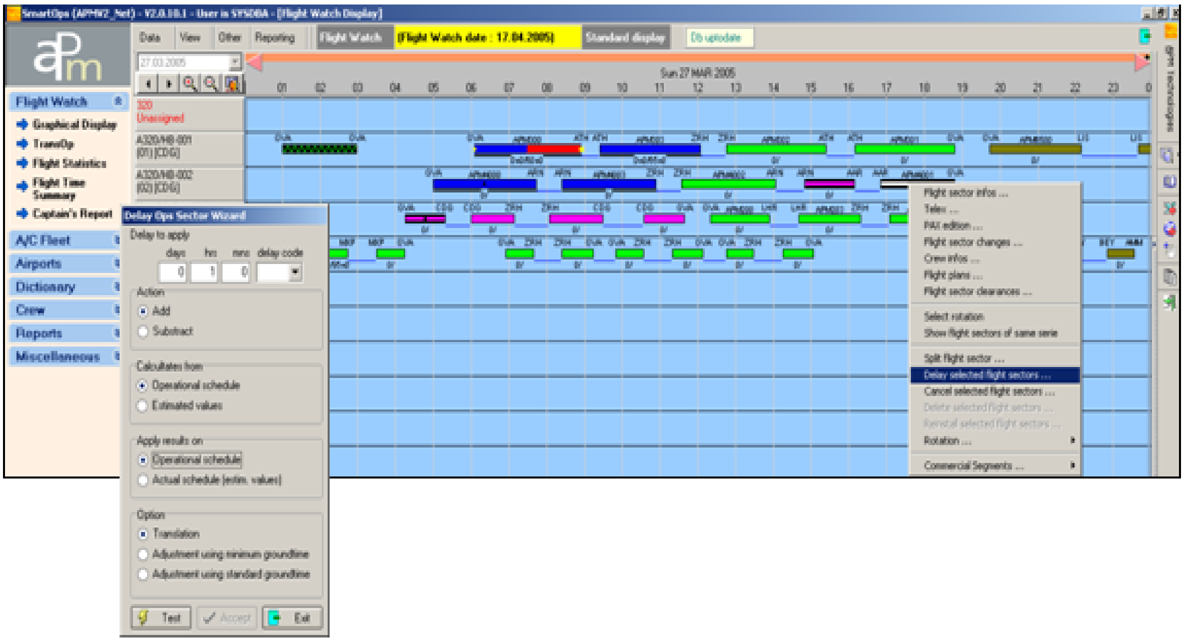

Fig. 4.5 - SmartOps window

- Delay to apply - enter the delay (in days-hours-minutes)
- Delay code - select the reason for the delay
- Add / Subtract - select the appropriate one

- Calculates from - select the appropriate option
- Apply result on - select the appropriate option
- Option - select the appropriate one
- Test - Pressing the button will check the result on the screen
- Accept / Exit - click the button to perform the appropriate action
- Similarly, you can cancel the delay of selected flight sectors:
- Select delayed flights
- Click the right mouse button
- Select "Un-delay selected flight sectors"
- It is possible to cancel selected flight sectors:
- Select flight sectors
- Click the right mouse button.
- Confirm - Click YES. [20]

Note: ASM message RIM, CNL (telegram of flight resumption) is automatically generated by the system.

There is a function to check / compile a report of the aircraft commander. To do this, select Captain's report.

- Selection filter
- Press the Select button
- Select a flight sector from the list
- Double-click the mouse or click the yellow Display detail button
- Click New Search, if necessary
- Flight Log Routing
- Tech. Log - enter the Tech Log ID - (optional)
- Flight Log Group Number - Enter the group number (optional)
- Number of Landings - Enter the number of landings you have made
- Number of "Go Arounds" - enter the number of times you want to go around.
- Over flight route - enter the company's flight route that was used for the flight

- Flight Log - check that the time of flight, ground movement, installation / removal of pads is correct
- Fuel burn - enter the data (only manual entry is possible)
- Delay - check the delay and delay code
- Click the edit button (triangular symbol) to finish/correct the CPS report
- Check the accuracy of the data.
- The Fuel Uplift tab.
- Click "Cancel selected flight sectors"
- Confirm - click YES

And similarly, you can restore the selected flight sector:

- Select flight sector(s)
- Right-click the mouse
- Click Re-install selected flight sector.
- Select the tab
- Click the edit button "+" with the mouse
- Enter the amount of fuel to be refueled
- Check the authenticity.

The PAX Management tab (Figure 4.6). [20]

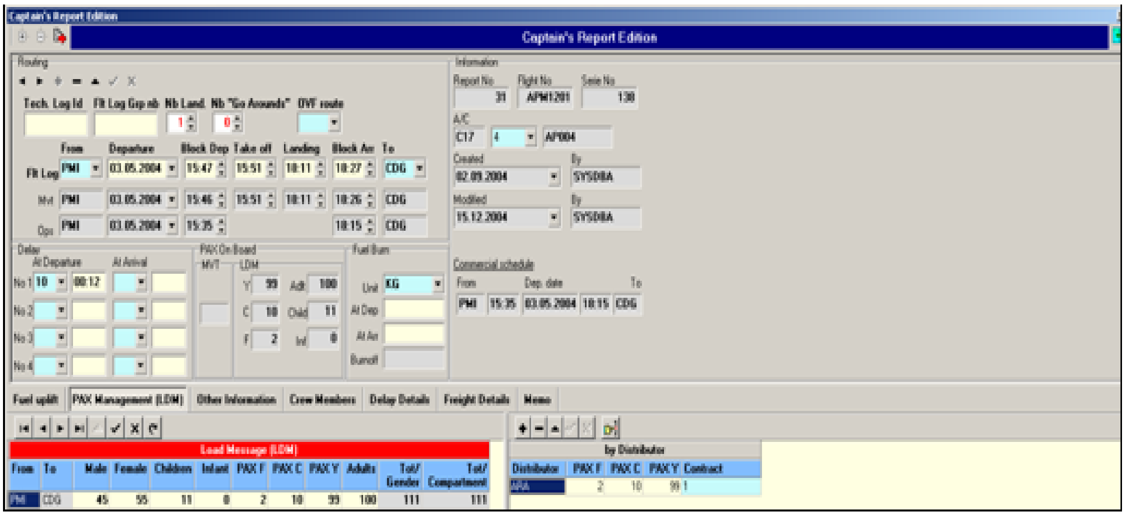

Fig. 4.6 - SmartOps window

Download the message:

- Select a check box

- Click the Edit button
- Check the correctness of LDM messages (telegrams about flight loading)
- Check the accuracy of the data
- Distributor
- Click the edit button "+" with the mouse
- Enter passenger data for each distributor on the flight sector (Data for APM Revenue Planner)
- Check the accuracy of the data.

Thus, the SmartOps module has a wide range of functionality and represents windows of high graphic quality that provide the user with a large amount of information about flight operations, in a timely and virtually error-free manner. However, without purchasing the full package of the system of modules for financial modeling and control of flight operations SmartOps - the module provides very limited functions from the potential range [21].

RM Rocade

The RM Rocade automated system, used by such major Ukrainian air carriers as Aerosvit and Ukraine International Airlines, is a software and hardware complex designed to automate the planning and control of airline flights by allocating the necessary human (aircraft crews) and material (aircraft) resources, including monitoring and making changes at the current and operational planning stages.

The RM Rocade system is organized as follows: data from reference books → entering the seasonal schedule at the seasonal planning stage → entering resources → off-line changes at the current and operational planning stages → combining all of the above in the LIVE worksheet in on-line mode → the current schedule and roster.

The RM Rocade system automates the following production processes:

- creating a seasonal schedule;
- current schedule planning;
- operational schedule planning;
- rostering for the next month at the current planning stage;
- rostering at the operational planning stage.

All types of telegrams (SSM, ASM, MVT, LDM) processed in the RM Rocade system must comply with the IATA format. Telegrams that do not comply with this format or contain incorrect data are placed in a special folder called "Errors" by the message processing module of the RM Rocade system. In order for telegrams from this folder to be processed by RM Rocade, they must be corrected to conform to the IATA format. [20]

The program is available only in English and has no analogues in Russian or Ukrainian.

The RM Rocade system has several sections:

- crew organization system;
- schedule creation system;
- a system for allocating aircraft for flights;
- SLOT;
- a system for keeping statistics;
- operational control system (ROC).

The production processes performed with the RM Rocade system are carried out in the following sequence:

- charter and scheduled flights planned for a given season (data comes from the planning department);
- slots are provided by the ATCs for departures and arrivals (data is received after requests to the ATCs);
- restrictions on the operation of the substation due to scheduled maintenance (data comes from the engineering department).

This data is entered into the program and it automatically assigns aircraft to flights. The draft seasonal schedule is then approved.

Within 3 days, depending on the situation, the PS can be changed, depending on operational maintenance and unscheduled repairs, as well as depending on current and strategic planning. These actions result in the current schedule.

Next, crews and flight attendants are scheduled: personal data about each pilot and flight attendant are entered and crews are automatically assigned to each flight, and changes can be made to these crews manually. As a result of this planning, a crew roster is formed. [20]

At the end of each shift, the statistics department analyzes the flights performed.

In the RM Rocade program, the coordinating controller uses the Operations Control (ROC) section. In this section, you can see the status of each aircraft, whether it is on the ground or in the air. The ROC module will show various warnings about time and station conflicts. Various SITA messages can be sent from the ROC module.

At the beginning of the work, the period of interest is set, from 1 day to 2 months, in order to better and more clearly see the further movement of the aircraft.

Information about the flight status is provided in a color scheme. Data on the color variants and explanations to them, characterizing the status of the aircraft, are presented in Table 1.1 and provide a visual representation and the ability to quickly navigate in case of a delay in takeoff or a long absence of landing and predict possible further flight delays.

