CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF TRANSPORTATION SCIENCES

Marcela Růžičková

GLOBAL FLIGHT PROCESSING SYSTEMS

Bachelor’s thesis

2016

CZECH TECHNICAL UNIVERSITY IN PRAGUE
Faculty of Transportation Sciences
Dean's office
Konviktská 20, 110 00 Prague 1, Czech Republic

K621..Department of Air Transport

BACHELOR'S THESIS ASSIGNMENT

(PROJECT, WORK OF ART)

Student's name and surname (including degrees):

Marcela Růžičková

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Guides for elaboration

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- Historical Development of Air traffic, ATC and Flight Planning
- Current System Overview
- Flight Plan Processing Systems Description
- IFPS and ERAS
- Flight Plan Processing Issues and Specific City Pairs Simulation
- Suggestion of Possible Solutions

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Bachelor's thesis supervisor: **Ing. Michal Pazourek**

Ing. Bc. Jakub Hospodka Ph.D

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L. S.

.... doc. Ing. Stanislav Szabo, PhD. MBA
head of the Department of Air Transport

.... prof. Dr. Ing. Miroslav Svítek, dr. h. c.
dean of the faculty

České vysoké učení technické v Praze, Fakulta dopravní

I confirm assumption of bachelor's thesis assignment.

....
Marcela Růžičková
Student's name and signature

Prague .... December 30, 2015

ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE
Fakulta dopravní
děkan
Konviktská 20, 110 00 Praha 1

K621..**Ústav letecké dopravy**

ZADÁNÍ BAKALÁŘSKÉ PRÁCE

(PROJEKTU, UMĚLECKÉHO DÍLA, UMĚLECKÉHO VÝKONU)

Jméno a příjmení studenta (včetně titulů):

Marcela Růžičková

Kód studijního programu a studijní obor studenta:

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Zásady pro vypracování

Při zpracování bakalářské práce se řiďte osnovou uvedenou v následujících bodech:

- Historický vývoj letecké dopravy, řízení letového provozu a plánování letů
- Specifikace současného systému
- Systémy pro zpracování letových plánů a jejich popis
- IFPS a ERAS
- Problematika spojená se zpracováním letových plánů, simulace specifických příkladů
- Návrh možných řešení

Rozsah grafických prací:	dle pokynů vedoucího bakalářské práce
Rozsah průvodní zprávy:	minimálně 35 stran textu (včetně obrázků, grafů a tabulek, které jsou součástí průvodní zprávy)
Seznam odborné literatury:	EUROCONTROL - IFPS Users Manual FAA ICAO Flight Planning Interface Reference Guide EUROCONTROL History Book

Vedoucí bakalářské práce: **Ing. Michal Pazourek**

Ing. Bc. Jakub Hospodka Ph.D.

Datum zadání bakalářské práce: **24. října 2014**
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L. S.

doc. Ing. Stanislav Szabo, PhD. MBA
vedoucí
Ústavu letecké dopravy

prof. Dr. Ing. Miroslav Svítek, dr. h. c.
děkan fakulty

Potvrzuji převzetí zadání bakalářské práce.

Marcela Růžičková
jméno a podpis studenta

V Praze dne .... 30. prosince 2015

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Prohlášení

Prohlašuji, že jsem předloženou práci vypracovala samostatně a že jsem uvedla veškeré použité informační zdroje v souladu s Metodickým pokynem o dodržování etických principů při přípravě vysokoškolských závěrečných prací.

Nemám závažný důvod proti užívání tohoto školního díla ve smyslu § 60 Zákona č. 121/2000 Sb., o právu autorském, o právech souvisejících s právem autorským a o změně některých zákonů (autorský zákon).

V Praze dne: 24.8.2016 ……………………………………….

Marcela Růžičková

CZECH TECHNICAL UNIVERSITY IN PRAGUE
Faculty of Transportation Sciences

GLOBAL FLIGHT PLAN PROCESSING SYSTEMS

Bachelor's Thesis

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Marcela Růžičková

ABSTRACT

The thesis is generally engaged with the problematics of the flight plan processing. It describes the air traffic history and the development of individual fields. It specifies the current system, defines basic terms of flight planning and air traffic control, and explains the interactions between them. The prime part of the thesis is focused on an analysis and description of the flight plan processing systems with emphasis on the European and American systems as the two most perfect ones. The thesis highlights similarities and differences that cause irregularities and complications. Practical part includes specific flight plan simulations and illustrations of the mentioned problems. It also suggests several solutions.

Keywords:

Flight Plan, Flight Plan Processing, Air Traffic Control, IFPS, ERAS

ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

Fakulta dopravní

SYSTÉMY ZPRACOVÁNÍ LETOVÝCH PLÁNŮ S CELOSVĚTOVOU PŮSOBNOSTÍ

Bakalářská práce

Srpen 2016

Marcela Růžičková

ABSTRAKT

Práce se zabývá problematikou zpracování letových plánů. Popisuje historii letecké dopravy a vývoj jednotlivých oblastí. Specifikuje současný systém, definuje základní pojmy z oblasti plánování letů a řízení letového provozu, a vysvětluje interakci mezi nimi. Hlavní část práce tvoři analýza a popis systémů zpracování letových plánů se zaměřením na evropský a americký systém, jako dva nejdokonalejší příklady. Práce poukazuje na společné vlastnosti i odlišnosti, díky nimž dochází k nepravidelnostem a komplikacím. Praktická část zahrnuje simulaci konkrétních letových plánů a ilustraci zmíněných problémů. V závěru nabízí několik návrhů řešení.

Klíčová slova:

Letový plán, Zpracování letových plánů, Řízení letového provozu, IFPS, ERAS

Table of Contents

1 Abbreviations

ABI	Advance Boundary Information
ACK	Acknowledgement Message
ACT	Activate Message
AFP	ATC Flight Plan Proposal
AFS	Aeronautical Fixed Service
AFTN	Aeronautical Fixed Telecommunication Network
AIP	Aeronautical Information Publication
ANAC	National Civil Aviation Agency
ARO	Air Traffic Service Reporting Office
ARTCC	Air Route Traffic Control Center
ATC	Air traffic control
ATCO	Air Traffic Control Officer
ATCU	Air Traffic Control Units
ATFCM	Air Traffic Flow and Capacity Management
CASA	Computer Assisted Slot Allocation
CDA	Continuous Approach Operation
CFMU	Central Flow Management Unit
CHG	Modification Message
CNL	Cancel Message
CTOT	Calculated Take-off Time
DLA	Delay Message
DME	distance measuring equipment
DOF	Date of Flight
EASA	European Aviation Safety Agency
EOBT	Estimated Off Block Time
ERAS	En Route Automation System
ETFMS	Enhanced Tactical Flow Management System
FAA	Federal Aviation Administration
FDO	Flight Data Operator

FIR	Flight Information Region
FLS	Flight Suspension Message
FPL	Flight Plan
IBS	Integrated Flight Briefing System
ICAO	International Civil Aviation Organization
IFPS	Integrated Initial Flight Plan Processing System
IFPZ	IFPS Zone
IFR	Instrument Flight Rules
ILS	Instrument Landing System
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirements
MAN	Manual Message
NATCA	National Air Traffic Controllers Association
NDB	Non Directional Beacon
NMOC	Network Manager Operations Centre
NOTAM	Notice to Airmen
OLDI	On Line Data Interchange
ORM	Operational Reply Message
PAR	Precision Approach RADAR
PATCO	Professional Air Traffic Controllers Organization
PBN	Performance Based Navigation
PSR	Primary Surveillance Radar (PSR)
RADAR	Radio Detection and Ranging
REJ	Rejection Message
RPL	Repetitive Flight Plan
SAM	Slot Allocation Message
SAR	Search and Rescue
SES	Single European Sky
SESAR	Sky ATM Research
SLC	Slot Cancellation Message
SRM	Slot Revision Message

SSR	Secondary Surveillance Radar
UAC	Upper Area Control Centre
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	VHF Omni Directional Radio Range

2 Introduction

In these days flight plan processing rules the world of air traffic. No aircraft can depart from, arrive to, or just overfly a country without submitting a flight plan. Due to an enormous number of airspace users, a pilot is not able to decide to fly and do so immediately, but everything has to be announced in advance. A flight plan, containing details about the routing and aircraft characteristics, is passed to a particular operations center. This unit analyzes the data and accepts or rejects the flight plan depending on the information it includes. Flight plan distribution and passing the data to the air traffic control centers on the route belong to the responsibilities as well.

In the last two decades, the world has gone through the birth and development of flight plan processing systems. Although there is a certain flight plan consistency, systems in different countries vary. Some of the states stopped at the beginning, and their services work only in the most basic way, other systems grew in centralized flight plan managements offering not only validation and acceptance, but also correcting the imperfections or suggesting alternative routings which are more efficient regarding the time or fuel consumption. Flight plan processing systems work with a set of networks and altogether manage an enormous amount of information which are exchanged through the communication air to ground, or even ground to ground.

At one time operators are planning a route for an aircraft, and a few minutes later they have to change the whole plan due to weather conditions, airspace restrictions, or customer requirements. Flight plan processing systems represent an important, and frequently used component of air traffic. It depends on their functions whether they facilitate the whole process, or cause delays due to their imperfections. Therefore the thesis is aimed on the problematics of global flight plan processing systems.

There are three prime objectives the thesis is about to meet. The first goal is to look into the history, and follow the development of air traffic, air traffic control, and flight planning. The thesis is going to get into current numbers and show a picture defining the airspace traffic density as we know it today; starting with the early aviation, moving through the first flight and the beginnings of air traffic control, covering developments of air traffic connected with the Wars and technical innovations. The second aim represents a system description. Beginning with an overview and defining the basic terms in air traffic control and flight planning, as the two main components of a successful flight plan processing; mentioning the interaction and communication between them. Related is the point of describing four different systems – the Russian Federation, Brazil, Europe, and the USA, aiming at the last two as the two most efficient flight plan processing systems of Integrated Initial Flight Plan Processing System and En Route Automation System. The last objective is to show how flight plan processing works in real life and define the issues that can occur while operating flights throughout different countries with various flight plan processing systems. The thesis also includes practical city-pair simulation with generated flight plans and distribution addresses on which the problems are detected. A brief description of possible solutions coming from those examples is to be mentioned.

3 History Background

3.1 From the Past until Today

3.1.1. An Early History

People were always fascinated by birds and their ability to fly. At the beginning it seemed to be just a dream. Myths were created about humans being able to watch the ground from the air, and provoke the God by the desire of being closer to him. The most famous tale tells the story of Daedalus and Icarus, two men who were trying to escape from Crete with the use of artificial wings. Many more fantasies followed this legend. However, Leonardo da Vinci was the first one to think about flying as science. [1] Shortly before the turn of the 16th century his sketches demonstrated ornithopters inspired by birds flapping their wings. Many thinkers followed da Vinci's ideas, but the whole concept required deeper knowledge of aerodynamics, mechanics of flying and gear, so the development lasted for many more years.

Technical and scientific progress came during the 18th century; it was the Age of Enlightenment which followed renaissance and humanist ideals. Western Europe - France and Great Britain - represented main centers of these thoughts. People became interested in nature sciences and technical innovations which supported growth of physics, chemistry, and other fields. [2] Aviation belonged to new areas that were meant to be explored. The development of lighter-than-air and heavier-than-air machines started approximately at the same time, but due to less challenging implementation, successful hot-air balloons and hydrogen balloons were created a hundred years before the Wright's flight in 1903. The entire 19th century was devoted to balloons. A challenging problem appeared with the impossibility to direct the aircraft, because not people but weather and wind conditions had the control over it. Early solutions offered rudders but those contradicted physical laws; the development had to go further. In the late 18th century, Sir George Cayley became engaged with physics of flying. [1] He coined and defined basic terms like lift, thrust, or drag; designed a curve - shaped wing and confirmed that Bernoulli's equation from 1738 works for air as well.

In the 1850s people were trying to implement the world leading steam power (first acknowledged to James Watt in 1765) into the field of flying. John Stringfellow and Samuel Henson firstly used steam power for their monoplanes, and so the era of geared flying machines began. [3] However, soon it showed to be an inappropriate solution especially due to big weight of the machine. In the first half of the 19th century, internal combustion engine was invented as an effort to replace the steam power. After the successful development and implementation in other areas, the engine found its place in aviation. In the early 20th century, Alberto Santos Dumont created the first airship actuated by the combustion engine, and he was soon followed by Gustave Whitehead with his first airplane. One of the most important days for aviation came on December 17^{th} 1903 when the first controlled flight ever took place in North Carolina. A 12-seconds long success of Wright Brothers gained public interest, however, the air traffic had no practical use in that time. Later, in 1909, Louis Blériot´s flight across the English Channel showed, that there begins a new form of transportation. Followed by many more similar achievements, people have realized that this world could not be held without strict rules and limitations.

3.1.2 Air Traffic Beginnings

At the beginning, it was the airmail that gave birth to air traffic. The USA delivered almost 2 000 letters and postcards in 1911 during an International Air Meet, and for the first decade it appeared at the top of this field. [4] Three years later, Thomas Benoist started operating the first scheduled air service between St. Petersburg and Tampa in Florida. An 18-mile route which took about 23 minutes impressed passengers by saving time while flying over Tampa Bay instead of driving around it. However, the business died soon due to the end of the season and passengers using cheaper railroad transportation.

At the same time European states concentrated on the status of the airspace. They were discussing the ownership of areas above the countries; whether a single state has sovereignty over its airspace, and if it is possible for others to use it as well. [5] In 1910, 20 European nations gathered in Paris and established the basic principles influencing aviation at the first European Air Law Conference. Not the whole list of goals was met, but representatives managed to formulate several problems important for the future of air navigation. Due to a huge disagreement, the question of national territories was not answered, and neither was the right to fly an aircraft over a foreign state. During the World War One, air traffic played an important role in tracking enemy positions and movement of soldiers. It was the War that made Europeans look deeper into the airplane evolution. First air traffic companies were established, development went faster, airplanes' speed grew, and so it was needed to control and direct planes in order to avoid crashes. In 1919, the first Convention on the Safety of Air Navigation was signed. [5] 27 States established the International Commission for Air Navigation (ICAN). The idea of carrying passengers was invented in Germany. [1] Zeppelins made it start, and around 1920 France and the UK joined with the use of converted bombers. These flights created a calm but unusual air traffic density which caused collisions, not only but mainly connected to poor visibility. First rules needed to be applied – weather information exchange and separated tracks over the Channel were established. Few years later, the United Kingdom came with the rules of light signals around local airfields.

3.1.3 The Birth of Air Traffic Control

European air traffic services before the World War One consisted of data gathering and preparation of the information which were distributed to pilots before the flight. Technical support prior to take-off and after landing was also one part of an early air traffic control service, later advanced with the use of air ground equipment. The first air traffic controller (called starter) was an individual, generally an experienced pilot, responsible for keeping the airfield regulations. [6] He directed take-offs, landings, and taxying of airplanes, showed areas where the aircraft were supposed to park, kept records in the take-off books, confirmed necessary board documents, and, with the use of a rocket gun, allowed or denied landings while using green or red signals. Duties and possibilities of a starter ended by planes take offs. Outside the airport area the traffic was not that heavy, and so there was just a little need for an organized system. [4] The so called "see and be seen" practice became a simple and sufficient method of traffic avoidance. Pilots orientated themselves using their eyes only; at the airports there were flags, informative signs, wind sleeves, and – in the case of low visibility – warning lights or beacons. Pilot's visual range was about 3 miles, and he pursued curve-shaped routes. Following the shortest possible ways between two points came with the use of higher altitudes and better visibility. Compasses and maps with specific aviation data were important helpers.

Meanwhile, air traffic in the USA was still used mainly for the airmail service. Initially pilots worked only during daylight, but after sunset, airplanes were replaced by trains. In 1921 the U. S. postal service decided to do a daring experiment. [7] Four planes took off during the night following only a set of bonfires on their ways. James Herbert Knight was the only pilot who ended his journey successfully. With the vision of a faster service provided, U. S. postal service equipped some of the routes by rotating beacons, and started to plan overnight flights. Due to fast development and competition, the traffic got heavier. Not only the aircraft were faster, but there were hundreds of them in the airspace every day. It caused many delays. Federal regulations were needed and so in 1926 Air Commerce Act was signed. [7] This law made the Secretary of Commerce responsible for improving the navigation, establishing new routes and certifying pilots and aircraft. In the late 1920s, an air traffic net connecting Europe and the USA started to shape.

3.1.4 Development of an Early Air Traffic Control

After the World War One the number of airspace users grew. Not only leisure and sport activities made people want to fly. First commercial airliners tried to catch the attention and offered transports on various routes, military aviation expanded, and the development of airmail service went further as well. Balloons and airships were still quite favorite. Beside all that was mentioned, pilots needed to go through trainings to be able to handle the aircraft. With the increase in the number of flights, it was difficult to create reliable air schedules and maintain the world of aviation safe. An important and necessary component was the development of ATC.

Implementation of radio connection meant a huge progress while dealing with long distances between aircraft and ground. Communication was not kept as an open interview, but information, questions, and answers were converted into three letter codes starting with the letter Q, and sent and received in Morse code. [6] The use of so-called Q-code appeared to be very efficient due to its internationality; every crew knew exactly what those three letters mean without a need of translation to their native languages. Q code was a forerunner of current aviation phraseology. At the beginning, radio connection was used mainly for data compilation. Updated on the actual weather conditions or situation at the final airport, the pilot was still the one responsible for the flight. The possibility of crew to inform ground personnel about the continuation of the flight turned up to be useful as well. In the case of an accident or emergency landing, it could hasten potential rescue operations. Pilot updated the ground on the aircraft's location, altitude, wind conditions and other data. The ground controller kept record of these in the protocol. However, the illustrated message exchange did not have the character of an air traffic control, because all the responsibility stayed in the hands of the pilot.

Radio connection was not only about communication, but the research of waves spreading allowed to create directional antennas which were able to figure out the direction where the waves come from. [6] An operator conducted localizing of the aircraft with the use of a special wheel that allowed the antenna to rotate. The member of the crew who was responsible for keeping contact with the ground could send different Q-codes for either gaining the position from the ground personnel or calculating it on his own with the use of data from two different ground stations. The final position was specified in degrees and minutes of latitude and longitude, or, more often, defined with the use of kilometers from important points, e.g. bigger towns. The whole process took less than a minute. In Europe, Croydon Airport in London was a pioneer in this area. [8] Air traffic officers and radio officers were hired and created the first concept of controlling the aircraft based on radio position fixing. A new system that represented a first step for establishing the radio navigation was approved and introduced to the world in 1922. G. J. H. Jeffs, a British ATC employee, is the one connected with the development of the main part of the system. The service enabled constant position calculating, and it became responsible for distribution of navigational data, meaning at some point for the right routing of the flight. Radio networks were divided into several sectors, each of them had one main station which coordinated the cooperation among the other stations. Every spot had telephonic and radio telegraphic connection facilitating an immediate communication. Workers at those stations were the first air traffic controllers.

In the meantime, the USA did not lag behind. Lambert Field, known for Charles Lindbergh´s home field, took an action and became famous for hiring the first air traffic controller in 1929. [9] Archie League, a previous barnstormer, was the one who directed airplanes from the ground with the use of a pair of signal flags GO and HOLD (shown in figures 1 and 2). Few years later, the flags were replaced by light guns, which (with the help of colors and flashes) enabled to focus on one aircraft only. Cleveland´s airport was the first airfield to host a radio-equipped control room, and a radio receiver soon became a need for every aircraft. It helped pilots to orientate themselves in poor visibility conditions, and allowed them to communicate with the ground. Two important names in the ATC development are also Ear Ward and Glen Gilbert. [1] Ear Ward, an airmail pilot who worked for American Airlines, started to worry about heavy traffic and realized, more than others, that there is a need for proper rules in order to avoid air collisions. It was Mr. Ward who thought about radio as an important contact between all flights, because it enabled flow of information between anyone who could be affected by the presence of planes in the airspace. To make it successfully usable, he had to persuade all American operating companies to follow this method. And he did. Ward’s assistant, Glen Gilbert, has the credit for publishing these rules. No safe solution could be made without adherence of planes to the principles such as clearances provided by ground personnel. This was the milestone for establishment of an active air traffic control. Most of the rules are kept until today. The ground operator guided pilots to keep necessary separations between aircraft, informed them about weather and wind conditions and other traffic in the area. The idea of the ground operator was the one which developed itself into a position of an air traffic controller we know today.

 

Figure 2 and 2: Archie League at St. Louis Lambert Municipal Airport [9]

3.1.5 The Expansion of Commercial Aviation

During the 1930s commercial aviation started to grow, and the number of air traffic controllers likewise. In comparison with 9 300 miles of routes in 1920, ten years later the length grew to the unbelievable number of 28 900 miles. [4] At the beginning, air traffic represented the least safe form of transport. Not only, but also with the help of developments in the field of air traffic control and other aviation-related services, it slowly began to rise into the safest one.

As mentioned, before the essence of the radio-concept in Europe was based on ground stations which calculated direction towards the aircraft that was emitting. A huge network of air localizing stations was built to handle the traffic. The USA applied a system of radio directional beacons. The location of beacons and directions they emitted were set in order to specify the net of airways. Long-wave and middle-wave receivers were utilized to identify the signal. The system enabled the use of radio range also during an approach.

Constructers tried to use localizing antennas for aircraft, which would allow pilots to figure out their direction without any help of the ground personnel. [6] A solution did not seem to be that easy because the quality of localization depended on the size and location of the rotating antenna and the space on and inside the aircraft was limited. At the beginning, radio antenna was inbuilt symmetrically to the fuselage. A pilot had to turn the whole airplane towards the transmitter in order to get the location. Later an on-board radio compass was created. The antenna, located in the cover of the airplane, automatically turned to the particular direction by a special motor.

This direction was distributed to the crew. Aircraft used long-wave or middle-wave signals. The position of the ground transmitters, frequency and time of emitting was generally known.

"In the USA airlines began to press for coordination and tracking of flights beyond airports – along entire air routes." [7] Newark, Cleveland, and Chicago were three air traffic control centers authorized by the Commerce Department. In 1935 the first flight monitoring center was established in Newark, by 1936 all of them started to operate. The first Controllers used wall clock, area charts, notepads, radio transmitters/receivers, and mental calculations. Airplanes, represented by boat-shaped weights, were moved across the maps (as shown in figure 3). Pilots were informed about weather conditions and followed other necessary instructions. These "radio rooms" became forerunners for ATC centers. [9] The original ATC Service was under the control of the first involved companies. To become a global project, however, the control needed to be taken by states, and that is what happened. The Air Commerce Department took the control through a public service that became known as Civil Aviation Authority in 1936. During 1938 and 1939 new technical applications appeared and these were set as a standard ATC equipment. A few of them, like headsets and teletypes, kept working in many countries for lots of years, and in some parts of the world they are still used without any change.

An interesting fact is that the official term of air traffic control was officially adopted by British Air Ministry in 1939. [1] It was the UK, where the first ATCO (Air Traffic Control Officer) school started the same year. The control was divided into two fields – the Aerodrome (Tower) and the Area Control. Landing and taking-off from the ground including the area of about 3-5 miles around the airfield was the task of The Aerodrome. The rest stayed under the Area Control. The system, however, was not as perfect as it is today – airplanes' altitudes moved around 10 000 feet only due to their performance.

Figure 3: Controllers separating traffic using maps and shrimp boats [7]

3.1.6 Second World War and its impact

It might be sorrowful, but the fact is that the air traffic development is closely related to the military aviation and wars. Aircraft played a huge role in the Second World War. [4] There happened to be an enormous technological development which represented an explanation for a few hundred thousands of aircraft which were produced and subsequently destroyed in this period. An average speed of an aircraft was approximately 342 miles/h, the fastest machines, mostly jet-engine-experimental, could fly over 559 miles/h. Equipped with cannons, machine-guns, and bombs, the weight of the planes could grow up to six tons. The crew of the aircraft consisted of one pilot only.

Second World War brought along a lot of improvements. Although the basic idea remained the same, radio navigation allowed to be more precise than ever before when controlling the flights. It empowered pilots to navigate themselves with the use of radio signals only. Former equipment was replaced by Non Directional Beacons. [9] NDBs, as they were called, represented simple transmitters with an easy installation but with large amount of interference and less reliability under bad weather conditions. World War Two also detected problems of flying in high altitudes; therefore the first research with pressurized cabins was conducted. Probably the most important technological advancement came with the invention of jet engine, although its adoption by civil aviation took a few more years. Before the Second World War, jet engines existed in laboratories only. [10] The first of its kind, HeinkelHe178, was invented by a German physicist Hans von Ohain, and it experimentally flew in August 1939. Based on this advancement, Anselm Franc developed an engine suitable for a fighter. Me262 was the first jet airplane to fly in combat, but due to high fuel consumption it spent most of the time on the ground. Further in the West, Frank Whittle stood by the construction of the first British jet fighter, the Gloster Meteor. England shared its know-how with the U. S. and about 25 new engines of the company Rolls-Royce were sold to Soviet Union.

1944 was an important year for coordination of an international civil air traffic. It was the year when ICAO (International Civil Aviation Organization) was established. This topic is covered in chapter 3.2.

Radio Detection and Ranging (RADAR) appeared after World War Two. Originally created for military defense, the transponder helped in the area of friend or foe problem. *“Synchronized transmitter and receiver emit waves and process their reflections for visual display.”* [7] One big disadvantage was represented by a non-rotating antenna joined with bad accuracy of the target direction. The U. S. decided to use it only for the final landing tracks of the planes – these GCAs (Ground Controlled Approaches) seemed to be the first RADAR in ATC. The system was very flexible. The airplane, equipped only with a radio, was guided by a controller. It became favorite especially during bad weather conditions with poor visibility. This unique landing tool appeared at Heathrow in 1947. However, it could be used only for one airplane at a time, and guided the pilot to a certain decision height. In 1946, civilian control towers were equipped with RADARs, and six years later this procedure became a routine. Later the system was named The Precision Approach RADAR (PAR).

Instrument Landing system (ILS), developed in the late 50s, became a more precise way for landing. [11] Utilizing more equipment, both airborne and ground, it is possible to provide service for more than just one aircraft at a time. Another advantage is leading the airplane closer to the runway in comparison with PAR – from a distance of 20-30 miles before the runway threshold to a few feet above it.

In 1950 a radar with a rotating antenna allowed to monitor all flights approaching the aerodrome. [9] Aircraft's echoes were displayed as long light lines. The position information was the only one provided, a controller kept in mind the identity, and a pilot updated information about his altitude. Known as terminal radar, the system worked for guiding planes around the aerodromes. In 1951, Approach unit was created, intended to take care of the take offs and landings; large traffic density made controllers separate a special part for airport operations to maintain safety.

Standard NDBs became unreliable when operating long haul flights. Higher frequencies appeared to be more accurate and less likely to fail during weather changes. New type of beacons was invented, a combination of VOR (VHF Omni Directional Radio Range) and DME (Distance Measuring Equipment). [11] VOR was the one giving positional information relative to the device, and DME extended the distance of radio navigation. These two elements represented the most important navigation tool for the next years. They filled the airspace with more precision and allowed the traffic density to grow. Separation between airplanes could be smaller without the errors and tolerances of their forerunners.

3.1.7 Jet Era

In the late 1950s, the first jets appeared. A speed of 550 miles per hour and capacity of 181 passengers were the new numbers to work with. [7]

British De Havilland DH 106 1 Comet was the first jet commercial aircraft carrying passengers. 11 000 kilometers between Heathrow and Johannesburg were flown in 1952 under the control of British Overseas Airways Corporation. [12] The whole journey took, with a few stopovers on the way, 23.5 hours. However, after the successful start, first failures appeared, and during 1952-1954 Comet had series of tragic accidents. Subsequent investigation revealed the reason in material fatigue. Production was stopped for a while and constructors needed to transform some parts of the aircraft from the base. The renewal showed to be successful and the development could continue. In 1955, Comet 4 was the generation that stood against Boeing 707 in the first-transatlantic-flight competition. [13] Comet 4 was able to carry up to 100 passengers. British government scrupled to implement the new machine because it had doubts after the former failures. [12] However, everything went fine, and in 1958 two Comets 4 defeated Boeing while flying two transatlantic flights from London and New York. Both aircraft had to stop in Gander to refuel. Boeing 707 overcame the ocean three weeks later, but still became the winner with the capacity almost doubled in comparison with Comet 4 and the ability to operate flights during shorter time (with the speed of 476 km/h).

The first European jetliners were planned to operate middle and long-haul flights. Later, due to a few small changes, jet planes became economic even for domestic and shorter international routes. The French started to think about new planes shortly after the War and the project was financed by the government. The jetliner Caravelle took off for the first time in 1955. [14] It could carry between 55 and 65 passengers. The aircraft was not used for services within France only, Caravelle 6 flew in the service of United Airlines from 1961 until 1970. Soviet Union introduced its Tu-104 in 1956. [15] One year later Czechoslovak Airlines started to operate Tu-104 on the route Prague-Moscow and so they became one of the most modern airlines of that time. CSA were the only operator other than Aeroflot that could use this aircraft, and became the third in the world to offer scheduled jet services.