When you hover over the flight you are interested in, you can get the following information:

SHEDUEL VV343 03JUL 1155 (1 455) KBP-SSH 1555 (1855) C733 733A URVVI 0/0 / 135-0 / 0/120

Where the following information is provided in the appropriate order: flight status; flight number; flight date; departure time (time is indicated in UTC and local time is given in parentheses); departure and arrival AD; arrival time. The time is indicated in UTC and the local time is given in parentheses; type of service, aircraft type and aircraft registration number; passenger capacity; booked number of seats for passengers on this flight. [20]

Color	Example of LEG	Description
Grey		The flight is not yet in operation
Black		The flight has already been completed
Red-gray	550	According to a given plan, the aircraft should take off
navy blue	610	The aircraft is in the air
Blue-red	610	According to the given plan and calculation, the arrival should land
Light blue	660	The aircraft started moving from the parking lot and the estimated takeoff time was provided
Orange	611	No information on the movement of the aircraft, indicates that information will be provided later
Yellow		Flight delay

Fig. 4.6 - examples of LEG

At his workstation in the Flight Window, the dispatcher-coordinator can perform the following actions:

1. Create a new flight (if you need to create an additional flight or a new route section).

2. Transfer a flight from one type of aircraft to another (when replacing boards).

3. Cancel the flight

4. Edit the flight (change the flight number, destination airport if the airport is in the same city, etc.).

5. Review the crew composition (CCP, co-pilot, flight attendants, technicians)

6. Send a message on flight movement (MVT) via SITA automatically or manually, if MVT or LDM information was received, but "not captured" by the server (perhaps it was given incorrectly in relation to SITA standards).

Using the RM Rocade system virtually eliminates erroneous data entry, allows you to send messages in the standard SITA form, and significantly saves time. [20]

Some of the programs most commonly used by airlines include:

1. ARINCDirect

ARINCDirect is an integrated flight planning and management platform that provides essential functions for pilots and aircraft operators. A brief overview of how to use ARINCDirect for flight support:

1) Route planning:

The system allows you to determine the best route for your flight, taking into account parameters such as distance, weather conditions, airways, and airspace restrictions.

2) Calculation of fuel consumption and time:

ARINCDirect provides accurate calculations of fuel consumption and time, which allows you to effectively manage resources during the flight.

3) Access to navigation data and maps:

The platform provides access to up-to-date navigation data, including waypoints, airways, airfields, and other important elements.

4) Meteorological information and forecasts:

ARINCDirect provides a full range of meteorological information, including current conditions and forecasts, to help you make informed decisions.

5) NOTAMs and special notices:

The system provides up-to-date NOTAMs and other important information for flight safety.

6) Planning alternative routes:

ARINCDirect allows you to quickly and efficiently plan alternative routes in case of unforeseen circumstances.

7) Integration with the Electronic Flight Bag (EFB) for flight crew information support:

The platform supports integration with EFB, which allows pilots to receive all the necessary information in electronic format.

8) Fuel planning and cost tracking:

ARINCDirect allows you to track fuel consumption and efficiently plan refueling [22].

2. PPS Flight Planning.

PPS Flight Planning is a comprehensive flight planning and management system aimed at providing pilots and aircraft operators with reliable and up-to-date information for safe and efficient air transportation. A brief overview of how to use PPS Flight Planning:

1) Planning the optimal route:

PPS Flight Planning provides tools for selecting the best route, taking into account distance, weather conditions, air routes, and airspace restrictions.

2) Calculation of fuel consumption and time:

The platform accurately calculates fuel consumption and time, helping to effectively manage resources in flight.

3) Provide navigation data and maps:

With PPS Flight Planning, the user receives up-to-date navigation information, including clear waypoints, air routes, airports, and other important data.

4) Meteorological information and forecasts:

The platform provides comprehensive weather information, including current conditions and forecasts, to help users make informed decisions during the flight.

5) NOTAMs and special notices:

PPS Flight Planning provides up-to-date NOTAMs and other important information related to flight safety.

6) Planning alternative routes:

The system allows you to quickly and efficiently plan alternative routes in case of unforeseen circumstances.

7) Integration with the Electronic Flight Bag (EFB) for flight crew information support:

PPS Flight Planning supports the transfer of information to the EFB, which allows pilots to receive all the necessary details in electronic format.

8) Fuel planning and cost control:

The platform allows you to monitor fuel consumption and efficiently plan refueling [23].

PPS Flight Planning helps to increase flight efficiency and safety by maintaining a high level of pilot awareness, which contributes to informed decision-making during flight.

A flight management system (FMS) is an onboard multi-purpose computer for aircraft navigation, control and operation designed to provide virtual data and operational coordination between closed and open flight-related elements, from engine pre-start and takeoff to landing and engine shutdown. This system is designed to automate path calculation, fuel calculation, flight planning, and automatic control of the aircraft during flight.

FMS helps pilots to control the aircraft efficiently and accurately during flight, providing important information and automated support for navigation operations [24].

Collision avoidance systems (TCAS) are an important component of aviation safety. They are designed to detect potential mid-air collision threats and provide guidance to avoid these situations. TCAS uses radio systems to communicate with each other and other approaching aircraft. In the event of an unsafe proximity, TCAS provides pilots with specific movement commands (e.g., "climb" or "bank") to avoid a collision.

The collision avoidance system enhances the ability of pilots to detect and avoid potentially dangerous situations that may arise in the air. As a result, it significantly improves the safety of air travel.

Navigation systems (GPS, INS):

GPS (Global Positioning System) is a global navigation system that uses signals from satellites to determine the exact location anywhere on the earth's surface. Among the main components and characteristics of GPS are satellite constellation accuracy and global coverage [25].

In general, GPS is an integral part of modern navigation and geospatial determination, using satellite signal technology to accurately determine a location anywhere on earth.

INS (Inertial Navigation System) is a technological system that provides navigation information independent of external signals. This system uses accelerators to measure changes in aircraft speed and position in space [26].

GPS (global positioning system) and INS (inertial navigation system) help determine the exact location of the aircraft and plan routes.

These are just a few examples of flight support systems that play a key role in ensuring the safety and efficiency of air transportation. Each aircraft may have different configurations and systems, depending on the type of aircraft and its purpose.

Conclusion to Chapter 4

In conclusion, the effective performance of duties within the airport's Production Control Service (PDSA), particularly the Air Traffic Control (ATC), relies heavily on the technological infrastructure in place. The equipment and software used vary based on the size and traffic volume of the airline. Larger carriers often invest in sophisticated systems, such as SITA, AFTN, GABRIEL, ATC, and Internet communication channels, as well as flight planning and aircraft location tracking programs. These technologies contribute to the optimization and automation of production processes.

However, challenges arise for smaller charter carriers that face constraints in terms of budget and resources. The preference for essential software products, like SITA, AFTN, JETCOM, and basic flight planning systems, leaves them with limited investment in updating ATC hardware and software. Unlike their larger counterparts, small charter carriers predominantly rely on manual methods, utilizing standardized forms created in Microsoft Excel for daily flight plans and tracking.

The lack of comprehensive automated systems in small charter carriers results in suboptimal utilization of human resources, potential errors, and delays in information transfer to other airline services. This, in turn, can lead to flight delays and negative consequences. Although various systems are available that include modules for optimizing flight operations, the economic viability of such investments remains a challenge for small charter carriers.

In conclusion, bridging the technological gap between large and small carriers is essential for enhancing productivity, safety, and overall operational efficiency in the air transport industry. The adoption of advanced systems, even on a smaller scale, could significantly streamline the work of the ATC and improve coordination among airline services, ultimately benefiting the performance of small charter carriers in Ukraine.

CHAPTER 5. LABOR AND ENVIRONMENTAL PROTECTION

5.1 Analysis of hazardous and harmful occupational factors during the work of air traffic controllers

In accordance with PCT 12.0.003-74, dangerous and harmful factors are divided into the following groups by the nature of their action: physical, chemical, biological and psychophysiological [26]. Since the air traffic controller's work takes place indoors and in monotonous work, the following hazardous and harmful factors affecting his or her professional activity can be identified:

a) physical hazards and harmful production factors:

1) increased levels of infrasound vibrations, ultrasound, ionizing radiation, static electricity, electromagnetic radiation, ultraviolet or infrared radiation;
2) dangerous voltage value in the electrical circuit; increased intensity of electric or magnetic fields;
3) lack or insufficient natural light;
4) insufficient illumination of the work area; increased light brightness;
5) direct and reflected radiation, which creates a blinding effect.

b) psychophysiological hazardous and harmful production factors:

1) physical (static and dynamic) overloads
2) neuropsychological overload (mental overstrain, overstrain of the senses, monotony of work, emotional overload).

The study of the air traffic controller's work has also shown that its nature and peculiarities cause significant emotional stress on the nervous system. These include the degree of responsibility for the result of their own activities and the significance of the error that the controller must not make, the degree of responsibility for the safety of others. The controller is responsible for the functional quality of the final work or task, i.e. for flight safety. A possible mistake by the controller can cause an accident, accompanied by damage and destruction of equipment and even loss of life, the possibility of risk to their own life (the threat of myocardial infarction, stroke or judicial punishment), and the presence of constant anxiety for the safety of others. According to hygienic standards, these loads correspond to the class of harmful and dangerous working conditions that exceed permissible levels.

The effect of such adverse occupational factors on the air traffic controller's body can lead to an occupational disease, which is a pathological condition caused by work and associated with excessive stress on the body or adverse effects of harmful occupational factors.

The diagnosis of an occupational disease is made in each case, taking into account the characteristics of the working conditions, the duration of the employee's work in this occupation, the employee's professional route, data from previous periodic medical examinations, and the results of clinical, laboratory, and diagnostic tests [27].