In the American world, there were three main aircraft producers during 1950s – Boeing, Douglas and Lockheed. Government sponsored them at the beginning (using mainly the money originated from airmail service), however, later the companies financed everything on their own. As mentioned before, Boeing was working on its 707. The plans started in 1952, but the concept was secret, and Boeing showed its new aircraft to the public in 1954 as the first American jetliner. [16] Firstly meant for the military purposes, and later transformed into a civilian version, the 707 could carry between 124 and 170 passengers depending on the cabin configuration. The first company which utilized the aircraft for the transatlantic flight was Pan American in 1958 on the route New

York-Paris, three weeks after the success of Comet 4. Later, Douglas and its DC 8 joined the American jet market. In 1956, the first commercial accident with more than 100 deaths occurred. Two aircraft hit each other over the Grand Canyon National Park and both crashed into the ground. Due to this accident, the control of air traffic in the United States moved forward, and the Federal Aviation Administration (FAA) was created. [7] FAA was responsible for safety regulations, navigation, and air traffic control for civil and military aircraft. In 1960, FAA started to require transponders with the possibility of sending radar beacon; this was necessary for identifying the aircraft. Controllers saw each radar blip as an individual flight, wrote it on a shrimp boat, and moved it along the map as mentioned before.

The implementation of jet aircraft had to bring along improvements in the field of ATC. During the 60s, the ATC world introduced Secondary Surveillance Radar (SSR). [9] With the use of existing radar technology (renamed to primary surveillance radars (PSR)), the responder was capable of replying to a signal sent by the ground located SSR. A number, which appeared on the radar display, represented an identifier of the flight. It helped the SSR not only to determine the position of the aircraft, but also automatically provide information about its altitude. Aircraft detection became much easier than before. Even today SSRs are used due to lower prices and cheaper maintenance.

3.1.8 EUROCONTROL and FAA

In 1958, 7 European states established a technical working group called EUROCONTROL which had the primary aim of discussing European aviation and problems that can occur. [5] Countries presenting their ideas and opinions were Belgium, France, Italy, Luxembourg, the Netherlands, the Federal Republic of Germany, and the United Kingdom. The set of participating people included both civilian and military delegates. Two years later, in 1960, EUROCONTROL was established as the European organization for the safety of air navigation. The act was signed by six of the former countries, excluding Italy. The organization’s goal was to quickly react to the growing technological and economic development of air traffic control. It was the first institution that started to integrate individual European states in the area of air traffic. The history and purpose of EUROCONTROL is described further in the chapter 3.2.

In 1958, the Federal Aviation Act established FAA in the United States. [7] The organization related to the first regulation efforts that appeared in 1926 due to the Air Commerce Act. The organization started to be responsible for regulation of all aspects of American civil aviation.

In 1966, air and ground traffic responsibilities were combined by the U. S. Department of transportation. [1] The institute took control over the FAA as well.

An agreement between FAA and EUROCONTROL was signed in 1964. [5] It represented a milestone in the cooperation between the USA and Europe with the aim of safe and efficient ATC service. The new arrangement meant free technical information exchange and sharing air traffic statistics within the two organizations.

3.1.9 Computers on the Scene

Air traffic controllers were becoming busier. Excluding the necessary stuff, there appeared to be several tasks, certainly not connected clearly to air traffic control, but fundamental within the whole process. Measuring distances and calculating times and speeds, passing the information manually through a telephone, these were just a few things that distracted the attention of many workers. The situation called for computer help to get rid of those tasks. After several experiments, starting already in 1956, FAA was the one that begun to develop complex systems. [9] First software allowed calculation, another one was responsible for transmitting and distributing the information within different control sectors. In 1965, a radar upgrade was introduced, and transformed the whole system into a computerized one, as shown in figures 4 and 5. *"Radar Data Processing (RDP) and Automated Radar Terminal System (ARTS) were able to show readouts*

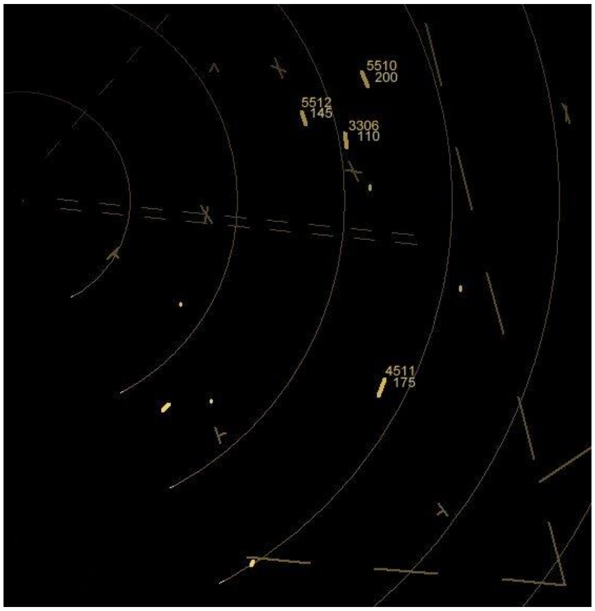

Figure 4 and 5: Air traffic controller using a radar [17]

of an aircraft's call sign, location, altitude, and speed." [1] Real data were received by all control centers and by about 60 busiest airports ten years later. Shrimp boats and maps became out of date. More developed systems included the Short Term Conflict Alert (STCA) which warned of possible loss of separation 2 minutes in advance. In 1981 the Traffic Collision Avoidance System was introduced.

Some of the computer systems developed in 1980 had already most of the functions that are available today. [6] A controller was able to record the radar data, calculate aircraft trajectories, update information connected to flight planning, generate alerts, store whatever number or fact he might need, and display all those data on the screens at the control center. All of this at one time.

3.1.10 Bad Times for the United States

The Professional Air Traffic Controllers Organization (PATCO) existed from 1968 as a United States Trade union. Poor working conditions made the personnel announce a strike in August 1981. [1] They required better salaries and wanted to lower the hours to 32 per week. However, being federal government employees, ATCOs broke the law by striking. President Reagan noted the strike as a danger to the national safety and asked the controllers to return to work. Only small amount of them did so. Reagan fired almost 11 400 employees who ignored the order with the ban of returning to federal service ever. FAA faced the loss of personnel, the number of flights was limited, there were new hires and some military controllers transferred from smaller facilities, which had to be closed, to bigger ones. PATCO was decertified and it lost the right to represent workers. In 1987, as the numbers of daily flights grew again, safety concerns appeared and air traffic controllers needed a union they could address their concerns to. National Air Traffic Controllers Association (NATCA) was founded. [7] NATCA promised not to declare an illegal strike ever but was actively pushing the FAA for improving the working conditions like hiring new people and installing new technologies. It works until today.

3.1.11 New Trends until present

A significant milestone in the history of civil air traffic (and air traffic control) was low-cost coming on the market. Already in 1944, during the Chicago Conference, the USA offered Europe an agreement regarding the liberalization of the market. [5] However, European countries were economically suffering after the World War Two, and they were afraid of the USA leading the business. [18] Agreements about prices and specified operators on specified routes were the only inputs of the discussion; practically it meant the operation of a single national airline in every country. The USA were the first ones to liberalize their domestic market in 1978. Southwest airlines became a model for all later low-cost companies. [19] In Europe, the UK and Ireland went into liberalization of their routes during the 1980s. It created good circumstances for the establishment of the first low-cost operator Ryanair. Europe enabled free prices and the law to conduct air traffic services on domestic market by a foreign company. [20] This gave the operators an absolute freedom in the means of routes, capacities and prices.

The big competition started and the traffic got even heavier. Increase in the number of roles that the ATC had to fulfill led to the first ideas about a sophisticated flight plan processing system which would adopt some of the responsibilities. In 1994 a European Integrated Initial Flight Plan Processing System (IFPS) started to collect flight plans for EUROCONTROL flights. Two years later Central Flow Management Unit (CFMU; today known as NMOC, Network Manager Operations Centre) started to coordinate the airflow through the cooperation with approximately 40 ATC centers. In 1996, IFPS was able to distribute all flight plans for CFMU area, and from 2004 the system works fully in the way we know it today. In the United States En Route Automation System (ERAS) was fully implemented in 2007 as the part of En Route Automation Modernization (ERAM).

One of the significant on-going EUROCONTROL projects Single European Sky ATM Research (SESAR) is a part of a Single European Sky (SES). SES, founded in 1999, states an initiative responding to the huge number of flights daily which need to be handled by ATM. The basic idea of the project is to transform current form of providing air navigational services in Europe with the aim to increase airspace capacities while keeping the high safety levels and maximal service quality. [21] EU countries are required to create a friendly background for controllers and service providers. SES concept, except for institutional changes and regulations, offers its own technological pillar represented by SESAR. SESAR is aimed on development and implementation of a new system for organizing of the air traffic for the 21st century. [6] The whole project targets mainly a more effective division of the airspace and modern air ground equipment and on-board tools. These new technologies and procedures enable aircraft to fly more direct routes, lower the fuel consumption, minimalize waiting time, and generally avoid or at least lower the delays. Simply, it helps the operators to plan the flight efficiently. Another current initiative that is worth to mention represents Continuous Descent. *"Continuous Descent Operation is an operation, enabled by* *airspace design, procedure design and ATC facilitation, in which an arriving aircraft descends continuously to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the final approach fix."* [21] In general aircraft create a lot of noise and atmospheric emissions that have a big influence on airports background and increase the operational costs. To mitigate the effects of air traffic Continuous Descent Operation (CDO) and Continuous descent Approach (CDA) were agreed on to be implemented in 2008. The principle of CDA is shown in figure 6. This concept brings not only economic benefits, but also enables to lower the effects on the environment.

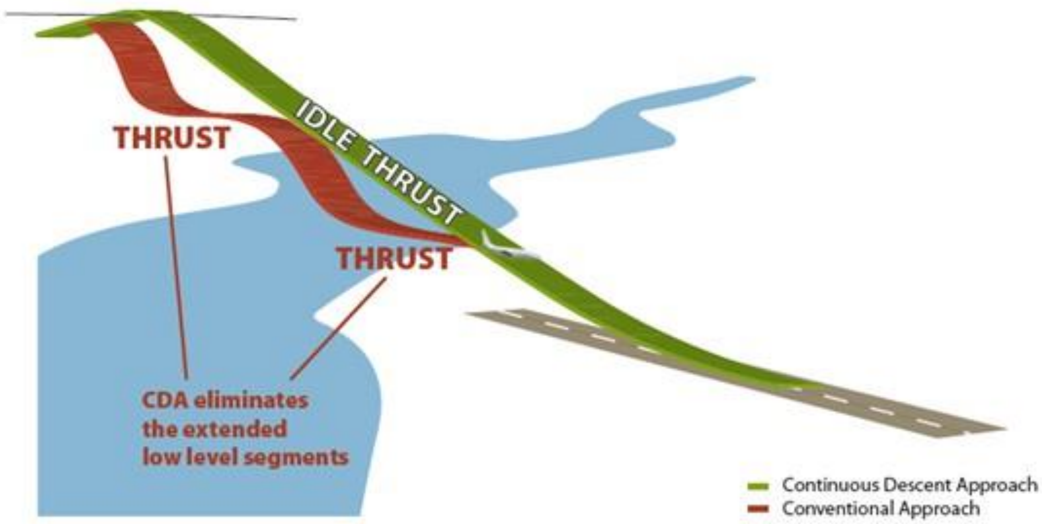

Figure 6: Conceptual Diagram of CDA [21]

Aviation became a significant stimulus for globalization in the fields of economy and politics all around the world. [22] The numbers in air transport were gradually growing during the years. The amount of passengers has increased ten times from what it used to be in 1970. [23] Cargo traffic registered growth as well. [24] The progress, which can be seen in figures 7 and 8, was possible mainly due to costs reduction connected with advances in air traffic efficiency and liberalization of the market in the USA and Europe. [25] In these days, travelling to further countries does not make any problems, and people use airplanes to go to holidays or business trips ordinarily. Therefore, air traffic has undoubtedly an important impact on tourism, economic structure of individual countries as well as on international market and investments.

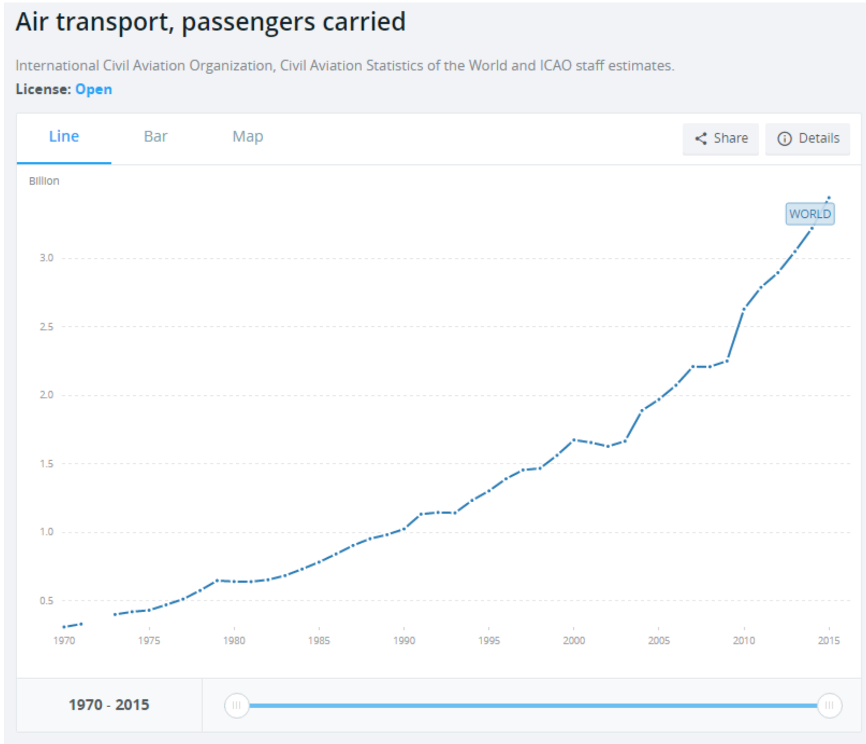

Figure 7: Passengers carried 1970-2015 [23]

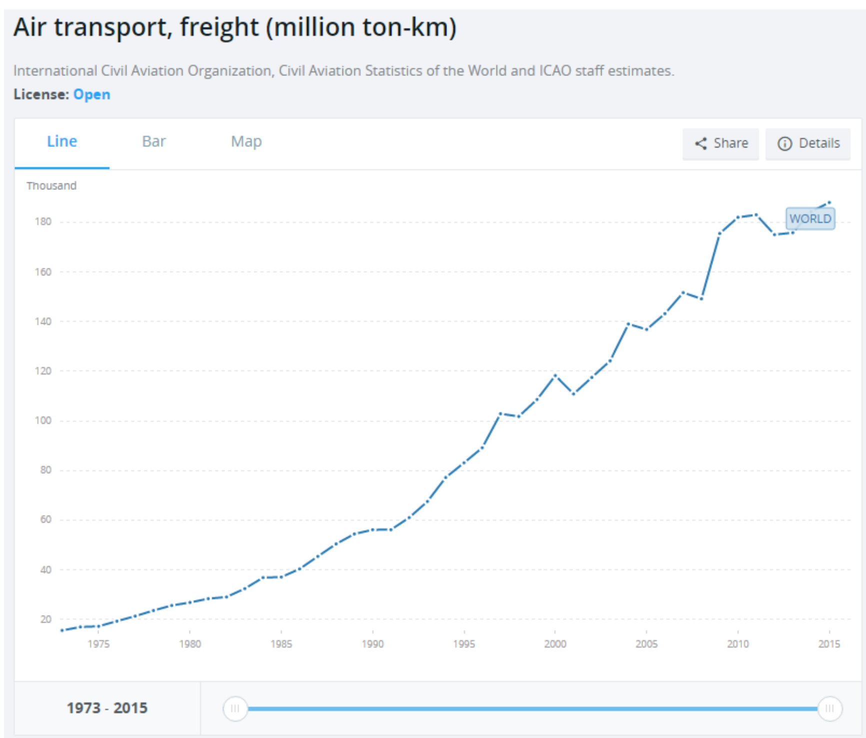

Figure 8: Freight carried in million ton-km 1970-2015 [24]

3.2 System Integration

3.2.1 Before the Birth of EUROCONTROL

Technical developments and increasing size of the air traffic brings along a growing demand for airspace capacities, ATC support, and especially cooperation and coordination of these services not only within Europe. The history of international collaboration leads back to the first Convention on the Safety of Air Navigation (1919). Following the same principles, the Convention on International Civil Aviation was signed in Chicago (1944). The agreement dealt with the question of national airspace sovereignty, standardization and cooperation in the field of air traffic from both the technical and operational side. It also set the rules for ICAO, International Civil Aviation Organization. [5] ECAC (European Civil Aviation Conference) was established in 1955 with the goal of progressive approach to safe, effective and sustainable European system. The start of jet planes was the impulse for the coordination in air traffic control services and use of airspace above Europe.

3.2.2. History of EUROCONTROL

As mentioned before, EUROCONTROL came from a working group in 1960. An international organization saw its main goal in the development of the best available systems that promised fluent air traffic control while keeping the high level of safety and low costs. [26] It started coordinating the actions of individual national air traffic control organizations and helping with international flights pans, developing new methods and technologies, and organizing the training of the air traffic controllers.

The former goal of EUROCONTROL was a total integration of the upper airspace above Europe under the control of one organization. [27] This plan, highly encouraged by ICAO, included an establishment of three controlling units for the whole Europe. The idea has not been accepted because countries were not willing to give up the sovereignty above their own airspace. However, during the international conference in Brussels, an agreement was signed about the cooperation when handling safety of air traffic control. The act came into force in 1963. An experimental center was opened in France four years later, and its goal was to research and develop procedures and technologies of the air traffic administration. In October 1969 IANS (Institute of Air Navigation Services) was opened in Luxembourg meant for providing necessary training of personnel from all member states. Later in 1971, a uniform payment system was created for the use of air traffic routes – every provider of the air traffic paid for the use of airspace depending on the lengths of the route and Maximum Takeoff Weight (MTOW). [5] The money were collected by the internationally uniform office, which divided these money into financing of navigational aids, air traffic control centers and others.

During 1970s EUROCONTROL was facing two main problems which were related to each other. An increased interest in air traffic and efforts to reduce the costs. [20] In 1971, Central Route Charges Office (CRCO) was created, and member-countries started to collect single fees for every flight that required the service of their air traffic control. [28] The system showed to be very effective. Air traffic demand was increasing and therefore international ATC centers needed to be established. In February 1972, the first Upper Area Control Centre (UAC) appeared in Maastricht, meant to cover the airspace above Belgium, Luxembourg, the Netherlands, and the north part of Germany. [5] The unit works until today and after London it is the busiest center in Europe. Two years later, UAC Shannon was created to handle flights between Europe and North America. UAC Karlsruhe started controlling the flights above the south part of Germany in 1977.

During 1980s and 1990s, the air traffic was still increasing. EUROCONTROL was not able to react appropriately, and many flights, mainly in the south and south east, were delayed. In January 1986, supplements were added to the original agreement, and the main goal of EUROCONTROL moved from a total integration to international cooperation. [5] At the end of the year, ministers of transportation met for the first time and discussed creation of a center which would coordinate the traffic flow above Europe, minimize delays, and increase the effectivity of transportation. CFMU started to operate and coordinate the flights of all twenty member countries on March 1996 and immediately created success; the ordinary delay was a half than in 1989. Implementation of IFPS improved the situation even more.

In June 1997, a new revised version of the agreement was signed, that added take-off and landing runways to the planning process, established partnership with new institutions, and strengthened cooperation of civil and military airspace users. ATC service in Central Europe was part of this revision as well. Changes included plans for UAC Vienna; [29] a center that is meant to control the traffic above Bosnia Herzegovina, the Czech Republic, Croatia, Hungary, Slovenia, Slovakia, Austria, and part of north-east Italy.

3.2.3 EASA and JAR

Prior to the establishment of the European Aviation Safety Agency (EASA), European air traffic was driven by Joint Aviation Authorities (JAA). JAA had the responsibility for publishing regulations, licensing, and certification standards for the aircraft and maintenance. [30] After long discussions and disagreements, a set of regulations was presented to reach the common ground between states. These rules are known as Joint Aviation Requirements (JAR). Until the ratification by national governments, JARs had no legal respect, but most of the European countries adopted them as the base for their national administration. JAA had no connection to the EU, and it was replaced by EASA in 2003. Most of the functions stayed. JARs were practically brought to EU legislation to bind all member states. They had the goal of simplifying the type certification while handling joint ventures and supporting export and import of aviation products. JARs were accepted by national authorities of all member countries as the base of compliance with the national airworthiness codes.

3.2.4 The FAA

Federal Aviation Administration, existing in the U. S. since 1958, fills the same function as EASA. Both of these offices are responsible for the certification of new aircraft for business use, and they have an agreement together about mutual acceptance of the aircraft certificates and pilot licenses.

4. System Overview

Regarding the flight plans and their distribution, there are two important components of a successful structure – flight planning and air traffic control. In this chapter, the thesis is going to define basic terms for both fields and briefly describe the interaction and forms of communication between them.

4.1 Air traffic Control

4.1.1 Definition of Air Traffic Control

According to the ICAO definition air traffic control is *"a service provided for the purpose of a) preventing collisions between aircraft, and on the manoeuvring area between aircraft and obstructions, and b) expediting and maintaining an orderly flow of air traffic."* [31] In general, air traffic control represents a service responsible for safety of all aircraft on the ground or in the air. Coordinating planes, organizing air traffic flow, and keeping sufficient distances between individual aircraft are the main tasks of ATC. Providing information and other additional support to pilots belong to its responsibilities as well.

4.1.2 Interaction with Flight Plans

According to Vít Soukup, FPL administrator at Air Navigation Services of the Czech Republic: *"During the flight planning phase there is no bigger interaction between FPL software (operator) and air traffic control. ATC starts to play its role as soon as the flight plan is submitted and ready for use."* [32]

Airspace generally is divided into several parts and within these segments particular controllers are responsible for tracking the aircrafts' movements. Copies of flight plans for all the flights entering the airspace are sent to ATC Units. According to the standards, ATC should get a particular flight plan a few hours before EOBT (Estimated Off-block Time). However the reality is often different. Operators submit flight plans at any time, even an hour or less before the estimated departure. These plans are mostly still accepted, and flight data are distributed further, arriving to ATC units even 30 minutes before departure. In Europe, flight plans get a special mark saying that they were late-filed or late-updated, but the whole process of distribution works as usual. While getting a message from EUROCONTROL, the operator knows the FPL was processed. The USA uses the same message system to inform the operator about the correctness of a flight plan, however, there are several ATCs/countries that do not communicate at all. In some cases, it is the pilot waiting for clearance who finds out first that the flight plan was not successfully processed. The system of flight plan processing and communication within an operator and ATC is further described in chapter 5.

One more component in the chain of actions is worth describing; this comes into place when ATC cannot automatically process the flight plan and accept it into its database. FDO (Flight Data Operator) represents a service of correcting the flight plan and updating it into a version ATC can work with. Flight plan incompatibility can be related to defects in routing or unfamiliar type of the aircraft. Once edited, the flight plan is filed into the ATC database and waits for the next steps. FDO does not concern the operator of the aircraft, it is used only on the level of air traffic control. Rejections causing a flight plan correction from the side of the operator are described in chapter 5.3.4.

4.1.3 Data Exchange between ATC Units

While an aircraft is in the air, the pilots are instructed by particular controllers in the segment. The ATC unit at the same time passes the information to the next country or airspace where the aircraft heads towards. OLDI (On Line Data Interchange) is utilized for flight data processing. Notes are sent from neighbor countries to inform about the new approaching aircraft. Two basic procedure messages that are important to mention are ABI and ACT:

- ABI (Advance Boundary Information) represents a notification message that is sent 40 minutes prior to aircraft's entrance to the national airspace. [33] It is a short piece of information that indicates a new plane requiring ATC attention. The system looks into its database and searches for an appropriate flight plan to correlate. If the particular plan is found, two strips are matched and ready for use. ATC is also able to create a flight record using the information from ABI message when there is no flight plan to correlate. In this case, AFP (ATC Flight Plan Proposal) needs to be forwarded to IFPS for distribution. AFP can only be sent by ATC and for airborne flights only. Beside the absence of the FPL in the database, other reason for AFP can be a rapid modification in the flight plan (for instance flight type change or unexpected transformation of routing).

- ACT (Activate Message) is received 15 minutes in advance of the aircraft. ACT automatically transmits *"details of a flight from one ATC unit to the next prior to the transfer of control."* [33] Information update is also one of the features that ATC works with. Previously representing just a mark on the monitor, the aircraft is correlated to the particular flight plan. ATC gets the real data, activates the flight plan, and starts instructing the pilot.

4.2 Flight planning

The main goal of flight planning is to determine the safest solution for the exact day and exact altitude. Many factors participate in creating the circumstances for particular time and situation and these are never the same for any flight. New calculations have to be prepared every time with the use of real data, current weather conditions, or any other details having potential influence on the flight. Cost expenses represent another important part of flight planning. Optimizing the plan in order to spare money on burning the fuel is a natural business component.

4.2.1 Flight Plan definition

ICAO definition describes flight plan as a *"specified information provided to air traffic services units, relative to an intended flight or portion of a flight of an aircraft."* [31] In other words, flight plan is a document informing about all important features of the flight. A pilot fills in a form which is then passed to different service stations, such as ATC or SAR (Search and Rescue), with the aim of informing them about the aircraft's route, characteristics, and other significant facts. A copy of the flight plan always stays with the pilot onboard.

In the past, distribution of a flight plan was quite a long lasting task. The work was performed manually; pilots filled a paper form and verbally delivered the data to the ATC unit via telephone. Although some parts of the world keep this system until today, most of the countries have moved to a digital version. With the use of modern technology, by pressing one button, FPLs can be sent to anybody. Two forms of flight plans can be seen - a full version or a shorter one. The full form includes a tabular description of an intended flight. The second option involves the same information but has the appearance of a message. Examples of both versions for one particular flight can be seen in attachments 1 and 2.

4.2.2. Flight Plan Description

Complex description related to flight plan filing is defined in ICAO Doc 4444, Appendix 2.

Every flight plan is required to include the following fields [34], [35]:

- **DATE OF FLIGHT**

  Date of flight (DOF) consists of a six-digit format YYMMDD, where YY symbolizes the last two digits of a year, MM is a representation of the month and DD indicates the calendar day. If necessary, all of them can start with zeros. When filling the flight plan, there is a possibility of using a pre-defined DOF & Time filling. Functions [+1] [+3] [+24hrs] automatically set the time and date of flight to one, three, or twenty four hours ahead of the current time. Flight is automatically assumed to depart in one hour if these fields are left empty. If the Time box includes a number that is less than 30 minutes ahead of a current time or even before, date of flight is automatically set for the next day.

- **MESSAGE TYPE**

  Message type indicates the purpose of the message, in this case it is FPL. Other possible message types are specified further in this chapter.

- **AIRCRAFT IDENTIFICATION**

  A maximum of seven characters is entered to specify the aircraft registration letters, or the company's label followed by the flight number. The aircraft identification has to include only letters and numbers; no dashes or other punctuation.

- **FLIGHT RULES**

  Flight rules are important to mention due to different regulations for IFR (Instrument Flight Rules) and VFR (Visual Flight Rules). There are four possible letters to specify the category which a pilot plans to comply with:

  - I for IFR
  - V for VFR
  - Y for an initial IFR flight followed by one or more flight rules changes
  - Z for an initial VFR followed by one or more flight rules changes

When Y or Z plan is prepared, VFR/IFR has to be included in the route string at all places of transition.

- **TYPE OF FLIGHT**

To denote the Type of flight, the following letters are used:

  - S for a scheduled air service
  - N for a non-scheduled air service
  - G for general aviation
  - M for military
  - X for everything else (X can be specified further in the flight plan using the field "Other information")

- **NUMBER**

If there is more than one aircraft, the number specifies the order. The box should be left blank otherwise.

- **TYPE OF AIRCRAFT**

Type of aircraft represents the aircraft manufacturer using its designator. Appropriate codes can be found online through an ICAO database (ICAO Doc 8643). If no label is assigned to a manufacturer, or there happens to be more than one type of aircraft in the flight, ZZZZ should be entered, and type specification should be included in "Other Information" box with the use of TYP tags. Type of aircraft determines its characteristics such as speed or possible altitude.

- **WAKE TURBULENCE CATEGORY**

Wake turbulence category is based on the weight of the aircraft:

  - L stands for light ones with takeoff mass of 7 000 kg/15 500 lb. and less
  - M stands for medium from 7 000 kg/15 500 lb. to 136 000 kg/300 000 lb. of take of mass
  - H stands for heavy with takeoff mass 136 000 kg/300 000 lb. and higher
  - J stands for Jumbo and is used exceptionally for heavy aircraft (such as the Airbus A380-800)

This specification is needed for segregation of the flights. There are general rules about how different categories can follow each other or not, and what minimal distances should be maintained.

- **EQUIPMENT**

Equipment includes the whole set of necessary COM, NAV and SSR tools which the aircraft has and can use. Individual things are represented by stated one-letter-suffixes. COM/NAV equipment and SSR equipment are separated by an oblique stroke. Regarding the flight plan sample in Attachments 1 and 2, S stands for Standard COM/NAV Setup which is considered to be VHF, RTF, VOR or ILS. If none of them is included, or the aircraft has some others, more suffixes need to be inserted to describe the equipment. If letters R (Performance Based Navigation) or Z (other equipment carried) are included, field “Other information” has to specify the corresponding PBN (Performance Based Navigation) data or other equipment. Surveillance equipment behind the oblique stroke indicates S which stands for transponder mode S, including both pressure-altitude and aircraft identification transmission. The whole list of appropriate suffixes can be found in ICAO documents. The most common pair of codes for general aviation is S/C.