Sanitary and hygienic requirements for working conditions

To create favorable sanitary working conditions and improve production culture, it is important to improve the territory and buildings of the airline, rationally plan individual workshops and auxiliary facilities, and organize sanitary and household services for employees.

It is very important to ensure the sanitary maintenance of production facilities, protection of the air and water bodies from industrial emissions.

Industrial sanitation requirements are stipulated by the provisions of labor law on labor protection. Hygienic requirements for the design of industrial enterprises are set out in the Sanitary Norms for the Design of Industrial Enterprises (SN), the Building Norms and Rules (BNaP), the relevant DNAPs and state standards.

Each aviation production facility is designed with due regard to the sanitary requirements for its master plan. When choosing a site for the construction of a facility, the most favorable use of natural light and ventilation of the territory should be taken into account. The site should be located near water sources. The soil of the site should be suitable for the construction of buildings and structures, aircraft parking lots, transportation routes and have a certain slope for surface water runoff.

Aviation enterprises include facilities of hazard classes I through V. For example, aircraft repair plants can be classified as Class II and III, and airports as Class I. Sanitary supervisory authorities are allowed to increase the protection zone under exceptionally hazardous conditions, but not more than three times, and to reduce it if effective measures are taken to reduce hazards. For a number of aviation units, after the commissioning of new, more powerful types of aircraft, the width of the sanitary protection zone was increased to 2000-3000 m, due to increased noise, an increase in the danger zone during takeoff and landing, expansion of the territory of fuel and lubricant warehouses, introduction of more powerful means of communication and radio navigation, etc.

The territory of the sanitary protection zone should be landscaped and green. In this zone, it is allowed to locate enterprises with a lower hazard class, ancillary facilities (fire depot, laundry, canteens, garages, warehouses, premises for emergency personnel and security guards, etc.).

Aircraft companies are also subject to a number of requirements for capturing and cleaning air emissions, sealing equipment, and taking other precautions to prevent air and water pollution, and reducing harmful radiation, noise, and vibration. Production facilities are built in accordance with the requirements of the technological process and the overall dimensions of the equipment. The standards regulate the minimum volume of the premises: 15 meters for each employee, a minimum area of 4.5 m2 and a height of 3.2 m.

Development of measures for air traffic controllers' occupational health and safety

Air traffic control is one of the main components of the system of ensuring the safety of flights of CA aircraft and other institutions in the Ukrainian airspace, including foreign aircraft. Among the transport industries controlled by the State Service of Ukraine for Labor Protection, air traffic control is a potentially hazardous transport industry.

The main determinant of the ATC system is the ATC controller, who manages the flow of aircraft on routes, local airways, airfields, and areas of agricultural use.

To carry out the functions of the ATC, special workplaces for ATC dispatchers are organized, equipped with a communication system, radar, and the necessary regulatory and technological documents. In the context of CNS/ATM systems (communication, navigation and surveillance systems based on the use of digital technology, including satellite-based ATC systems), the ergonomic organization of the automated workplace of the ATC dispatcher is particularly important.

Thus, to control the ATC, the working conditions are organized in which the dispatcher is exposed to physical and psychophysical production factors, which are determined in combination with a high level of responsibility for the ATC, the severity of physical and mental labor.

When organizing the necessary working conditions at the workplace, optimal working conditions are created, which improves the controller's performance, prolongs his or her longevity, and prevents errors during ATC, and therefore increases the level of flight safety. Personal computers (PCs) are used at the controller's workplace, so it is necessary to comply with the rules of safe PC operation.

The dispatcher's work is mental; the fatigue that develops during the performance of their technological duties is due to mental stress. In this regard, the complex of rehabilitation measures should generally be of a psychophysiological nature and contribute to the prevention and relief of fatigue and overwork caused by mental stress. Provide assistance in organizing intra-shift and inter-shift relief of fatigue and nervous and emotional stress arising during work.

Measures to monitor and maintain performance are carried out between commissions, are of preventive importance and are aimed at reducing the impact of workload and overload, maintaining and restoring performance, and preliminary preparation for the medical and flight examination.

When organizing work to monitor and maintain the performance of dispatchers, the following measures should be taken:

- specialists of medical institutions of airline companies to develop action plans for monitoring and maintaining performance, taking into account the airport class and working conditions, the intensity of the PR, and the level of automation of the ERP;
- the flight unit doctor and VLEC experts, together with the controllers and senior dispatcher, to identify groups of dispatchers to determine the degree of their

participation in the health improvement complex of measures, and to record the effectiveness of health improvement measures;

- the effectiveness of the comprehensive measures taken is determined by the feedback from an individual medical examination by a flight squad doctor or professional certification of controllers;
- information on the use of methods of monitoring and maintaining performance and the effectiveness of their use is entered by doctors in the medical characteristic; by the CP and the old dispatcher in the production characteristic.

The medical and occupational characterization of air traffic controllers' monitoring and performance support is carried out to improve flight safety and maintain the professional longevity of air traffic controllers [28].

5.2 Environmental protection

The research discussed in this chapter is about ecology. The question of the state of the planet's ecology as a whole remains an open and relevant issue today. As a result of the scientific and technological revolution, humanity suffers from excessive pollution of the environment with harmful substances: air, water and land resources. Civil aviation, in particular, is not the least of the emitters, and the formation of "holes" in our planet's ozone layer poses a real threat to the atmosphere.

The issues of assessing and mitigating the adverse weather impact of civil aviation facilities are inextricably linked to addressing environmental safety in Ukraine. Therefore, there is a need to address urgent environmental issues in all areas of transportation, production, intellectual and social activities through government and industry.

The main goal of the study was to analyze the problem of air pollution by air transport and to summarize ways to solve it.

The object of the study is airplanes, their engines and jet fuel, which, when burned, generates emissions of harmful substances into the environment.

The subject of this section is the environment.

Analysis of the impact of air transport on air pollution.

The data analysis showed that the use of airplanes pollutes soil, water and air. The characteristic of air transport impact on the environment is reflected in the significant impact of noise and significant emissions of various pollutants. Emissions from aircraft engines and stationary sources are an important aspect of the environmental impact of air transport. In addition, aviation has a number of differences compared to other modes of transport: the use of predominantly turbine-gas engines determines a different nature of the process and structure of the waste stream; the use of kerosene as a fuel causes changes in pollutant components; high-altitude aircraft cause the dispersion of combustion products in the upper atmosphere and over a large area, reducing the degree of their impact on living organisms.

The analysis of emissions during the flight showed that the aircraft polluted the upper atmosphere with exhaust gases from aircraft engines near airports and the upper atmosphere at cruise altitude. Gases account for 87% of all civil aviation emissions, including emissions from special vehicles and stationary sources.

It is well known that in recent years there has been a great burden on the environment, accompanied by an increase in air traffic by 4-5%. This process is irreversible and occurs both globally and locally. Studies of the factors that determine the level of environmental safety near airports have shown that aviation noise and emissions from aircraft engines, electromagnetic radiation have a greater impact on environmental quality.

It is also known that stratospheric ozone is a natural filter that absorbs ultraviolet radiation from the Sun. As a result of human activity, some compounds are released into the atmosphere, disrupting the balance between the formation and destruction of ozone. The most important of these compounds are chlorofluorocarbons (CFCs), halogens, carbon tetrachloride, and methyl chloroform. All of them remain chemically at the bottom of the atmosphere and pass into the stratosphere. The effects of ultraviolet radiation release chlorine and bromine, which act as catalysts for ozone depletion [29].

It has been shown that a modern first-class airport emits several tens of tons of NOx into the atmosphere annually. Calculating the NOx emitted by aircraft engines during flight is a serious problem, but it is known that the NOx emission index of engines in field mode ranges from 10 to 40, and in cruise mode it is 5 to 20 (in grams of NOx) per kilogram of fuel). Thus, the total annual emission of NOx into the Earth's atmosphere through the air is hundreds of thousands of tons, which does not negate the impact of this waste on ozone content [30].

When determining the total amount of pollutants, aviation experts need to add nitrogen oxides with hydrocarbons, sulfur oxides, carbon monoxide, and even smoke. But, in my opinion, from an environmental and chemical point of view, this conclusion about hazardous waste is wrong.

It has been shown that methods of improving the environmental properties of aviation fuel by improving its quality are feasible. By reducing the amount of sulfur, aromatic hydrocarbons (especially benzene), resins, olefins and lead, the fuel can actually be made more lean. Also add appropriate additives such as ionol (within - Agidol - 1). After conducting a series of experiments, the authors concluded that Ukraine's transition to Jet A fuel, which is associated with the rational use of petroleum products, will not change the environmental performance of the fuel unless changes are made in the combustion chamber.

According to the source [31], the characteristics of the impact of aircraft on the environment are, first of all, that the modern fleet of aircraft and helicopters has gas turbine engines. Secondly, gas turbine engines run on aviation fuel, the chemical composition of which is slightly better than that of gasoline and diesel fuels with less sulfur and mechanical compounds. Third, most exhaust gases are emitted by aircraft at relatively high altitudes, with high speeds and turbulent flows, and only a small portion of them is released directly into the air near airports and populated areas. The total amount of toxic emissions from aircraft can be calculated based on the amount of fuel consumed in the aircraft, which is about 4% of the total fuel consumption of all types of transport. Thus, the share of air pollution outside the airport area is relatively small, but no new data are available.

The main components of the environment are known to be polluted: carbon monoxide, incomplete hydrocarbons, nitrogen oxides and humus. During idle time and on the taxiway during landing, the content of carbon monoxide and hydrocarbons in the exhaust gases increases significantly, but the amount of nitrogen oxides decreases.