- **DEPARTURE AERODROME**

Specific airports are represented by four-character indicators which can be found in ICAO Doc 7910. If the aerodrome is not specified in the document, code ZZZZ is inserted and the airport is specified in “Other Information” field using the DEP tag with either its name or specific location in degrees and minutes of latitude and longitude.

- **TIME**

Time indicates the exact time of departure. The 24-hour format HHMM includes two digits for hours and two digits for minutes, both pairs starting with zeroes if necessary. As mentioned before, the Time field can be automatically filled if the pilot chooses so when filling in the date of flight.

- **CRUISING SPEED**

Maximum of five characters can be inserted into the field starting with a letter N followed by the actual speed in knots, M (Mach number) followed by ratio, or K followed by speed in kilometers.

- **LEVEL**

A cruising level for the initial or whole segment of the route is inserted into the field. The format includes flight level, represented by letter F (F085 flight level 85) and followed by three digits, A (A055 5500 feet altitude) for plain altitude followed by three digits, S (S0150 means 1500 meters) as Standard metric level in tens of meters followed by four digits, M (m0610 6100 meters altitude) for plain altitude in tens of meters followed by four digits and V as uncontrolled VFR.

- **ROUTE**

A route is set by VORs, waypoints and other navigational aids which lead pilot to the destination. Created chain of points describes the path of an aircraft every 30 minutes or 200 NM of the flight. Intended changes of speed, level, track, or flight rules need to be included as well. Points can be distinguished by a code, their coordinates, or with the use of a reference point and distance from it.

- **DESTINATION AERODROME**

Airport indicators can be found in ICAO Doc 7910. Code ZZZZ is used for aerodromes not listed. The airport is then specified in the same way as the departure aerodrome, in “Other Information” field using the DEST/ tag.

- **TOTAL ESTIMATED ENROUTE TIME**

Total EET is indicated in the HHMM format.

- **ALTERNATE AERODROME**

As well as departure and destination aerodromes, specific airports’ codes can be found in ICAO Doc 7910. Code ZZZZ is inserted if the aerodrome is not listed and further specification in “Other Information” field is needed using the ALTN/ tag. The alternate aerodrome is usually set within 100 miles from the destination aerodrome; for VFR flight plans, alternate aerodrome is not required.

- **OTHER INFORMATION**

Other information field is meant for all additional, significant, or just useful facts which are not able to be mentioned in the previous boxes. The information is given and specified with the use of particular tags. The thesis has already mentioned DEP/, DEST/, TYP/ or ALTN/. Others can inform about the need of special handling (hazardous materials STS/HAZMAT), en route delay (DLE/) or any other necessary facts using the tag remarks (RMK/student training).

- **ENDURANCE**

A field indicating total fuel endurance in HHMM format.

- **PERSONS ON BOARD**

It shows the total number of people onboard involving both passengers and crew noted in three digits. If the information is not known during the flight planning process, code TBN (to be notified) can be entered.

- **EMERGENCY RADIO**

Listed is the radio specification. The data are following:

  - UHF while emitting and receiving at 243. MHz
  - VHF while emitting and receiving at 121.5 MHz
  - ELT when an emergency locator is available

- **SURVIVAL EQUIPMENT**
- **JACKETS**

Codes mean following:

  - LIGHT – lightning equipped
  - FLOURES
  - UHF/VHF if radio equipped

- **DINGHIES (NUMBER)**
- **DINGHIES (CAPACITY)**
- **DINGHIES (COVER)**

The field includes the information about potential canopies.

- **DINGHIES (COLOR)**
- **AIRCRAFT COLOR AND MARKINGS**
- **REMARKS**

The field Remarks includes other survival equipment which has not been mentioned or is specially worthy as an SAR information/operation

- **PILOT-IN-COMMAND**

The field includes a name of the pilot, phone contact is recommended.

4.2.3 Repetitive Flight Plan (RPL)

As described above, filling a flight plan is a necessary component for every flight due to the information it contains. If the flight is random, unique, or seldom operated, a new plan has to be created every time while executing the transport. However, bigger airlines do not have to file a flight plan every time they want to operate a specific route. For their regularly scheduled flights a repetitive flight plan can be utilized. According to ICAO definition, a RPL is *"A flight plan related to a series of frequently recurring, regularly operated individual flights with identical basic features, submitted by an operator for retention and repetitive use by ATS units."* [31] Repetitive flight plan is applicable to flights operated at least once a week; during the seasons they can be used even for charters.

4.2.4 Flight planning software

Prior to the development of computer technology, flight planning was based on maps, pens and papers. Operators built routes manually and calculated everything by hand. Just a tiny minority of countries and areas do it the same way today; mostly because they are not able to afford anything more innovative. However, current aviation fell in with flight planning software.

A good flight planning software is a key to get a coordinated and well-structured flight plan that maximizes safety and reduces costs to the lowest numbers possible. The program itself looks into the database, evaluates all possible routes, and picks up the one which is the most suitable. Different optimizations can be set in the program. Time represents one of them – being able to choose the fastest route possible. Weather conditions play an important role in comfort of the flight; an operator can choose a smooth route and avoid turbulences or any other complications during the flight. Permits are needed while crossing some areas, and if the flight has to be conducted quickly, it is desired to choose a route without any additional needs that could result in a flight delay. Political situation consideration also represents an optimization. Systems allow to automatically avoid countries in which the situation is not stable. These and many more elements serve as facilitators to operator because they help to quicken the flight planning.

4.2.4.1 URANOS

URANOS is a planning software developed by a Czech company NAV Flight Services. Since 1992, it represents a complex tool for IFR flight planning all around the world. Services include precise fuel calculation and flight costs which allow operators to optimize the money spent on a particular flight. Those calculations are based on performance data of the aircraft, and so URANOS is able to determine the best solutions for every flight. [36] Main functions involve route creation (such as auto-router or suggestion of a suitable airport), OPS board including submission of FPL and sending/accepting of related messages, calculation of OFP according to the performance data and User's data such as NOTAMs (Notice to Airmen) or overfly permissions. As stated by the developers, URANOS is unique for easy and intuitive control.

4.2.4.2 PPS

Preflight Planning System (PPS) is a flight planning software created by a Danish company Air Support. Due to the possibility of different update service packages, it provides a customized solution for every user - Air Support is able to offer solutions for specific operated segment as well as operational working space within the same unit. [37] Unlike the other products and their web applications, PPS uses standard installation to users' computers. The prime advantage of this method is data accessibility during a short-term Internet Failure. Major functions and features include route creation, calculation of weight and balance, or time and fuel needs involving reserves. Important parts of PPS are weather briefings, NOTAMs, or wind and temperature forecast charts. Lufthansa database is the main source for PPS. The software makes automatic update- information connected to the stored routes and notifies operators about significant changes. Everyone is able to refresh the data within 60 seconds using any ADSL connection.

4.2.4.3 LIDO

LIDO stands for Lufthansa Integrated Dispatch Operation and represents another flight planning software that helps dispatchers to find an optimal route for a particular situation. In 1995, an IT segment (later called Lufthansa Systems) was divided from Lufthansa and started developing software for different fields in aviation. As the other planning systems, LIDO promises to calculate the most efficient and reliable solution. [38] A web interface is used for distributing particular data in order to get the necessary information. According to their website, LIDO does not help only with the optimization of the flight, but it also provides a statistical analysis of the chosen routings.

LIDO represents twenty years of experience, and it is used by a total of 110 airlines all over the world including Air France, Emirates, China Southern, or Czech Airlines.

4.2.5 What happens with the Flight Plan

Submission of a flight plan is not the end of the process. As soon as the flight plan is ready and accepted, a set of procedures/checks has to be conducted.

Once an operator determines an aircraft's path, it is indispensable to review the entire routing and research requirements of individual areas regarding the fees, permits, and other necessary documentation. Overflight permit represents an approval from civil authorities to enter the country's airspace. Strict requirements are imposed by many countries while some of them do not ask for any special documentation. Most of the European states do not require overflight permits, but Middle East, Africa, Asia and America do. [39] Concerning landing requirements, the situation is almost identical. Permit-request processing lasts usually from three to five days, but e.g. Mongolia lets the applicants wait for up to fourteen days. In addition, specific routes all around the world cannot be used due to political reasons. Except for all mentioned above, operators have to cover special request forms, operating hours, or potential language barriers.

Some of the necessary checks represent also navigational and approach fees, landing, parking, and passenger service charges. The operator is required to cover these costs (if he is not identified, the owner of the aircraft takes this responsibility). Different countries have different fees calculation, state flight charges at military airports are waived.

In case of emergency, a flight plan serves as the base for Search and Rescue Service. SAR is responsible for coordinating searches and rescue missions, providing medical support, and evacuating survivors to safe places. As mentioned above, parts of the flight plan are devoted to survival equipment, capacity of the aircraft, or colors and markings it has. All these specific information help SAR, with the assistance of supportive entities, to find the aircraft and save human lives.

4.3. Communication

4.3.1 Aeronautical Fixed Service and Aeronautical Fixed Telecommunication Network

The Aeronautical Fixed service (AFS) is a set of networks providing data to handle air traffic. [43] The service is classified directly under ICAO and associates many voice and data networks and circuits, including the most important ones such as AFTN (Aeronautical Fixed Telecommunication Network), AMHS (Air Message Handling System) and CIDIN (the Common ICAO Data Interchange Network).

AFTN, as the worldwide first system of this kind, is responsible for a major part of the data interchange within AFS. Messages and digital data can be sent only between fixed stations with the same or at least compatible communication characteristics. AFTN transfers significant information such as Distress, Urgency, Flight Safety, Meteorological, Flight Regularity, Aeronautical Information Services, Aeronautical Administrative and Service Messages. [44] The system uses different priority indicators, and the most important messages are transmitted as the first ones (messages named above are set in the order of priority).

As shown in figure 9, the message format is defined in ICAO Annex 10.

AFTN is used by PPS with its AMEXSY (AFTN Message Exchange System) for transferring data and information between Air Support and all FIRs (Flight Information Region). URANOS utilizes AFTN as well. LIDO is compatible with AFTN and another network system SITA. SITA, however, is not spread worldwide (for instance American ERAS does not support it). Another solution can be communication via fax or phone calls, and manual filing in countries where the technology is not on that developed.

Message part		*Component of the message part*	*Elements of the component*	*Teletypewriter character*
HEADING	HEADING LINE (see 4.4.15.1.1)	Start-of-Heading Character	One Character (0/1)	SOH
		Transmission Identification	a) Transmitting-terminal letter b) Receiving-terminal letter c) Channel-identification letter d) Channel-sequence number (*Example:* NRA062)	......
		(*If necessary*) Additional Service Indication	a) One SPACE b) No more than the remainder of the line (*Example:* 270930)	→
	ADDRESS (see 4.4.15.2.1)	Alignment Function	One CARRIAGE RETURN, one LINE FEED	<≡
		Priority Indicator	The relevant 2-letter group	..
		Addressee Indicator(s)	One SPACE An 8-letter group given in sequence for each addressee (*Example:* **EGLLZRZX→EGLLYKYX→EGLLACAD**)	
		Alignment Function(s)	One CARRIAGE RETURN, one LINE FEED	<≡
	ORIGIN (see 4.4.15.2.2)	Filing Time	6-digit date-time group specifying when the message was filed for transmission	......
		Originator Indicator	a) One SPACE b) 8-letter group identifying the message originator	→......
		Priority Alarm (*used only in teletypewriter operation for Distress Messages*)	Five characters (0/7)(BEL)	
		Optional Heading Information	a) One SPACE b) Additional data not to exceed the remainder of the line. See 4.4.15.2.2.6.	
		Alignment Function	One CARRIAGE RETURN, one LINE FEED	<≡
		Start-of-Text Character	One character (0/2)	STX
TEXT (see 4.4.15.3)		Beginning of the Text	Specific identification of Addressee(s) *(if necessary)* *with* each followed by one CARRIAGE RETURN, one LINE FEED *(if necessary)* The English word FROM *(if necessary)*(see 4.4.15.3.5) Specific identification of Originator *(if necessary)* The English word STOP followed by one CARRIAGE RETURN, one LINE FEED *(if necessary)* (see 4.4.15.3.5) *and/or* Originator's reference *(if used)*	
		Message Text	Message Text with one CARRIAGE RETURN, one LINE FEED at the end of each printed line of the Text except for the last one (see 4.4.15.3.6)	
		Confirmation *(if necessary)*	a) One CARRIAGE RETURN, one LINE FEED b) The abbreviation CFM followed by the portion of the Text being confirmed.	
		Correction *(if necessary)*	a) One CARRIAGE RETURN, one LINE FEED b) The abbreviation COR followed by the correction of an error made in the preceding Text	
ENDING (see 4.4.15.3.12.1)		Alignment Function	One CARRIAGE RETURN, one LINE FEED	<≡
		Page-feed Sequence	One character (0/11)	VT
		End-of-Text character	One character (0/3)	ETX

Figure 9: AFTN Message Format [44]

4.3.2 IBS – INTEGRATED FLIGHT BRIEFING SYSTEM

The Integrated Flight Briefing System (IBS) is a program developed by Aeronautical Information Service of the Czech Republic. It is a service which assists pilots (or other users) during the pre-flight phase. IBS provides generic information in order to support the decision making, and it allows the pilot to perform a safe and efficient flight. The aeronautical information is obtained using the additional data from supplementary sources. [45] IBS has the goal of data accessibility enhancement during the preflight phase. However, the user has to pay attention to different services and different data sources, because it cannot be tailored to specific needs of an individual flight.

Users do not have to be registered to gain at least some of the information. NOTAMS, weather conditions, ATIS (Automatic Terminal Information Service), and AIP (Aeronautical Information Publication) are freely accessible. However, filing a flight plan, reviewing and modifying it, as well as the pre-flight preparation (shown in figure 10), requires registration.

Figure 10: IBS Preflight Bulletin [45]

5. System Description

To get a complex outline, the thesis looks at four specific examples; systems of the Russian Federation, Brazil, EUROCONTROL, and the United States. These were recommended by the ABS Jets Director of Ground Operations – each of them has a specific attitude towards flight planning. Although all of the countries are governed by ICAO standards, they still have several individual rules, regulations and requirements. Therefore, the pre-flight planning phase is important, it avoids complications and potential delays or cancellations. The chapter is devoted mainly to IFPS and ERAS as the two most perfect flight plan processing systems.