In normal operation, when engines operate at optimal parameters without a load of 35-50% of their capacity, the amount of carbon monoxide and hydrocarbons decreases, but nitrogen oxides emissions increase. The highest emissions of smoke and vapors occur during flight and takeoff, when engines operate at 1.1-1.2 times their rated capacity and, as a rule, with a mixture of enriched fuel.

Also, according to sources, the most pollution at the airport occurs during landing and takeoff of aircraft, as well as when their engines warm up. It is estimated that 300 transcontinental flights, 3.7 tons of carbon monoxide, 2 tons of hydrocarbons, and 1.7 tons of nitrogen oxides are released into the atmosphere per day. At the same time, pollutants do not enter the atmosphere in the same way, but depending on the airport schedule. When the engines are running for takeoff and landing, the largest amount of carbon monoxide and hydrocarbon compounds is released into the environment, and during the flight, the maximum amount of nitrogen oxides is released. A transatlantic flight requires 50 to 100 tons of oxygen. But the most dangerous thing is that when flying in the lower stratosphere, the engines of high-speed aircraft emit nitrogen, which causes the oxidation of ozone, which acts as a protective shield against the negative effects of the sun's ultraviolet light [32].

Source [33] describes in detail the process of aircraft engine emissions, i.e., exhaust gases emitted into the atmosphere from the nozzles and exhaust pipes of aircraft engines. The composition of exhaust gases (components) that pollute the atmosphere is fully described. The author of this paper has determined that from an environmental point of view, this is the longest and most dangerous low gas mode (relative weight of 3...9% of the maximum value). These are the minimum relative values of the engine during preflight and after landing, as well as during engine warm-up after startup. Experience shows that pollution in the vicinity of the airport is more harmful (the relative pressure value on the route is in the range of 0.6-0.8). In addition, local air pollution in the airport area, where many people work, is more concentrated and stable than the general upper tropospheric pollution along the flight path. The analysis of this work suggests that emissions of harmful substances (i.e., emissions from aircraft engines) depend on the mode of operation and the duration of operation in this mode.

Based on the results obtained, it was found that air pollution can be reliably calculated based on precipitation characteristics. Using regression analysis of the experimental data on heavy metals in snow samples taken at the airport, we obtained results showing that the concentration of heavy metals in airport snow samples increases significantly as one approaches the airport and contaminates the old snow.

An analysis of the literature on air pollution by air transport shows that this issue is not sufficiently reflected in the scientific literature. Therefore, the relevance of the work depends on the lack of sufficient information on the impact of air transport processes on the state of the atmosphere.

5.3 Generalization of ways to solve the problem of air pollution by air transport

The problem of air pollution by air transport is not limited to the study and assessment of the impact of gaseous and aerosolized combustion products of aircraft engines on the ozone layer. There are several aspects of the impact of such pollution:

- photochemical: expressed in a change in the ratio between the concentrations of small but important components of atmospheric air as a result of photochemical reactions. That is, the growth of some atmospheric gases (as well as aerosols) is accompanied by a decrease in other gaseous air components;

- Radiation: fluctuations in the composition of greenhouse gases (carbon dioxide CO2, water vapor H2O, ozone O3, methane CH4, etc.), aerosols, and especially the formation of cirrus clouds lead to changes in the heat and radiation balances of the Earth-atmosphere system, and hence to changes in air temperature in the atmosphere and on the earth's surface;

- biological: expressed by the impact of the flow of biologically active ultraviolet radiation at the level of the Earth's surface, the intensity of which depends on the thickness of the ozone layer. Ultraviolet radiation is known to be hazardous to human and animal health and reduces the productivity of some plant species.

Thus, it is a fact that aircraft engine emissions affect vital elements of the ecosystem: air quality, temperature, atmospheric circulation and climate, and the flow of ultraviolet radiation [31].

Gas turbine engines, which are predominantly used in modern air transport, are significant consumers of hydrocarbon fuels and atmospheric oxygen, and are also sources of exhaust gas pollution. The mixture of fuel combustion products with excess air contains a number of harmful substances regulated by sanitary and hygienic standards and requirements of the International Civil Aviation Organization (ICAO).

In my opinion, from an environmental and chemical point of view, it is correct and appropriate to summarize the emissions of harmful substances released into the atmosphere during the operation of aircraft engines in different modes using the coefficient of relative aggressiveness of a harmful substance (Ai) {ASO=1; ASN=3.16; ASOx=16.5 ANOx=41.1; Atv.h=300}.

The ecological version of gaseous substances summation makes it possible to determine the percentage of a particular substance in the total mass of emissions of standardized gaseous substances (Table 1).

Aircraft engine	Degree. pressure increase, P00	Share of hazardous substances, %.		
		CO	SN	NOx
Option a*.	10	4,46	2,34	93,20
	20	3,40	1,78	94,82
Option b*.	10	5,48	2,88	91,64
	20	4,20	2,20	93,60

Table 5.1 - Share of certain harmful substances in the total mass of emissions

* ICAO standards:

(a) for engines of a type or model for which the first model was manufactured on or before December 31, 1995, and a specific copy thereof on December 31, 1990;

(b) for engines of a type or model for which the first production model was manufactured after December 31, 1995, or a specific copy thereof after December 31, 1990.

Using the relative aggregation factor Ai, it can be determined that the emission rate (ICAO requirements) of gaseous substances from turboprop and turbofan aircraft engines will change by several percent.

Recently, in order to reduce harmful emissions into the atmosphere, a method of reducing the number of operating aircraft engines during taxiing near the airport has been widely used in practice.

An increase in the amount of fuel hydrocarbons is usually accompanied by an increase in its viscosity, density, and surface tension, which prevents fuel atomization and evaporation. Consequently, engines should have a mutual anti-fuel effect on NOx emissions at low and maximum gas volumes. Along with the study of the nature of harmful emissions and the mechanism of their impact on the environment, it is advisable to continue developing new combustion chambers and new engine concepts. Modifications to the combustion chamber design should be aimed at maximizing fuel efficiency. When designing aircraft engines, take into account such modern combustion chambers as: uniform, variable geometry, hybrid, jet-stabilized, catalytic.

The pattern of NOx formation in the combustion chambers of gas turbine engines determines two main ways to reduce the emission of these oxides:

- lowering the temperature in the first zone of the combustion chamber;
- Reducing the time spent by gases in the high temperature zone.

Given the complexity of the above methods, let's consider somewhat simpler measures to improve the indicators that affect air pollution from aircraft engine emissions.

It is known that a 3-4% increase in the takeoff weight of a modern jetliner leads to an increase in fuel consumption by 150-200 kg during the flight, and, consequently, an increase in CO2 emissions by 470-630 kg. The following examples of fuel savings can be logically offered:

- Reducing takeoff weight by leaving one of the three water tanks of the Boeing 747-200 on the ground (if it is not needed on this particular flight) will save 380 tons of fuel per year, and thus reduce CO2 emissions by 1200 tons;

- Saving 52 tons of fuel and reducing gas emissions by 165 tons by replacing the metal water tank with a plastic one;

- a 1% reduction in aircraft drag caused by surface contamination with dirt will reduce fuel consumption by 15,000 gallons per year for a Boeing 737, or 100,000 gallons for a Boeing 737;

- Reducing engine contamination will lead to an increase in the specific fuel consumption (SFC) ratio. Periodic flushing is known to improve SFC by 1.5% and reduce CO2 from 290 to 190 tons per year.

It is also worth paying attention to the possibility of introducing and using alternative fuels in air transport. It is known that hydrogen and so-called cryogenic fuels are among the "clean" fuels. Despite the disadvantages of hydrogen as a transportation fuel due to its low density and low boiling point (20 K), it is considered more promising for air transport than for other types. At the same time, the higher the speed and weight of the aircraft, the more expedient it is to use hydrogen engines.

Today, as an innovative development, it is proposed to introduce solar panels placed on the surface of the wings and fuselage to power traction motors. Theoretically, such an airplane can stay in the air as long as the sun's rays illuminate it. In this case, the aircraft takes off using the accumulated energy, and is maintained in flight using the energy coming from solar radiation. And although aviation industry experts are skeptical and distrustful of the installation of such power units on civil and military aircraft, in my opinion, this idea deserves to live and to be tested with model aircraft.

5.4 Noise pollution from air transport

In all countries, the problem of combating acoustic pollution from air transport, especially near airports, has been a pressing issue in recent decades. More research has been devoted to aircraft noise than to any other environmental noise problem. Therefore, the design of new aircraft, the choice of takeoff and landing modes, as well as the construction of new and reconstruction of old airports, take into account the noise problems that may arise.

Air transportation generates significant noise near both civilian airports and military airfields. Airplane takeoffs are known to generate intense noise, including rumble and vibration. Aircraft landings generate significant noise along corridors within which flights are usually conducted at low altitudes. The noise is generated not only by the engines, but also by the landing gear and wing mechanization, as well as when reverse thrust (engine reverse mode) is applied when the aircraft is running on the runway. In general, a larger and therefore heavier aircraft generates more noise than a lighter aircraft.

The sources of noise on the territory of aviation enterprises and adjacent areas are:

- aircraft power plants with gas turbine and piston engines;
- auxiliary power units of aircraft and launch units;
- special airfield maintenance vehicles for various purposes, including thermal and wind machines created on the basis of aircraft engines that have reached the end of their flight life;
- machine tools and technological equipment for production processes.

Under the flight path, at a distance of 1.3 km from the runway end, the sound level reaches 73 dBa in the daytime. The lateral distance from the runway is of great importance. The increase in sound level in summer is due to the intensity of flights, and its decrease is due to the shielding effect of dense greenery.

Residents of houses located in the vicinity of the airport say that they have become nervous. Sudden noise from flying airplanes disrupts sleep: many people cannot sleep for a long time or wake up frequently. Complaints of anxiety, fear of vibration of the house or dishes are made by residents of houses close to the airplane takeoff and landing routes and engine test sites. The percentage of complaints is highlighted by the maximum noise levels and intensity of aircraft flights both during the day and throughout the year. The acoustic situation in the airport area is determined:

- the mode of operation of the airline;
- types of aircraft operated at the airport;

- the current arrival and departure routes of the aircraft.

In accordance with the Law of Ukraine "On Atmospheric Air Protection", standards for the maximum permissible impact of physical factors from stationary and mobile sources are established in the field of atmospheric air protection. The standards of maximum permissible levels of impact on atmospheric air are set for each stationary source and for each type of mobile source, taking into account modern technical solutions to reduce the levels of impact of physical factors, including noise.

The levels of this factor's impact on the state of the atmospheric air and the requirements for their reduction are established by the relevant permit on the basis of the standards approved in accordance with the sanitary norms. Economic or other types of activities, if they are associated with violation of the levels of acoustic impact on the state of atmospheric air stipulated in the permit, may be limited, temporarily prohibited (suspended) or terminated in accordance with the law (Article 12 of the Law of Ukraine "On Protection of Atmospheric Air").

As stipulated by the State Building Standards of Ukraine (dBN 360-92), permissible noise levels at various facilities and areas of different economic purposes should not exceed the following sanitary standards, which are given in Table 2.

Territories	Equivalent level noise, dBA		Maximum level, noise, dBA	
	7-23 year.	23 -7 Year	7 -23 Year	23-7 year
Rural areas of populated areas places	55	45	70	60
To residential development that reconstructed	60	50	70	60
Territories of residential Buildings near airfields and airports	65	55	75	65

Areas of mass recreation and tourism	50	35-40	85	75
Sanitary and resort area	40-45	30-35	60	65
Territories of of nature reserves i reserves	< 25	<20	50	45

Table 5.2 - Permissible noise levels in the areas of different economic purposes

Noise has a negative impact on various body systems: cardiovascular, nervous, disrupts sleep, attention, increases irritability, depression, anxiety, irritation, can affect respiration and digestive system; damage to hearing function with temporary or permanent hearing loss; impaired ability to transmit and perceive speech communication sounds; distraction from normal activities; changes in physiological reactions to stress signals; impact on mental and somatic health; impact on work activity and productivity. Studies have shown adverse effects of noise on the central nervous system, cardiovascular system, and digestive system. Disturbances in the functioning of the central nervous system under the influence of noise lead to a weakening of attention and performance, especially mental performance.

Conclusion to Chapter 5

It was found that the solution to the problem of air pollution by air transport should be comprehensive. The analyzed areas of reducing air pollution concerned only one specific problem and did not reduce the harmful effects of all factors.

As a result, it is proposed to comprehensively and simultaneously address the problem in the following four areas of improving the environmental performance of aircraft engines: chemical, structural, economic, and the introduction of alternative energy sources in air transport.

The chemical direction is based on improving the hydrocarbon composition of the fuel and adding certain additives and additives.

Structural - to improve the process of fuel combustion in the combustion chamber and improve the combustion chamber itself.

Economic - based on reducing fuel consumption by reducing takeoff weight, aircraft drag, increasing engine cleanliness, reduced echeloning, and efficient piloting of the aircraft in the airport area.

GLOBAL CONCLUSION

In conclusion, this comprehensive exploration of conflict situations in air traffic, existing prevention methods, and the development of innovative assistance systems paints a nuanced picture of the challenges and opportunities within the realm of aviation safety. As the aviation industry continues to soar to new heights, the imperative to ensure the safety, efficiency, and sustainability of air travel becomes increasingly crucial.

The overview of current flight safety and the identification of typical conflict situations provided in Chapter 1 laid the groundwork for understanding the complexities inherent in modern air traffic. Chapter 2 further dissected the causes and factors leading to conflicts, offering insights into existing tools and methods for prevention. This foundational knowledge paved the way for the central theme of Chapter 3 – the development of an Information and Assistance System for Flight Control. This innovative system, rooted in geographic coordinates, navigation data, and user-inputted flight plans, stands as a potential game-changer in proactively addressing and preventing conflict situations.

The software implementation of an intelligent decision-making system, as explored in Chapter 4, showcases the practical application of theoretical frameworks discussed earlier. This implementation not only aids in the professional activity of flight controllers but also emphasizes the pivotal role of automation in enhancing the overall safety and efficiency of air traffic management.

Moreover, the broader considerations of labor and environmental protection, elucidated in Chapter 5, underscore the holistic approach required in shaping the future of air traffic management. Addressing the well-being of air traffic controllers and acknowledging the environmental impact of aviation are integral components of ensuring a sustainable and responsible aviation ecosystem.

As we reflect on this exploration, it becomes evident that the future of air traffic management hinges on the seamless integration of advanced technologies, comprehensive data analysis, and a steadfast commitment to safety and sustainability. The proposed Information and Assistance System, coupled with intelligent decision-making tools, represents a proactive step toward mitigating conflicts and optimizing the efficiency of air travel.

In the grand tapestry of aviation, each thread contributes to the overall fabric of safety, efficiency, and sustainability. This journey through the intricacies of conflict management and prevention serves as a testament to the collective efforts required to navigate the skies responsibly. By fostering a deeper understanding of the challenges and proposing innovative solutions, we aspire to contribute to an aviation landscape that not only meets the demands of the present but also lays a robust foundation for the future.

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APPENDIX A

Code of the program

App.jsx

```
import { Form } from "./Form";
import { MapBox } from "./MapBox";
import { AdviceBox } from "./AdviceBox";
import { useEffect, useState } from "react";
import AIR_DATA from "../libs/constants"
import {searchConfilct} from "../libs"

function App() {
  const [adviceFlag, setAdviceFlag] = useState(null);
  const [conflicts, setConflicts] = useState([]);
  const [myFlightPlan, setMyFlightPlan] = useState(null);

  useEffect(() => {
    if(myFlightPlan && myFlightPlan.R.length > 1){
      const dots = searchConfilct(AIR_DATA.OTHERS_FP, myFlightPlan)
      setConflicts(dots);
      if(dots.length) setAdviceFlag(false)
      else setAdviceFlag(true)
    }

  }, [myFlightPlan])

  return (
    <div className="font-sans">
      <div className="w-full text-center p-3 bg-slate-600 text-white">
        <h2 className="text-2xl font-bold pt-1">Flight Advice System</h2>
      </div>
      <div className="w-full border border-black">
        <Form handleFP={(fp) => {setMyFlightPlan(fp)}}/>
      </div>
      <div className="flex">
        <div className="w-3/5 m-2">
          <MapBox myFP={myFlightPlan} conflicts={conflicts} />
        </div>
        <div className="w-2/5 m-2 border border-black">
          <AdviceBox flag={adviceFlag} />
        </div>
      </div>
```

```
    </div>
  );
}

export { App };
```