5.1 The Russian Federation

Although the Russian Federation is partially located in Europe, its ATC philosophy is slightly different from procedures that are followed by the rest of the continent. Rosaviatsiya, The Federal Air Transport Agency (FATA), was established in 2010, and it took over the control of civil aviation as a part of the Russian government structure. [40] Its duties include responsibility for air operations and navigations as well as traffic management system. Main Air Traffic Management Center (MATMC) is a part of State ATM Corporation of Russia which covers coordination of the Russian airspace utilization and organization of air traffic within the national area.

Two big differences were making operations into the Russian airspace inefficient in the past – language and metric system. Prior to 1991, neither air traffic controllers nor the pilots flying in the Soviet airspace were required to use English language when communicating with ground stations or other aircraft. In fact, most of them did not speak English at all, and they only used Russian. After 1983, three main ATC centers were equipped with translators who would be able to help in case of an English-only speaking pilot. [40] The second big issue represented the metric system. Flight levels, aircraft speed, wind speed, and rate of climb or descent; all measurements were given in metric units. Conversion charts belonged to indispensable tools.

Since the fall of the Soviet Union in 1991, the Russian Federation has changed significantly. Not only the nation itself, but different fields including aviation were affected as well. Over the years the situation was slowly becoming better. Since 2011, after an ICAO request, all international and domestic flights are conducted only in English. The metric system is not in use anymore, and so some of the obligations are out. However, particular differences still stay. For instance, altimeters are set to QFE, meaning that the air pressure is converted to the altitude of an airport. In Europe, the altitude is set to QNH, and altimeters indicate altitude above sea level. In the Moscow air zone, defined as the busiest one, many restricted zones appeared. When planning a flight, the operator has to avoid these areas, and use an alternative which may increase the costs. Also, non-Russian pilots are required to use international air routes only; crew's certificates have to be validated by the Russian authorities for using other parts of airspace. [39] Airport fees calculation is different from the rest of Europe, and crews need visas as well as the passengers. All these small differences create a big diversity, and they mean additional work while planning and operating a flight arriving into the Russian Federation or overflying its airspace.

In the last years, the Russian Federation has gone a long a way towards the EUROCONTROL standardization regarding the flight plan processing. ATC informs about the FPL status (using ACK and REJ messages, described further in the chapter 5.3.4), and it also communicates very well with the FPL initiator in case of any errors. A flight plan has to be submitted at least 1 hour prior to EOBT.

5.2 Brazil

In Brazil, ANAC (National Civil Aviation Agency) is the civil aviation authority responsible for regulations and safety of air traffic. Since 2006, ANAC has replaced Air Force's Civil Aviation Department when incorporating its structure and functions. The agency is subordinated to the Brazilian president. Safety and efficiency management come under the Department of Airspace Control (DECEA). DECEA is a governmental organization that provides Air traffic management, Aeronautical information system, Meteorology and cartography, Information technology, Flight Inspection, or Aeronautical Telecommunication. [41] Brazilian ATC service is provided mainly by the military personnel.

When planning a flight over the Brazilian airspace, landing permits are compulsory for every stop regardless of the type of flight. [39] A request has to be sent in advance. After landing and paying the landing fees (those cannot be paid in advance), a flight plan including next routing is validated, both for destinations within Brazil or outside the country. Once the FPL is validated, it takes 45 minutes until it becomes active. Next 45 minutes represent the time of activity when the departure is possible. Potential delays must be announced 30 minutes after the FPL becomes active. If there is more than just one stop in Brazil, domestic overflight permits are necessary. [42]

There are few airspace restrictions in Brazil, but all flights between Brazil and Europe, as well as between Brazil and Africa, must use specific entry and exit points published by NOTAMs. Particular routing can be different according to the destination. NOTAMs, being set for every airport, also cover requirements for FPL information included in the field 18; these are landing permit number (when necessary), name of aircraft operator, pilot's license number, previous departure airport, and receipt number for the payment of landing fees. [42] Any missing or incorrect information from the operator's side causes rejection of the FPL. The biggest issue is that the ATC does not communicate the rejection towards the operator - usually it is the pilot waiting for clearance who finds out. This fact represents a problem mainly for international operators. After filing the new version, another 45 minutes are applied to make the FPL active. Correction and resubmission of a new FPL can be made via AFTN or by phone to ATC.

NOTAMs are changed frequently, and some of them are available only in Portuguese. Controllers at smaller airports prefer to speak in their native language, and even if they speak English, it is not well understandable. Some ATCs are Portuguese-speaking only.

5.3 Europe and USA

5.3.1 Europe and IFPS

In the European *states "to ensure successful distribution of flight plans to air traffic service units, a flight plan that accurately represents the intentions of the flight must be submitted to, and acknowledged by the IFPS before the flight may operate under IFR as GAT within the IFPZ (IFPS Zone)."* [46] Centralized flight processing and distribution service is the task of NMOC. All planes entering, departing, or just transiting Europe within the general air traffic are required to file a flight plan with the Integrated initial flight plan processing system managed by NMOC. IFPS is responsible for the distribution of flight plans and associated messages to en route ATCs within the IFPZ (see figure 11). Flight plans are initially addressed to two units – Haren in Brussels and Bretigny in France. The interaction runs via both AFTN and SITA networks.

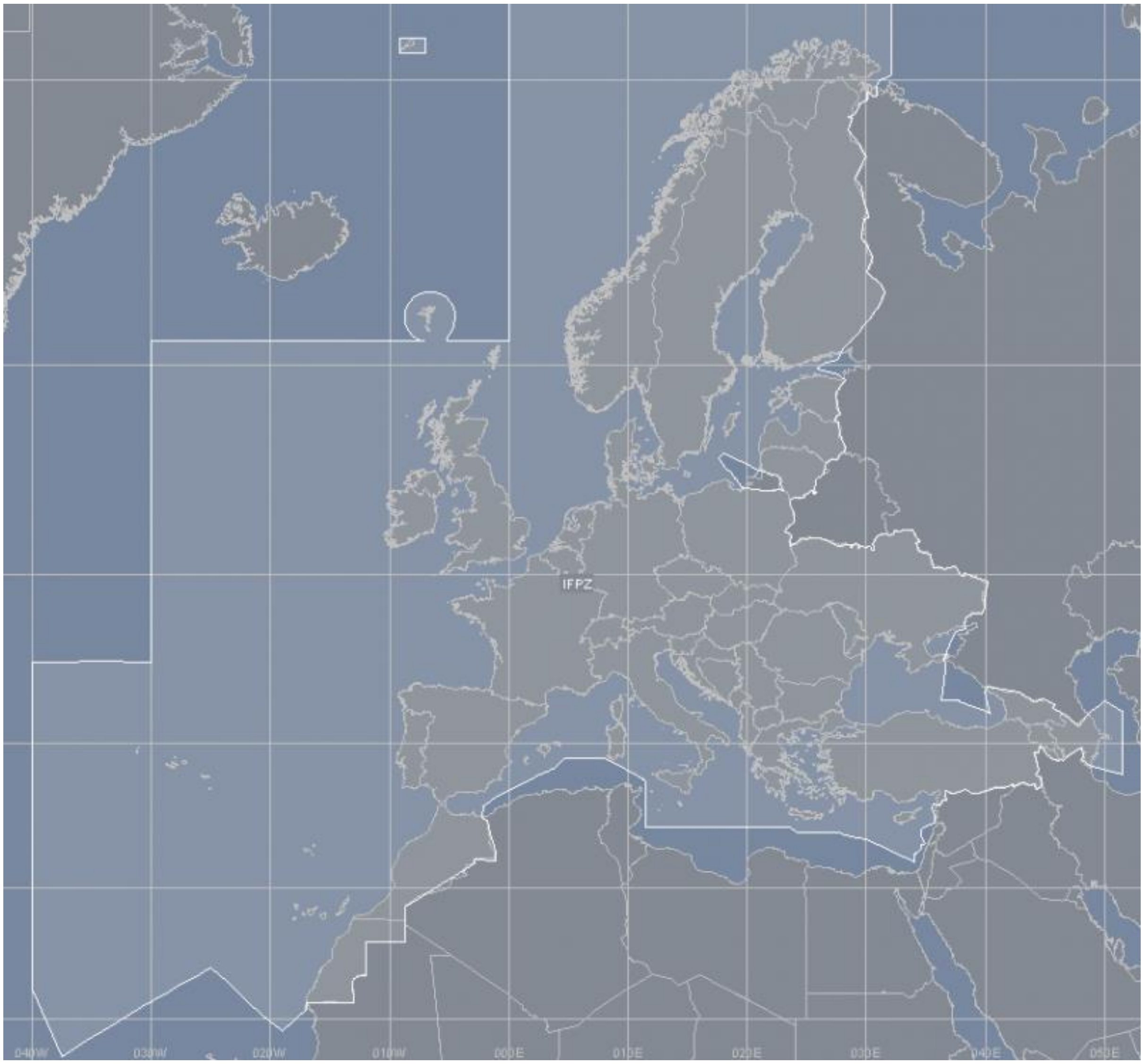

Figure 11: IFPS Zone [47]

Overflight and landing permits for EU members are generally not required, other countries might need special permits or documentation. [39] Some European aerodromes require airport slots for landing.

5.3.2 USA and ERAS

ERAS is a tool for filing flight plans within the U. S. domestic area under the control of FAA. [48] Flight plans and associated flight planning messages, corresponding to ICAO format requirements, are submitted via AFTN. ERAS checks the standards and formats, identifies the content, and decides whether the message can be processed or has to be modified before being acknowledged. Flight plans can be send up to 24 hours in advance of EOBT. Overflight and landing permits are required, permit numbers have to be sent to the Flight department or printed on Operational flight plan. If there is a change in the itinerary (for instance landing at a different airport than the initial one), permits can be changed for no charge. In addition, there are particular US airspace entry points which need to be kept.

5.3.3 Submission of a Flight Plan

IFPS and ERAS have a lot in common, but there are also numerous differences to consider. Both the European and American systems distribute flight plans and associated messages via AFTN network with the use of ICAO message format. Except for that, IFPS applies its own system ADEXP (Air Traffic Service Data Exchange Presentation) for data exchange within IFPZ.

Flight plans within Europe or the U. S. domestic airspace should always be submitted to the IFPS or ERAS for processing. IFPS requires to have a flight plan at least 3 hours before EOBT and not more than 120 hours in advance. Regarding the repetitive flight plan, the time border is moved to at least 20 hours before the aircraft is ready to commence moving to depart. ERAS allows to submit a flight plan only 24 hours in advance of EOBT. Modifications or complete replacements of flight plans are possible for both systems, up to a set time before EOBT; the standard is usually 30 minutes. Any flight-changing messages sent less than 30 minutes before the departure are automatically rejected. Possible cancelation of a filed flight plan is set to 30 minutes before EOBT as well.

5.3.4 Flight Plan Processing

Once an originator sends a flight plan, IFPS/ERAS processes it and sends a response. IFPS calls these responses Operational Reply Messages (ORMs). Messages serve as indicators of a flight plan status. There are two potential responses the FPL originator can get – ACK and REJ. The Acknowledgement (ACK) Message is sent when the flight plan is successfully processed; in this case IFPS/ERAS decides there is no error in the outline. While processing the message, IFPS does not take into consideration parts of the flight outside of IFPZ, and therefore it cannot ensure the correctness for those parts. Also, criteria such as ETOPS (Extended-range Twin-engine Operational Performance Standards) requirements are not a part of IFPS' job, and it is the responsibility of the originator to check all other obligations after receiving and ACK message. ACK does not necessarily mean that the flight has passed without any changes. IFPS can indicate some minor imperfections and correct them. To reveal whether any modification were needed, two formatted ACK messages can be sent – a short version or a longer report mentioning the transformations.

Reject (REJ) Message is sent by IFPS/ERAS in the case of an unsuccessful FPL processing. When receiving it from IFPS, every REJ includes an error list explaining the defects. The originator has to correct the message on his own, and re-submit it again in order to get the ACK message.

The European system uses one more ORM, and that is the Manual (MAN) Message which indicates manual processing of the message. If the FPL does not pass the automatic system, it might be transferred to an IFPS staff person who tries to make changes and correct the flight plan to an acceptable form. MAN message is always followed by either ACK or REJ message.

5.3.5 Other Messages Processing

Beside FPLs, IFPS/ERAS accepts and processes other messages too. While IFPS refers to them only as associated messages, ERAS divides them into three categories – Modification (CHG) Message, Delay (DLA) Message and Cancel (CNL) Message.

CHG message is used to modify any FPL part. There are several rules related to the message syntax that need to be followed, e.g. one CHG can change every FPL field only once. The CHG message also has to be sent from the same source as the FPL it refers to.

The purpose of DLA message is to change the intended departure of a submitted FPL. This modification, however, can be communicated via DLA only within the same date of flight. In the case of a delay and estimated departure after midnight, ERAS needs to get a CHG message to properly process the modification and change the date of flight to a next day.

CNL message indicates cancellation of a filed FPL.

CHGs, DLAs and CNLs can be acknowledged or rejected in the same way as FPLs. A complete list of messages can be seen in table 1.

Table 1: Message Overview

OPERATOR	IFPS	ERAS
FPL	ACK / REJ	
	MAN	
CHG	ACK / REJ	
	MAN	
DLA	ACK / REJ	
	MAN	
CNL	ACK / REJ	
	MAN	

5.3.6 Slot Allocation Process and Associated Messages

To understand the idea of slot allocation, the Air Traffic Flow and Capacity Management (ATFCM) has to be mentioned. *"ATFCM is a service that is enhancing ATFM with the objective of managing the balance of demand and capacity by optimizing the use of available resources and coordinating adequate responses, in order to enhance the quality of service and the performance of the ATM system."* [49] The slot allocation is implemented for departures from ATFCM area or from ATFCM Adjacent area when entering ATFCM area. A map in figure 12 shows the areas' boundaries. The system of slot allocation enables ATC to delay the aircraft on the ground for longer time in order to keep the optimal capacity in the air.