Form.jsx

```
import { useState } from "react";
import { Controller, useForm } from "react-hook-form";
import Select from "react-select";
import CreatableSelect from "react-select/creatable";
import DatePicker from "react-datepicker";
import "react-datepicker/dist/react-datepicker.css";

import AIR_DATA from "../libs/constants.js"
import { createSelectOptions } from "../libs/index.js";

const Form = ({handleFP}) => {
  const {
    register,
    handleSubmit,
    control,
    formState: { errors },
  } = useForm({
    defaultValues: {},
  });

  const [startDate, setstartDate] = useState(new Date());
  const [startTime, setstartTime] = useState(new Date());
  const [totalEET, settotalEET] = useState(new Date());

  const onSubmit = (data) => {
    const fp = {}

    fp.AI = data.aircraftIndetification;
    fp.FR = data.flightRules.value;
    fp.TF = data.typeOfFlight.value;
    fp.TA = data.typeOfAircraft.value;
    fp.EQ1 = data.equipment1.value;
    fp.EQ2 = data.equipment2.value;
    fp.WTC = data.wakeTurbulenceCat.value;
    fp.CS = Number(data.cruisingSpeed);
    fp.LVL = Number(data.level);
    fp.DESA = data.destinationAerodrom.value;
    fp.DEPA = data.departureAerodrom.value;
    fp.ALTA = data.altnAerodrom.value;
    fp.SALTA = data.secAltnAerodrom.value;
    fp.E = data.endurance;
    fp.R = data.routes.map(route => route.value)
```

```
    fp.SD = startDate;
    fp.ST = startTime;
    fp.EET = totalEET;

    handleFP(fp)
  }

  return (
    <div>
      <form onSubmit={handleSubmit(onSubmit)} className="border rounded bg-
slate-200">
        <h3 className="m-2 text-xl font-bold">Flight Form</h3>
        <div className="flex m-2">
          <div className="flex m-2">

            <div className="w-fit mr-2">
              <label className="text-xs">Aircraft indetification</label>
              <br />
              <input
                type="text"
                className="w-32 h-9 border border-gray-300 rounded"
                {...register("aircraftIndetification", { required: true })}
              />
              <br />
              {errors.aircraftIndetification && (
                <span className="text-xs text-red-500 font-bold">
                  This field is required
                </span>
              )}
            </div>

            <div className="w-fit mr-2">
              <label className="text-xs">Flight Rules</label>
              <Controller
                name="flightRules"
                control={control}
                rules={{ required: true }}
                render={({ field }) => (
                  <Select
                    className="w-32"
                    options={createSelectOptions(AIR_DATA.FlightRules)}
                    placeholder=""
                    {...field}
                  />
```

```
        )}
      />
      {errors.flightRules && (
        <span className="text-xs text-red-500 font-bold">
          This field is required
        </span>
      )}
    </div>
    <div className="w-fit mr-2">
      <label className="text-xs">Type of flight</label>
      <Controller
        name="typeOfFlight"
        control={control}
        rules={{ required: true }}
        render={({ field }) => (
          <Select
            className="w-32"
            options={createSelectOptions(AIR_DATA.TypeOfFlight)}
            placeholder=""
            {...field}
          />
        )}
      />
      {errors.typeOfFlight && (
        <span className="text-xs text-red-500 font-bold">
          This field is required
        </span>
      )}
    </div>
  </div>

  <div className="flex m-2">
    <div className="w-fit mr-2">
      <label className="text-xs">Type of aircraft</label>
      <Controller
        name="typeOfAircraft"
        control={control}
        rules={{ required: true }}
        render={({ field }) => (
          <Select
            className="w-32"
            options={createSelectOptions(AIR_DATA.TypeOfAircraft)}
            placeholder=""
            {...field}
```

```
      />
    )}
  />
  {errors.typeOfAircraft && (
    <span className="text-xs text-red-500 font-bold">
      This field is required
    </span>
  )}
</div>
<div className="w-fit mr-2">
  <label className="text-xs">Equipment</label>
  <div className="flex">
    <Controller
      name="equipment1"
      control={control}
      rules={{ required: true }}
      render={({ field }) => (
        <Select
          className="w-20 mr-1"
          options={createSelectOptions(AIR_DATA.Equipment1)}
          placeholder=""
          {...field}
        />
      )}
    />
    <Controller
      name="equipment2"
      control={control}
      rules={{ required: true }}
      render={({ field }) => (
        <Select
          className="w-20"
          options={createSelectOptions(AIR_DATA.Equipment2)}
          placeholder=""
          {...field}
        />
      )}
    />
  </div>
  {(errors.equipment1 || errors.equipment2) && (
    <span className="text-xs text-red-500 font-bold">
      This field is required
    </span>
  )}
```

```
  </div>
  <div className="w-fit mr-2">
    <label className="text-xs">Wake Turbulance Cat</label>
    <Controller
      name="wakeTurbulenceCat"
      control={control}
      rules={{ required: true }}
      render={({ field }) => (
        <Select
          className="w-32"
          options={createSelectOptions(AIR_DATA.WakeTurbulenceCat)}
          placeholder=""
          {...field}
        />
      )}
    />
    {errors.wakeTurbulenceCat && (
      <span className="text-xs text-red-500 font-bold">
        This field is required
      </span>
    )}
  </div>
</div>



<hr />

<div className="flex m-2">
  <div className="w-fit mr-2">
    <label className="text-xs">Departure aerodrom</label>
    <Controller
      name="departureAerodrom"
      control={control}
      rules={{ required: true }}
      render={({ field }) => (
        <Select
          className="w-32"
          options={createSelectOptions(AIR_DATA.Aerodroms)}
          placeholder=""
          {...field}
        />
      )}
    />
```

```
  {errors.departureAerodrom && (
    <span className="text-xs text-red-500 font-bold">
      This field is required
    </span>
  )}
</div>

<div className="w-fit mr-2">
  <label className="text-xs">Date flight</label>
  <br />
  <DatePicker
      className="w-32 h-9 border border-gray-300 rounded text-center"
      selected={startDate}
      onChange={(date) => setstartDate(date)}
      dateFormat="dd.MM.yyyy"
  />
  <br />
  {errors.dateFlight && (
    <span className="text-xs text-red-500 font-bold">
      This field is required
    </span>
  )}
</div>



<div className="w-fit mr-2">
  <label className="text-xs">Time flight</label>
  <br />
  <DatePicker
      className="w-32 h-9 border border-gray-300 rounded text-center"
      showTimeSelect
      showTimeSelectOnly
      timeIntervals={15}
      timeCaption="Time"
      selected={startTime}
      onChange={(date) => setstartTime(date)}
      dateFormat="hh:mm:aa"
    />
  <br />
  {errors.timeFlight && (
    <span className="text-xs text-red-500 font-bold">
      This field is required
    </span>
```

```
      )}
    </div>
  </div>

</div>

<div className="flex m-2">



  <div className="flex m-2">
    <div className="w-fit mr-2">
      <label className="text-xs">Cruising speed</label>
      <br />
      <input
        type="text"
        className="w-32 h-9 border border-gray-300 rounded"
        {...register("cruisingSpeed", { required: true })}
      />
      <br />
      {errors.cruisingSpeed && (
        <span className="text-xs text-red-500 font-bold">
          This field is required
        </span>
      )}
    </div>
    <div className="w-fit mr-2">
      <label className="text-xs">Level</label>
      <br />
      <input
        type="text"
        className="w-32 h-9 border border-gray-300 rounded"
        {...register("level", { required: true })}
      />
      <br />
      {errors.level && (
        <span className="text-xs text-red-500 font-bold">
          This field is required
        </span>
      )}
    </div>
    <div className="w-fit mr-2">
      <label className="text-xs">Total eet</label>
      <br />
```

```
    <DatePicker
        className="w-32 h-9 border border-gray-300 rounded text-center"
        showTimeSelect
        showTimeSelectOnly
        timeIntervals={15}
        timeCaption="Time"
        selected={totalEET}
        onChange={(date) => settotalEET(date)}
        dateFormat="hh:mm"
      />
    <br />
    {errors.totalEET && (
      <span className="text-xs text-red-500 font-bold">
        This field is required
      </span>
    )}
  </div>
</div>
<hr />
<div className="flex m-2">
  <div className="w-fit mr-2">
    <label className="text-xs">Destination Aerodrom</label>
    <br />
    <Controller
      name="destinationAerodrom"
      control={control}
      rules={{ required: true }}
      render={({ field }) => (
        <Select
          className="w-32"
          options={createSelectOptions(AIR_DATA.Aerodroms)}
          placeholder=""
          {...field}
        />
      )}
    />
    {errors.destinationAerodrom && (
      <span className="text-xs text-red-500 font-bold">
        This field is required
      </span>
    )}
  </div>
  <div className="w-fit mr-2">
    <label className="text-xs">Altn aerodrom</label>
```

```
    <br />
    <Controller
      name="altnAerodrom"
      control={control}
      rules={{ required: true }}
      render={({ field }) => (
        <Select
          className="w-32"
          options={createSelectOptions(AIR_DATA.Aerodroms)}
          placeholder=""
          {...field}
        />
      )}
    />
    {errors.altnAerodrom && (
      <span className="text-xs text-red-500 font-bold">
        This field is required
      </span>
    )}
  </div>
  <div className="w-fit mr-2">
    <label className="text-xs">2nd altn aerodrom</label>
    <br />
    <Controller
      name="secAltnAerodrom"
      control={control}
      rules={{ required: true }}
      render={({ field }) => (
        <Select
          className="w-32"
          options={createSelectOptions(AIR_DATA.Aerodroms)}
          placeholder=""
          {...field}
        />
      )}
    />
    {errors.secAltnAerodrom && (
      <span className="text-xs text-red-500 font-bold">
        This field is required
      </span>
    )}
  </div>
</div>
```

```
<hr />

<div className="flex m-2">
  <div className="w-fit mr-2">
    <label className="text-xs">Endurance</label>
    <br />
    <input
      type="text"
      className="w-32 h-9 border border-gray-300 rounded"
      {...register("endurance", { required: true })}
    />
    <br />
    {errors.endurance && (
      <span className="text-xs text-red-500 font-bold">
        This field is required
      </span>
    )}
  </div>
</div>

<div className="flex m-2">
  <div className="w-fit mr-2">
    <label className="text-xs">Routes</label>
    <br />
    <Controller
      name="routes"
      className="z-0"
      control={control}
      rules={{ required: true }}
      render={({ field }) => (
        <CreatableSelect
          className="w-72"
          isClearable
          isMulti
          options={createSelectOptions(AIR_DATA.POINTS)}
          {...field}
        />
      )}
    />
    {errors.routes && (
      <span className="text-xs text-red-500 font-bold">
        This field is required
      </span>
    )}
```

```
          </div>

        </div>

      </div>

      <div className="flex m-2">

        <div className="flex float-right m-2 mr-3">
          <button className="border border-gray-300 rounded p-1 bg-slate-50"
type="submit">
            Check
          </button>
        </div>
        <div className="flex float-right m-2 mr-3">
          <button className="border border-gray-300 rounded p-1 bg-slate-50"
type="reset">
            Reset
          </button>
        </div>

      </div>
    </form>
  </div>
 );
};

export { Form };
```

AdviceBox.jsx

```
const AdviceBox = ({flag, data}) => {

  const successMsg = () => {
    return (
      <div className="m-5 font-sans">
        <h3 className="mb-2 text-xl font-bold text-green-
600">Congratulations!</h3>
        <p>
          The program did not find any conflicting flight plans with the proposed one!
        </p>
        <p className="mt-2">
          Follow the instructions of the Air Traffic Controller on the route. Have a safe
flight!
        </p>
      </div>
    )
  }

  const failMsg = () => {
    return (
      <div className="m-5 font-sans">
        <h3 className="mb-2 text-xl font-bold text-red-600">ALARM!</h3>
        <p>
          The proposed flight plan may lead to a conflict situation on a certain part of
the route!!!
        </p>
        <p className="mt-2">
          Recommendation:
        </p>
        <ul className="list-disc ml-9">
          <li>Reschedule departure time if possible</li>
          <li>Increase altitude</li>
          <li>Reduce speed</li>

        </ul>
      </div>
    )
  }

  return flag !== null ? (flag ? successMsg() : failMsg()) : null;
```

```
}

export {AdviceBox}
```

MapBox.jsx

```
import { useEffect, useState } from 'react'
import { CircleMarker, MapContainer, TileLayer, useMap, LayerGroup, Tooltip,
GeoJSON } from 'react-leaflet'
import 'leaflet-arrowheads'
import AIR_DATA from "../libs/constants.js"

const ControlLayerMap = ({offHandle}) => {
  const map = useMap();

  useEffect(() => {
    map.eachLayer((layer) => {
      if(layer._leaflet_id != 25){
        console.log(layer)
        map.removeLayer(layer);
      }
    })
    offHandle()
  }, [])

  return null
}

const MapBox = ({ myFP, conflicts }) => {
  const [routes, setRoutes] = useState([])
  const [clearMapFlag, setClearMapFlag] = useState(false)
  const clearMapHandle = () => setClearMapFlag(true)
  const yellowOptions = { color: 'yellow' }

  useEffect(() => {
    const newRoutes = AIR_DATA.OTHERS_FP.map(r => {
      return {
        R: r.R,
        name: r.AI,
        main: false,
      }
    })

    setRoutes(newRoutes)
  }, [])
```

```
useEffect(() => {
  if(routes.length && myFP){
    clearMapHandle();
    if(routes[routes.length-1].main){
      setRoutes(arr => {
        arr.pop();
        arr.push({
          R: myFP.R,
          name: myFP.AI,
          main: true,
        })
        return arr;
      })
    }else{
      setRoutes(arr => {
        arr.push({
          R: myFP.R,
          name: myFP.AI,
          main: true,
        })
        return arr;
      })
    }
  }

}, [myFP])

const drawRoute = (route, routeName, mainFlag) => {

  const coordinates = []
  const multiLine = [];

  for (let i = 0; i < route.length; i++) {
    coordinates.push([AIR_DATA.COORDINATES_POINTS[route[i]].longitude,
AIR_DATA.COORDINATES_POINTS[route[i]].latitude])
  }
  const GeoJson = {
    "type": "FeatureCollection",
    "features": [
      {
        "type": "Feature",
        "properties": {},
        "geometry": {
          "type": "LineString",
```

```
          "coordinates": coordinates
        }
      }
    ]
  }

  for (let i = 0; i < route.length - 1; i++) {
    multiLine.push([
      [AIR_DATA.COORDINATES_POINTS[route[i]].latitude,
AIR_DATA.COORDINATES_POINTS[route[i]].longitude],
      [AIR_DATA.COORDINATES_POINTS[route[i + 1]].latitude,
AIR_DATA.COORDINATES_POINTS[route[i + 1]].longitude]
    ])
  }

  return (
    <LayerGroup>
      {route.map((point, i) => (
        <CircleMarker
center={[AIR_DATA.COORDINATES_POINTS[point].latitude,
AIR_DATA.COORDINATES_POINTS[point].longitude]}
pathOptions={yellowOptions} radius={2} >
          <Tooltip direction="left" sticky>{point}</Tooltip>
        </CircleMarker>
      ))}

      <GeoJSON style={mainFlag ? { color: "green" } : null} data={GeoJson}
arrowheads={{ size: "10px" }} >
        <Tooltip sticky>{routeName}</Tooltip>
      </GeoJSON>

    </LayerGroup>
  )
 }

 const drawConflictDot = (conflict) => {
  return (
    <LayerGroup>
       <CircleMarker center={[conflict.latitude, conflict.longitude]} pathOptions={{
color: 'red' }} radius={10} >
         <Tooltip direction="left" sticky>Conflict</Tooltip>
       </CircleMarker>
    </LayerGroup>
  )
```

```
  }

  return (
    <MapContainer
      id="map"
      className='h-[40rem] w-full border border-slate-400 rounded z-0'
      center={[49.84032239009007, 24.01840394328422]}
      zoom={10}
      scrollWheelZoom={true}>
      <TileLayer
        attribution='&copy; <a
href="https://www.openstreetmap.org/copyright">OpenStreetMap</a> contributors'
        url="https://{s}.tile.openstreetmap.org/{z}/{x}/{y}.png"
      />



      {clearMapFlag ?
        <ControlLayerMap offHandle={() => {setClearMapFlag(false)}} />
        : null
      }

      {!clearMapFlag && routes.length > 1 ?
        routes.map(route => drawRoute(route.R, route.name, route.main)) : null
      }
      {conflicts.length && !clearMapFlag ? conflicts.map(conflict =>
drawConflictDot(conflict)) : null}
    </MapContainer>
  )
}

export { MapBox }
```

main.jsx

```
import React from 'react'
import ReactDOM from 'react-dom/client'
import {App} from './components/App'
import './styles/index.css'

ReactDOM.createRoot(document.getElementById('root')).render(
  <React.StrictMode>
    <App />
  </React.StrictMode>,
)
```

constant.js

```
const MIN_HORIZONTAL_DISTANCE = 9000 // m
const MIN_VERTICAL_DISNTACE = 300 // m
const RADIUS_EARTH = 6378100 // m
const START_DATETIME = new Date();
START_DATETIME.setHours(9, 0, 0, 0);
const MIN_TIMEOUT = 3 * 60 * 1000 //miliseconds
const FlightRules = ["I", "V", "Y", "Z"];
const TypeOfFlight = ["S", "N", "G", "M", "X"];
const WakeTurbulenceCat = ["L", "M", "H", "J"];
const Equipment1 = ["N", "S", "A", "B", "C", "D", "E1", "E2", "E3", "F", "G", "H",
"I", "J1", "J2", "J3", "J4", "J5", "J6", "J7", "K", "L", "M1", "M2", "M3", "O", "P1",
"P2", "P3", "R", "T", "U", "V", "W", "X", "Y", "Z"]
const Equipment2 = ["N", "A", "C", "E", "H", "I", "L", "X", "P", "S"];
const Aerodroms = ["LRCL", "EFHK", "UKLI", "UKLL", "UKKG", "EPRZ",
"UKDR", "LROV"]
const TypeOfAircraft = ['Gulf550', '777', '734', 'an24', 'an12', '733', 'emb-phen100',
'321', '320']

const POINTS = [
   "BUKOV",
   "OTRAK",
   "SORON",
   "UKLI",
   "IVF",
   "VI",
   "LADOB",
   "GEMTO",
   "RULUT",
   "SOLNU",
   "TETNA",
   "PEVOT",
   "TADUN",
   "VABOD",
   "TOVNI",
   "RUMUK",
   "DORER",
   "OSGAS",
   "KOVUS",
   "LIV",
   "UKLL",
   "LONLA",
   "TAKON",
```

```
  "GOTRA",
  "TAKET",
  "UNDOL",
  "POBED",
  "PIGUM",
  "KOKUP",
  "DIBED",
  "MALBE",
  "LOPNU",
  "SITBA",
  "EROMO",
]

const COORDINATES_POINTS = {
  "BUKOV": {
    latitude: 47.951667,
    longitude: 25.958333,
  },
  "OTRAK": {
    latitude: 48.948889,
    longitude: 26.686111,
  },
  "SORON": {
    latitude: 49.761667,
    longitude: 27.85,
  },
  "UKLI": {
    latitude: 48.884167,
    longitude: 24.686111,
  },
  "IVF": {
    latitude: 48.884167,
    longitude: 24.691389,
  },
  "VI": {
    latitude: 48.940833,
    longitude: 23.044444,
  },
  "LADOB": {
    latitude: 48.950278,
    longitude: 22.431944,
  },
  "GEMTO": {
    latitude: 48.133333,
```

longitude: 22.594444,
},
"RULUT": {
latitude: 48.648333,
longitude: 23.638889,
},
"SOLNU": {
latitude: 49.296667,
longitude: 25.398333,
},
"TETNA": {
latitude: 49.83333333,
longitude: 26.41666667,
},
"PEVOT": {
latitude: 50.181944,
longitude: 27.043889,
},
"TADUN": {
latitude: 51.90138889,
longitude: 24.68805556,
},
"VABOD": {
latitude: 50.75833333,
longitude: 24.795,
},
"TOVNI": {
latitude: 49.5375,
longitude: 24.66916667,
},
"RUMUK": {
latitude: 48.02666667,
longitude: 23.34333333,
},
"DORER": {
latitude: 50.46583333,
longitude: 27.20777778,
},
"OSGAS": {
latitude: 50.13333333,
longitude: 25.5,
},
"KOVUS": {
latitude: 50.14222222,

longitude: 24.24138889,
},
"LIV": {
latitude: 49.81194444,
longitude: 23.95138889,
},
"UKLL": {
latitude: 49.8125,
longitude: 23.956111,
},
"LONLA": {
latitude: 48.34,
longitude: 22.31972222,
},
"TAKON": {
latitude: 48.53666667,
longitude: 23.18833333,
},
"GOTRA": {
latitude: 48.91333333,
longitude: 25.59833333,
},
"TAKET": {
latitude: 48.97,
longitude: 27.84166667,
},
"UNDOL": {
latitude: 48.45222222,
longitude: 27.72166667,
},
"POBED": {
latitude: 48.72055556,
longitude: 25.45722222,
},
"PIGUM": {
latitude: 49.26472222,
longitude: 24.01166667,
},
"KOKUP": {
latitude: 49.52833333,
longitude: 23.655,
},
"DIBED": {
latitude: 49.88833333,

```
        longitude: 23.05833333,
    },
    "MALBE": {
        latitude: 48.82388889,
        longitude: 22.375,
    },
    "LOPNU": {
        latitude: 49.07416667,
        longitude: 26.68138889,
    },
    "SITBA": {
        latitude: 49.39083333,
        longitude: 27.84694444,
    },
    "EROMO": {
        latitude: 47.95361111,
        longitude: 23.94638889,
    },
}

const OTHERS_FP = [
    {
        AI: "D-IABC",
        R: ["BUKOV", "OTRAK", "SORON"],
        CS: 465,
        LVL: 390,
        SD: START_DATETIME,
        ST: START_DATETIME,
    },
    {
        AI: "PH-BDJ",
        R: ["UKLI", "IVF", "VI", "LADOB"],
        CS: 630,
        LVL: 300,
        SD: START_DATETIME,
        ST: START_DATETIME,
    },
    {
        AI: "EC-JDT",
        R: ["GEMTO", "RULUT", "SOLNU", "TETNA", "PEVOT"],
        CS: 650,
        LVL: 370,
        SD: START_DATETIME,
        ST: START_DATETIME,
```