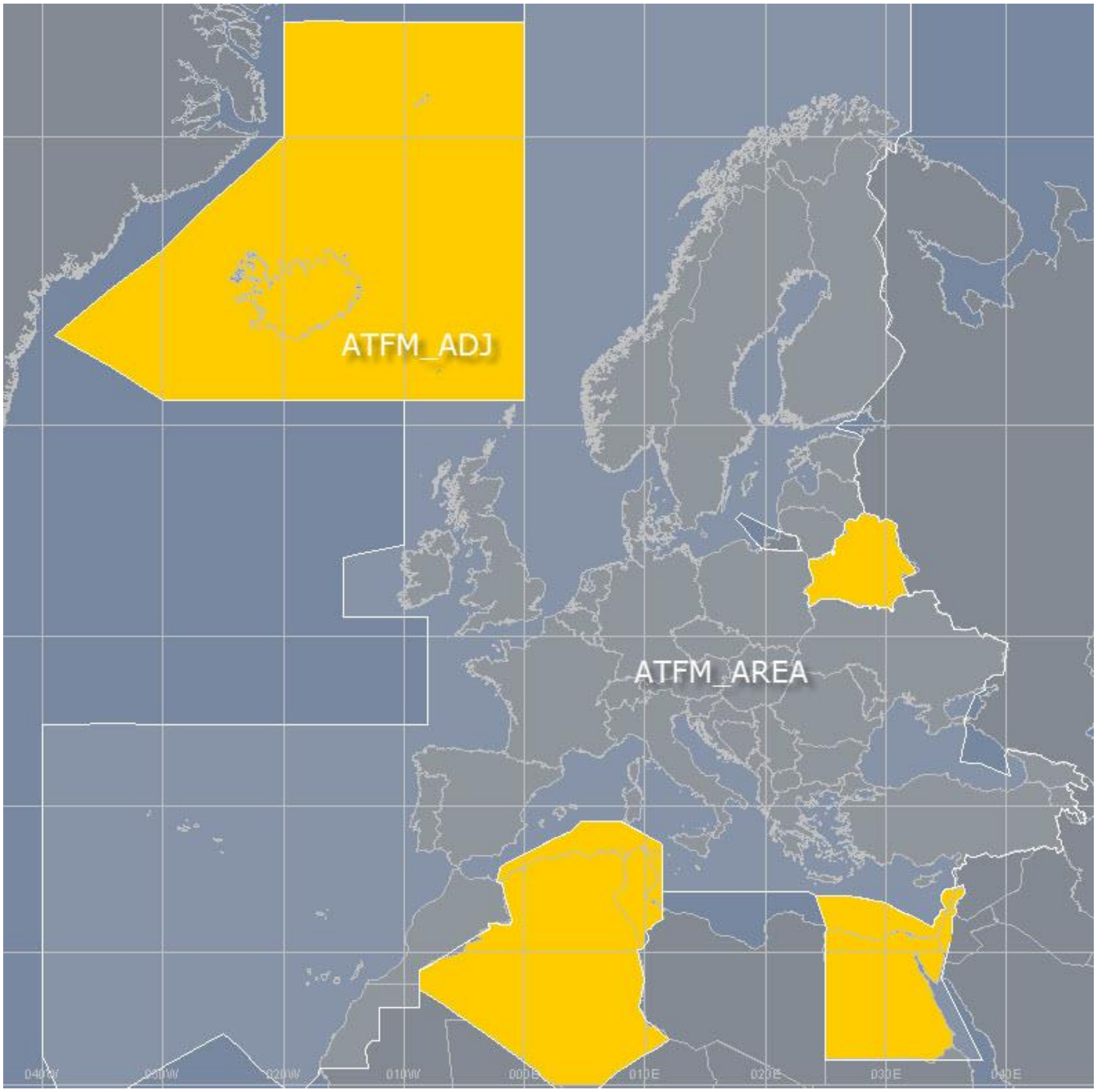

Figure 12: The map of ATFCM Areas [50]

Computer Assisted Slot Allocation (CASA) is an automatic and centralized system. The Network manager in cooperation with FMPs (Flow Management Positions) considers situation in the airspace, activates regulations where it is needed, and sends information about the restrictions to EFTMS*. "In accordance with the principle of "First Planned - First Served," the system extracts all flights entering the specified airspace and sequences them in the order they would have arrived at the airspace in the absence of any restriction."* [49] Take-Off time is calculated and the aircraft gets its CTOT (Calculated Take-Off Time) which is then passed to the operator and to ATC at the departure airport. Flight plan is active for +/- 15 minutes, CTOT is active -5/+10 minutes.

By filing a flight plan with ACK response, an operator automatically forms a request for a slot (the automatic request comes with RPL as well). Once the regulation is active, CASA starts to evaluate data from FPLs and RPLs, and every flight gets its provisional slot depending on the flight's ETO (Estimated Time over), however, this slot is expected to be modified. Particular time frame, no more than two hours before EOBT, a Slot Allocation Message (SAM) with a CTOT is distributed to the aircraft's operator and ATC. Such slot is created for all flights concerned by the regulation. In some cases, operators are willing to use the later departure time, and so they are able to "freeze" the slot and keep it by sending a specific DLA message to IFPS. However, by default all flights are in the status RFI (Ready for Improvement) and if there is any improvement (earlier departure) possible, Slot Revision Message (SRM) is sent automatically with the new CTOT. SRM can also be sent as a response to a DLA or CHG messages initiated by the operator. Slot Cancellation Message (SLC) comes when restrictions are canceled, and aircraft can depart without any delay – a flight gets back to its original departure time mentioned in the accepted FPL. If the aircraft misses its slot, Flight Suspension Message (FLS) is received and the flight stays suspended until a DLA message is distributed to create new EOBT.

An overview of associated messages is shown in table 2.

Table 2: Associated Messages

OPERATOR	ATC
FPL	CTOT
	SAM
	SLC
	FLS

5.3.7. Flight Plan Distribution

5.3.7.1 IFPS

In the past, a captain came to ARO (Air Traffic Service Reporting Office), gained the necessary information about his flight, and submitted a flight plan. ARO officers created a mental 3D trajectory, and sent the FPL to all air traffic units along the route.

Today there is the IFPS to simplify and expedite the process. From ARO (or directly from the aircraft operator or agency), flight plans are sent only to IFPS. The system creates a 4D trajectory and passes the flight plan to individual ATCUs (Air Traffic Control Units) on the route. As shown in figure 13, a copy of a flight plan is also sent to ETFMS (Enhanced Tactical Flow Management System). ETFMS represents, among other things, a database including capacities of individual regions. Every air region has its own capacity, and every airport defines the maximal amount of take-offs and landings per hour. The regions are united into bigger sectors which are characterized by their own hourly capacity. ETFMS continuously projects all processed trajectories into the European airspace, and it ensures that the traffic never exceeds the capacity. Results are provided to ACCs that work with them when controlling the traffic above their area.

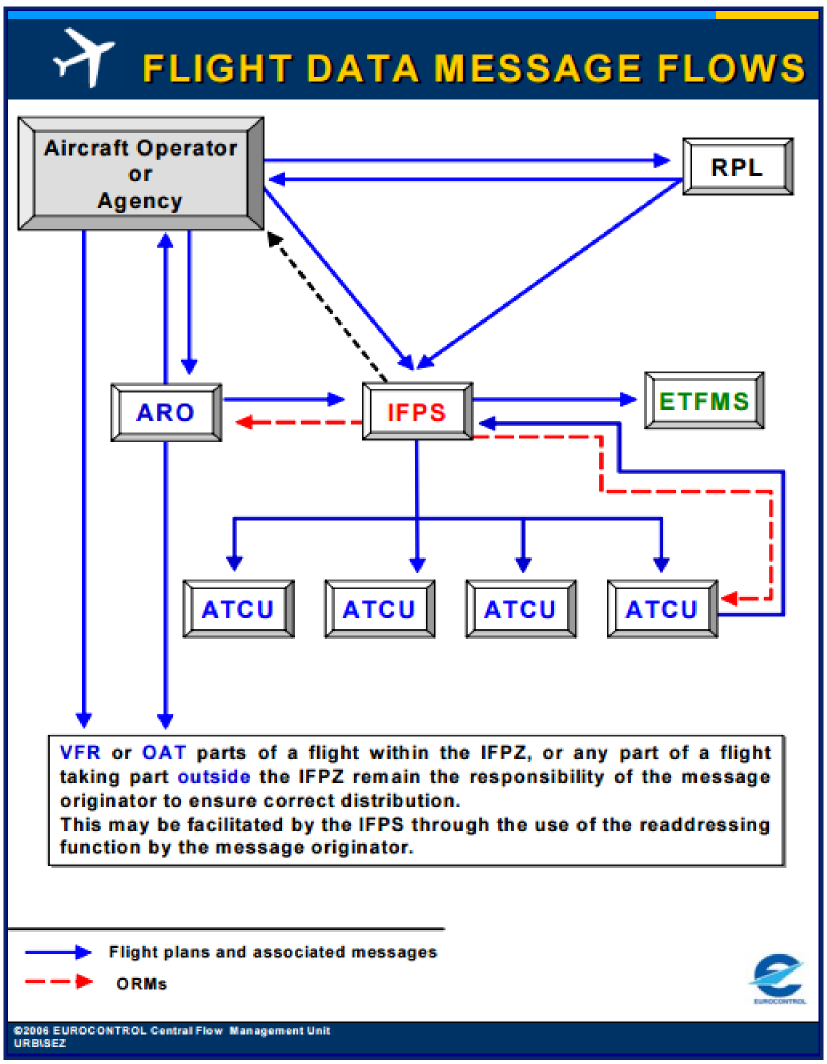

Figure 13: IFPS Flight Data Distribution [46]

5.3.7.1 ERAS

Flight plans sent to ERAS are distributed according to the routing they have. For flights remaining within the U. S. domestic airspace, FPL is sent only to the ARTCC (Air Route Traffic Control Center) of the departure airport, and flight data are automatically passed to each ARTCC on the flight route. While leaving the U. S. domestic airspace, a FPL is distributed in the same way - ARTCC of the departure airport is the only one to get the data, and these are then automatically forwarded further along the route. For aircraft entering the United States from or through Canada, FPLs are automatically passed from Canadian Automated Air Traffic System (CAATS), and so there is no need of any action. Sending a flight plan would only cause duplicates and processing problems. For the entrance from all other countries, except for Canada, a flight plan is distributed to the first U. S. domestic FIR on the route, further distribution is automatic.

6. FLIGHT PLAN PROCESSING ISSUES

The previous chapter has described different FPL processing systems. They have many similarities but several differences as well. By being interlinked and made to cooperate together, the diversity can cause problems. The practical part of the thesis looks at specific examples of issues that occur due to the imperfections and incompatibility of flight plan processing all around the world.

6.1 Specific City Pairs Simulation

The thesis works with four specific city-pair examples; each of them represents one of the systems listed in chapter 5. FPLs and distribution addresses are attached at the back of the thesis. All four examples represent IFR general aviation flights, and they are planned from Prague.

6.1.1 Prague - Venice (LKPR / LIPZ)

Entirely European flight is the first example (see attachment 3). As stated in the field of distribution addresses, this flight plan would be sent by default to two AFTN addresses (Haren and Brétigny). Letters “EU” at the beginning indicate a station location in EUROCONTROL IFPS zone. Each of those stations has control over a half of the airspace units, however, to make it easier for operators, flight plans are automatically sent to both. Haren and Bretigny distribute flight plans further, to ATCUs on the route, as described in chapter 5.3.7.1. Regarding the flight plan itself, no special requirements appear in comparison with usual flight plans. If the FPL is filed properly, no misunderstandings should occur regarding the processing because the whole flight is going to be happening within the IFPS zone. FPL distribution within the IFPZ takes only a few seconds, and if there are no irregularities the process should go smoothly.

6.1.2 Prague – Moscow (LKPR / UUEE)

Second example represents a flight from Prague to Moscow (see attachment 4). Although we are still in Europe, distribution of this particular flight plan would be more complicated. Beside Haren and Bretigny, the data have to be passed to the Republic of Belarus and the Russian Federation. Neither of the two is a member of IFPZ, but they both get a copy of a flight plan to work with. Minsk ACC (indicated by letters "UM" at the beginning of the distribution address) is the one responsible for distribution of the flight plan to Belarus stations. The Russian Federation (indicated by "UU") is using particular central addresses that passes flight plans domestically. Prague-Moscow flight does not require any special information to be added into the flight plan.

6.1.3 Prague – Chicago (LKPR / KORD)

The third example is Prague-Chicago route (see attachment 5). Flights planned from Central Europe to the U. S. airspace have some specifications because part of the fight takes place above the Ocean where no ATC units are located. To cover the part of the flight within the IFPZ, a FPL is sent to Haren and Bretigny as usually. Then, the data do not go straight to the United States, but have to be sent to the oceanic FIRs. Above the North Atlantic airspace, there is a system called Organized Track System (OTS) which defines particular routes ensuring sufficient horizontal separation between airplanes. Two area centers control the traffic, Gander driven by Canada navigational services and Shanwick as a British-governed center. In this particular example, Gander FIR is the one used (defined by "CZ" letter code at the beginning). Gander would be responsible for passing the data to the first U. S. domestic FIR on the route, and the flight plan distribution would continue normally as described in the chapter 5.3.7.2. A copy of the flight plan is also send to Greenland (defined by "BG" code). Flight plans from Europe to the United States do not have to meet additional special requirements.

6.1.4 Prague – Sao Paulo (LKPR / SBGR)

A flight from Prague to Sao Paulo is the last example the thesis works with (see attachment 6). Haren and Bretigny are still on the list of distribution addresses because the flight departs from Europe. Except for some Brazilian stations (letter code "SB"), a flight plan is also automatically sent to units at Senegal ("GO") and Cape Verde ("GV") which are airspace units on the route. Regarding the flight plans, Brazil defines special requirements every FPL must have in order to be accepted. Some of them are defined in the chapter 5.2, however, as mentioned, it is always necessary to follow NOTAMs and incorporate any updates that can occur. Because the thesis works with simulations only, remarks in the field 18 are only mentioned, but they are specified as to be announced. All information should be updated in time to ensure the acceptance of the flight plan.

There is one more interesting fact to mention. If an aircraft takes off in the Czech Republic, EUROCONTROL is responsible for accepting the flight plan and giving clearance to the aircraft. As stated before, IFPS represents a flight plan processing management assisting with filing the flight plans corresponding to ICAO standards only. Practically, IFPS would process a flight plan without the permit number being mentioned in the field 18. The aircraft would take off, and ATC units on the route get its flight plan as usual. Data would be passed along the route, and Brazilian ATC would have to request the permit number. However, when planning a flight back to the Czech Republic, the situation is different. Because of the departure from Brazil, aircraft without a properly filed flight plan would never be able to leave the airport.

6.2 Defining the issues

The simulations listed above illustrated flight planning in the reality. After acquiring an insight into the topic and discussing the problematics with the ABS Jets Director of Ground Operations, the six following issues were identified.

6.2.1 FPL Processing/Filing Time

As the requirements mentioned in the manuals state, FPLs should be filed particular time before EOBT. This fact, however, makes the flight planning much harder while considering weather changes, jet streams, or situation at the destination aerodrome. Weather variability is something that every operator has to count with, whether it is on the route or at the airport. There is a possibility of a storm when a plane has to fly around some areas, jet streams can increase or decrease the aircraft speed, and the time of flight can change as well. There is also an uncertainty regarding the amount of fuel. All these aspects can – and do – affect the flight planning and might be the reason for a delay in the submission of a flight plan.

Most countries have various rules regarding the FPL filing, and time requirements represent quite an issue when planning a flight from Europe to any destination outside of the IFPZ. For instance, ERAS does not require to have DOF included because the FPL should not be submitted earlier than 24 hours before departure. ERAS cannot store the data, and so it is the responsibility of the operator to send the flight plan exactly on time. When planning a flight to the United States, considering the time change, an operator can prepare the flight plan approximately 6 hours before EOBT. At the same time, in Brazil, a flight plan has to be submitted 1 hour prior to the departure. If the submission is delayed, and it is sent less than 1 hour in advance, ATC automatically delays EOBT to 1 hour after the FPL submission.

6.2.2 FPL requirements

The bases of flight plans are the same, however, some countries still have their own additional requirements. A set of differences can be seen in the field 18. For instance, Brazil requires to include pilots' license numbers. The small detail that might not seem important can cause a rejection of a flight plan in case the information is not included. Other data which cause the same complications can be the permit number or previous departure airport, as mentioned in the chapter 5.2 about Brazil. ERAS does not require to include DOF in the flight plan while IFPS does. If there is a flight plan for an aircraft departing from the USA and routing to Europe without DOF information, the system is inefficient and might cause misunderstandings at first sight.

6.2.3 FPL incompatibility

FPL incompatibility is related to various countries requirements. Different codes stating the same information could be one example. For instance, PBN is a component requiring further specification in the field 18. However, there are two different codes, PBN and NAV, defining the same piece of data (PBN used in Europe and NAV used in the United States for GNSS equipped aircraft). IFPS is not able to process the code NAV, and ERAS does not know what to do with PBN abbreviation. Operators are made to use both in the form to make sure their FPL will be processed correctly during all parts of the flight. A similar problem occurs with the RMK/PBT and RMK/CLR; clearance codes for Europe and Brazil. Meaning the same but stated differently, these codes can cause a rejection of a flight plan due to a missing information; even though it is physically there.

Another example could be a flight from Brazil to the USA. This particular FPL would include a long chain of codes in the field 18 (all required for Brazil) which ERAS would not be able to process.

Flight Plan incompatibility is related to the fact mentioned in 6.1.4. A FPL has to be accepted mainly at the country of departure, in this case the Czech Republic. FIRs on the route pass the FPLs somehow, even if the form is missing some requirements. The aircraft is airborne and on time, but it is still necessary to request the information needed for Brazilian airspace which causes complications on the route.

6.2.4 CTOT for out-of-EUROCONTROL flights

System of slot allocation is unique to EUROCONTROL, and for departures within the IFPZ, it works quite well. However, for flights departed outside the IFPZ and entering its airspace on the route, complications can arise. ERAS directs planes on its own, using a system which is similar but not compatible with the CTOT in Europe. Other countries do not have anything like that. An aircraft approaching the IFPS zone cannot be stopped, and so it is let into the airspace, sometimes at the expense of the IFPZ - departed flights. Always, there is some reserve in airspace capacities to ensure safe and efficient air traffic flow. Foreign aircraft are absorbed into this reserve; with a small amount of these flights in comparison with the EUROCONTROL ones, complications do not occur very often. However, undoubtedly it is a question to think about.

6.2.5. Communication ATC-Operator

A system of messages works quite well within the IFPS and ERAS. ACK or REJ are sent to inform the operator about the status of the flight plan (IFPS has the MAN message in addition). Beside Europe and the USA which have been described above, the Russian Federation, Iran, Cuba, Singapore, and Indonesia represent countries that use the same communication directed to the operator. Other countries neither send any messages nor inform about FPL processing in any other way. A previous rejection of a FPL is distributed only to the pilot when he does not get clearance due to a missing FPL at ATC.

Another problem is related to the CTOT messages. IFPS informs operators about slot allocation using SAM, SRM, FLS and SCL messages. ERAS, which has a similar system for slot allocation, applies the technique secretly. ATC assigns a slot, but there is no further communication to the aircraft operator, the information stays only within the level of control. Again, it is the pilot who finds it out shortly before the initial departure. If the fact is distributed to the operator, he is then able to consider a potential delay, and he might re-plan the flight in a way that is the most efficient for that particular situation.

6.2.6 Distribution Addresses

Distribution addresses for particular stations are defined in AIP. The process of distribution addresses is briefly described in 6.1 as the part of introducing the example flight plans.

There is a special software generating those addresses automatically. The system is sophisticated, and the operator can be ensured that the addresses are correct; if there is any imperfection detected, individual settings are changed and edited according to the will of the operator. This software, however, represents quite an expensive equipment and not all operators are able to afford it. Manual creation of the addresses, on the other hand, is very time-consuming and therefore very inefficient. Some sources include prepared addresses which can be used, those are only for flights with particular routing. Small diversity in the routing can cause the need of a new distribution address, so it can be stated that for every single flight there is a unique set of distribution addresses.

6.3 Possible Problem Solutions

Most of the above mentioned issues relate to insufficient ICAO unification. Although the organization sets many rules for flight planning and flight plan processing, there is a big benevolence regarding the local differences. Strict promotion of the rules from the ICAO side would help to avoid the most spread issues.

6.3.1 Standardization of the FPL Processing/Filing Time

Time requirements for filing flight plans should be identical, or at least very similar. This would facilitate operators' work; they would not be made to remember various times for different destinations. Consideration of the flight as a whole thing which is not divided into several segments (related to different airspace) supports the idea. If every flight plan had to be filed between two days and 2 hours before EOBT as a rule, it would give the operators more freedom when planning the flight. Also, regarding the Brazilian problem described in 6.2.1, flight plan filing should be more flexible. Undoubtedly, there have to be some limitations, but late filed FPLs could be considered individually. If the ATC circumstances allow the airplane to take off in thirty minutes, initial EOBT should be kept.

6.3.2 External Data Storage

To solve the problem of individual FPL requirements, based on the Brazilian example, a special data storage could be created. Various databases (e.g. landing permit database) could be connected with the flight plan processing system; the idea is an automatic correlation of a flight plan and particular information, according to the number of flight plans or any other significant information. Operators request landing permits in advance, and their applications have to be processed in order to get the needed documentation; in fact the permit numbers are already somewhere in the system, and it is pointless to include them in the flight plan again. Submitted FPL would be connected to the database, and the system would automatically match it with the landing permit number. The same solution could be applied to the pilots' license numbers. That way operators would fill in the data just once and not for every individual flight that the pilot performs. External data storage could make the list of manually-written remarks much shorter, and it would also contribute to the solution of flight plan incompatibility.

6.3.3 FPL compatibility

All codes specifying particular flight plan data should be the same. There is no need to use two or more different formulations for one single information (such as PBN-NAV and PBT-CLR examples illustrated in 6.2.3). Duplicates only cause misunderstandings during the flight plan processing, and they create more work for operators who have to define the same thing twice.

On the other hand, DOF should be added as a requirement for all flight plans. Date, as well as time, represents one of the basic things of planning. Moreover, it is only one more click the operator has to do in order to file a proper flight plan. The addition of DOF to the standards of flight plans would avoid situations described in 6.2.2.

Regarding the special FPL requirements, all flight plans should be identical. As mentioned above, individual data could be kept externally, and operators would list only standard information that are the same for every airspace. It would also facilitate the operators' work because they would not have to memorize/look up special FPL requirements – landing permit would be obtained in advance, and there would not be more requirements to meet. Other possible solution represents a system of additional messages. Initiated from the ATC, an automatic form asking for permit number would be the response to the flight plan submission. The operator would file and submit it in a few seconds. Automated message requesting additional information would not be only quicker, but it would also avoid FPLs rejections in case the operator forgets to include some information.

6.3.4 ATC-Operator Communication

For countries that do not have any form of ATC-Operator interaction, there is a need for at least some kind of communication regarding the flight plan processing. A simple automatic response, or even sending the flight plan back in order to inform the operator, would be sufficiently efficient form of marking the FPL as accepted. Special machine-operated phone line could represent solution for countries that do not use any computerized systems. The operator would send a specially-formatted text message including the flight plan number, and a generated response would come back informing him about the FPL status. An active communication between ATC and operators would avoid delays caused by unawareness of flight plan rejection.

The same problem is related to ERAS and slot allocation. If ATC decides to delay the aircraft, the operator should be informed about that.

6.3.5 Slot Allocation Web Interface

For maintaining the air traffic flow efficiency not only in IFPZ airspace, but also in other parts of the world, countries have to cooperate in the systems of slot allocation as well. A creation of shared web interface could help to fulfill this idea. A map of routes would be updated by individual ATCs according to the current situation in their airspace; other units would be able to see how many aircraft are about to be in particular airspace at particular time, and allocate and “save” the spots for individual aircraft not only within their control area, but even on different places along the airplane’s route. Moreover, operators, being only the observers, would be able to see the actual situation all around the world, and take it into consideration when planning a flight. The main idea is to enable the operators to check the possibility of slots and delays prior to the FPL submission. System compatibility could help to solve the problematics mentioned in 6.2.4.

6.3.7 System Expansion

Not only the establishment of new functions could work, but one possible solution could be an expansion of already existing and well-working systems behind the borders of Europe and the United States. Other parts of the world would easily adopt IFPS/ERAS. It relates to the idea of ICAO rules promotion, and it would include some of the solutions mentioned above such as standardization of FPL filing and processing time, FPL compatibility, the system of slot allocation, or communication between ATC and operators. Moreover, a system expansion would also solve the issue with distribution addresses.

7 Conclusion

In these days, there is an enormous amount of flights conducted daily in the world's airspace, and each of these flights has its own unique flight plan. Therefore the flight plan processing represents a frequently used service which is important for a smooth air traffic flow. Undoubtedly, it is always a target for innovations and improvements.

The thesis had three main objectives. The first one was to describe the history of air traffic, air traffic control, and flight planning, and to illustrate the development that led to the air traffic density we know today. The second aim represented a system description; definition of basic terms in air traffic control, flight planning, interaction, and communication within these fields. A related goal was the explanation of flight plan processing systems within the Russian Federation, Brazil, Europe, and the USA with focus on the European IFPS and American ERAS as the two most perfect ones. To show the flight plan processing in real life, definition of system advantages and imperfections, and proposal of possible problem solutions, were the tasks of the last part.

The development of air traffic, air traffic control, and flight planning is described in chapter 3 which is divided into eleven sections according to the specific time frames and events of the past. The history outline shows the advancement of air traffic from early dangerous experiments to the currently busiest and safest form of transportation. It describes the replacement of shrimp boats and maps by fully computerized system, and follows the transformation of entirely visual navigation into a set of beacons and RADARs. Specified is also the development of manual FPLs filing into the sophisticated automatized systems which facilitates work of ATC and operators. Lastly, the thesis mentions current trends such as low-cost concept or SESAR project that represent highly discussed topics in the world of aviation.

Chapters 4 and 5 are dedicated to the description of flight plan processing systems. The thesis illustrates the structure as a whole consisting of two main components: flight planning and air traffic control. With the help of basic terms definitions, it shows how closely related these two fields are, and emphasizes the importance of their interaction. Described are four specific systems each representing a different attitude towards the flight planning and processing. Brief descriptions of the Russian Federation and Brazil are mentioned, however, the thesis is aimed on IFPS and ERAS systems as the two most perfect ones. It gives a complex description of FPL submission, processing, and distribution; defines different time requirements for FPL filing and various forms of distribution. Messages related to flight plans, communicated between ATC and operators, represent an important part of the outline. European slot allocation process is illustrated as a very efficient form of ensuring a fluent air traffic flow.

The last, practical part is engaged with the issues related to flight plan processing. The thesis works with four city-pair FPL simulations created by PPS software, for an aircraft departing from Prague and flying individually to Venice, Moscow, Chicago and Sao Paulo. These specific examples were chosen as the units representing four different systems mentioned in chapter 5. The first part of the sixth chapter follows the FPLs themselves and highlights their similarities and differences. Further, it looks into the FPLs processing and recognizes complications that occur while combining different systems together. Based on the experience of ABS Jets Director of Ground Operations, six main problems, correlated to each other, were identified – different FPL processing/filing time, FPL incompatibility, individual FPL requirements, insufficient communication between ATC and operators, out-of-EUROCONTROL slot allocation process, and distribution addresses. Beside the need of a strict ICAO rules unification, the author offers following solutions:

- *FPL processing/filing time*

  Standardization is mentioned as the key to this issue. Necessary FPL filing time would be set between two days and two hours before EOBT for all systems. Operators would get more freedom regarding the flight planning. Moreover, in the case of a late-filed flight plan, the situation would be considered individually – if it is possible for the aircraft to take off safely, bureaucracy should be put aside, so that the flight can be conducted on time. This solution would avoid needless delays caused by a blind obeying of the stated rules.

- *FPL requirements*

  To deal with the problem of individual requirements, the author offers a creation of a special data storage. Databases of permit or license numbers would be connected with the FPL processing system, and automatically correlated with the FPL obtained according to the flight plan number. External data storage would allow to shorten the list of manually written remarks, moreover, it would also contribute to the solution of flight plan incompatibility - all individually obligatory data could be omitted, and so the flight plan requirements would be identical.

- *FPL incompatibility*

  Unification of the duplicate codes (such as PBN-NAV, or PBT-CLR) is needed in order to avoid misunderstandings and inefficiency. At the same time, DOF should be included to the requirements for all FPLs, because it is one of the basic fields for planning. The above mentioned external data storage is also related because it would avoid a FPL rejection in case of omitting any necessary information in the field 18. Another offered solution is the system of additional messages. Initiated from ATC system, an automatic form requesting the permit number would follow the submission of a FPL.

- *ATC-operator communication*

Concerning the insufficient communication regarding the FPL processing, a simple automatic response with the status of the flight plan could be applied. Countries without computerized systems could utilize a special phone line. If a proper message was sent, the generated response would be obtained with the information about rejection or acknowledgement of the flight plan. Also, implementation of CTOT, SAM, SLC, and FLS messages into ERAS would solve the inefficient slot allocation. Better communication between ATC and operators would eliminate delays due to the unexpected absence of the FPL at the ATC unit.

- *CTOT for out-of-EUROCONTROL flights*

Any slot allocations should be compatible within all related countries. Offered solution is the creation of a shared web interface which would be updated by individual ATCs according to the current situation in their airspace. Other units would have access to these data and work with the knowledge in order to plan the traffic flow more efficiently. Operators could also follow the actual circumstances and consider possible alternatives when planning a flight. The prime objective is the ability to predict potential delays prior to the FPL submission.

- *System Expansion*

The adoption of already existing systems would be one possible solution for countries that do not have their own flight plan processing. Expansion of IFPS/ERAS would support the idea of ICAO rules promotion; it would include some of the already mentioned subjects such as standardization of FPL filing and processing time, or FPL compatibility. Moreover, the system expansion would also solve the problem with distribution addresses.

The author believes that the above mentioned research, findings and experience can be used for her future works.

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12 Attachments