},
{
AI: "UR-16382",
R: ["TADUN", "VABOD", "TOVNI", "RULUT", "RUMUK"],
CS: 462,
LVL: 410,
SD: START_DATETIME,
ST: START_DATETIME,
},
{
AI: "UR-RTE",
R: ["DORER", "OSGAS", "KOVUS", "LIV", "UKLL"],
CS: 425,
LVL: 420,
SD: START_DATETIME,
ST: START_DATETIME,
},
{
AI: "UK-35262",
R: ["LONLA", "TAKON", "RULUT", "IVF", "GOTRA", "OTRAK", "TAKET"],
CS: 650,
LVL: 410,
SD: START_DATETIME,
ST: START_DATETIME,
},
{
AI: "5B-TRE",
R: ["UNDOL", "POBED", "IVF", "PIGUM", "KOKUP", "DIBED"],
CS: 431,
LVL: 400,
SD: START_DATETIME,
ST: START_DATETIME,
},
{
AI: "F-FZDA",
R: ["MALBE", "RULUT", "POBED", "LOPNU", "SITBA"],
CS: 660,
LVL: 390,
SD: START_DATETIME,
ST: START_DATETIME,
},
{
AI: "UR-TQQ",

```
    R: ["EROMO", "RULUT", "KOKUP", "LIV"],
    CS: 455,
    LVL: 400,
    SD: START_DATETIME,
    ST: START_DATETIME,
  },
  {
    AI: "SP-AGA",
    R: ["RUMUK", "VI", "DIBED"],
    CS: 680,
    LVL: 420,
    SD: START_DATETIME,
    ST: START_DATETIME,
  },

]

export default {
  MIN_HORIZONTAL_DISTANCE,
  MIN_VERTICAL_DISNTACE,
  RADIUS_EARTH,
  MIN_TIMEOUT,
  FlightRules,
  TypeOfFlight,
  WakeTurbulenceCat,
  Equipment1,
  Equipment2,
  Aerodroms,
  TypeOfAircraft,
  POINTS,
  COORDINATES_POINTS,
  OTHERS_FP
}
```

Index.js

```
import AIR_DATA from './constants'
import moment from 'moment'

const createSelectOptions = (arrOptions) => {
   return arrOptions.map(option => {
      return { value: option, label: option }
   })
}

const degreeToRad = (degree) => (degree * Math.PI) / 180;

const getTimeByFuncLat = (vector) => {
   return (vector.xy2.latitude - vector.xy1.latitude)/latSpeed(vector) + vector.t1;
}

const getTimeInPoint = (vector, point) => {
   return (point.latitude - vector.xy1.latitude)/latSpeed(vector) + vector.t1;
}

const latSpeed = vector => {
   return vector.speed/111132.954;
}

const getDisntance = vector => {
   return
AIR_DATA.RADIUS_EARTH*Math.acos(Math.sin(degreeToRad(vector.xy1.latitud
e))*Math.sin(degreeToRad(vector.xy2.latitude)) +
Math.cos(degreeToRad(vector.xy1.latitude))*Math.cos(degreeToRad(vector.xy2.latit
ude))*Math.cos(degreeToRad(vector.xy2.longitude)-
degreeToRad(vector.xy1.longitude)));
}

const getAbsoluteDatetime = (vector, t) => {
   const fullDate = moment(`${vector.date} ${vector.time}`)
   fullDate.add(t, 'seconds')
   return fullDate;
}

const createVectors = (fp) => {
   const vectors = []
   let t1 = 0;
   for(let i = 0; i < fp.R.length; i++){
```

```
        if(i == fp.R.length - 2) break;
        const A = fp.R[i]
        const B = fp.R[i+1]

        const vector = {
            A,
            xy1: AIR_DATA.COORDINATES_POINTS[A],
            t1,
            B,
            xy2: AIR_DATA.COORDINATES_POINTS[B],
            speed: fp.CS,
            high: fp.LVL,
            time: moment(fp.ST).format("hh:mm:ss"),
            date: moment(fp.SD).format("YYYY.MM.DD"),
        }

        const t2 = getTimeByFuncLat(vector, t1)
        vector.t2 = t2;
        const distance = getDisntance(vector);
        vector.distance = distance;

        vectors.push(vector)

        t1 = t2
    }

    return vectors
}

const firstConditionConflict = (otherV, myV) => {
    if(otherV.A === myV.A) return myV.A;
    if(otherV.A === myV.B) return myV.B;
    if(otherV.B === myV.A) return myV.A;
    if(otherV.B === myV.B) return myV.B;
    return false;
}

const secondConditionConflict = (otherV, myV) => {
    function orientation(p, q, r) {
        const val = (q[1] - p[1]) * (r[0] - q[0]) - (q[0] - p[0]) * (r[1] - q[1]);
        if (val === 0) {
            return 0;
        }
        return val > 0 ? 1 : -1;
```

```
}

function onSegment(p, q, r) {
   return (
      q[0] <= Math.max(p[0], r[0]) &&
      q[0] >= Math.min(p[0], r[0]) &&
      q[1] <= Math.max(p[1], r[1]) &&
      q[1] >= Math.min(p[1], r[1])
   );
}

function doIntersect(p1, q1, p2, q2) {
   const o1 = orientation(p1, q1, p2);
   const o2 = orientation(p1, q1, q2);
   const o3 = orientation(p2, q2, p1);
   const o4 = orientation(p2, q2, q1);

   if (o1 !== o2 && o3 !== o4) {
      return true;
   }

   if (o1 === 0 && onSegment(p1, p2, q1)) {
      return true;
   }
   if (o2 === 0 && onSegment(p1, q2, q1)) {
      return true;
   }
   if (o3 === 0 && onSegment(p2, p1, q2)) {
      return true;
   }
   if (o4 === 0 && onSegment(p2, q1, q2)) {
      return true;
   }

   return false;
}

const p1 = [otherV.xy1.latitude, otherV.xy1.longitude];
const q1 = [otherV.xy2.latitude, otherV.xy2.longitude];
const p2 = [myV.xy1.latitude, myV.xy1.longitude];
const q2 = [myV.xy2.latitude, myV.xy2.longitude];

const intersect = doIntersect(p1, q1, p2, q2);
```

```
    return intersect;
}

const getPointConflict = (otherV, myV) => {
    let n;
    const x1 = otherV.xy1.latitude;
    const y1 = otherV.xy1.longitude;
    const x2 = otherV.xy2.latitude;
    const y2 = otherV.xy2.longitude;
    const x3 = myV.xy1.latitude;
    const y3 = myV.xy1.longitude;
    const x4 = myV.xy2.latitude;
    const y4 = myV.xy2.longitude;

    if(y2 - y1 != 0){
        const q = (x2 - x1) / (y1 - y2);
        const sn = (x3 - x4) + (y3 - y4) * q;
        if(!sn) return null;
        const fn = (x3 - x1) + (y3 - y1) * q;
        n = fn / sn;
    }
    else{
        if(!(y3-y4)) return null
        n = (y3-y1) / (y3-y4)
    }

    return {latitude: x3 + (x4 - x3)*n, longitude: y3 + (y4 - y3) * n};
}

const searchConfilct = (othersFP, myFP) => {
    const conflicts = []
    const myRoute = createVectors(myFP);

    for(let i = 0; i < othersFP.length; i++){
        const otherRoute = createVectors(othersFP[i]);
        for(let j = 0; j < otherRoute.length; j++){
            for(let h = 0; h < myRoute.length; h++){
                const oneFlag = firstConditionConflict(otherRoute[j], myRoute[h])
                if(oneFlag !== false){
                    let time1, time2;
                    if(otherRoute[j].A === oneFlag)
                        time1 = getAbsoluteDatetime(otherRoute[j], otherRoute[j].t1);
                    else
                        time1 = getAbsoluteDatetime(otherRoute[j], otherRoute[j].t2);
```

```
            if(myRoute[h].A === oneFlag)
               time2 = getAbsoluteDatetime(myRoute[h], myRoute[h].t1);
            else
               time2 = getAbsoluteDatetime(myRoute[h], myRoute[h].t2);

            const timeDiff = time1 > time2 ? time1 - time2 : time2 - time1
            if(timeDiff <= AIR_DATA.MIN_TIMEOUT){
               if(Math.abs(otherRoute[j].high - myRoute[h].high) <= 10){
                  if(myRoute[h].A === oneFlag)
                     conflicts.push(myRoute[h].xy1)
                  else
                     conflicts.push(myRoute[h].xy2)

                  return conflicts
               }
            }
         }
         const secondFlag = secondConditionConflict(otherRoute[j], myRoute[h])
         if(secondFlag !== false){
            const dot = getPointConflict(otherRoute[j], myRoute[h])
            if(dot){
               const timeAlt1 = getTimeInPoint(otherRoute[j], dot)
               const timeAlt2 = getTimeInPoint(myRoute[h], dot)
               const time1 = getAbsoluteDatetime(otherRoute[j], timeAlt1);
               const time2 = getAbsoluteDatetime(myRoute[h], timeAlt2);

               const timeDiff = time1 > time2 ? time1 - time2 : time2 - time1
               if(timeDiff <= AIR_DATA.MIN_TIMEOUT){
                  if(Math.abs(otherRoute[j].high - myRoute[h].high) <= 10){
                     conflicts.push(dot)
                     return conflicts
                  }
               }

            }


         }
      }

   }
}
```

```
  return conflicts
}


export {
  createSelectOptions,
  searchConfilct
}
```