CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF TRANSPORTATION SCIENCE

MASTER THESIS

2020 **Bc. Pavel Hluska**

CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF TRANSPORTATION SCIENCE

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Analysis of IFR/AFIS implementation at the airport in České Budějovice

MASTER THESIS

2020

CZECH TECHNICAL UNIVERSITY IN PRAGUE
Faculty of Transportation Sciences
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MASTER'S THESIS ASSIGNMENT

(PROJECT, WORK OF ART)

Student's name and surname (including degrees):

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Code of study programme code and study field of the student:

N 3710 – IS – Intelligent Transport Systems

Theme title (in Czech): **Analýza implementace IFR/AFIS na letišti v Českých Budějovicích**

Theme title (in English): Analysis of IFR/AFIS implementation at the airport in České Budějovice

Guides for elaboration

During the elaboration of the master's thesis follow the outline below:

- Analysis of the airport in České Budějovice (its technical information, brief description of modernisation, etc.)
- Analysis of the airports in the Czech Republic and in the world (AFIS aiports)
- Analysis of air traffic services (types of services such as radio, Aerodrome Flight Information Service and air traffic control)
- Implementation of IFR/AFIS at the airport in České Budějovice (risk analysis)
- Airport recommendations considering gathered information

Graphical work range: As required by the supervisor

Accompanying report length: At least 55 pages of text (including figures, graphs and tables included in the accompanying report)

Bibliography: ICAO Annex 11, ICAO Annex 14, VFR Manual, EU Regulation 2017/373

Master's thesis supervisor: **Ing. Ota Hajzler**
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Tatiana Polishchuk, PhD.

Date of master's thesis assignment: **June 1, 2019**
(date of the first assignment of this work, that has be minimum of 10 months before the deadline of the theses submission based on the standard duration of the study)

Date of master's thesis submission: **May 18, 2020**
a) date of first anticipated submission of the thesis based on the standard study duration and the recommended study time schedule
b) in case of postponing the submission of the thesis, next submission date results from the recommended time schedule

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Bc. Pavel Hluska
Student's name and signature

Prague .....June 1, 2019

ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE
FAKULTA DOPRAVNÍ

Analýza implementace IFR/AFIS na letišti v Českých Budějovicích

Diplomová práce

2020

Bc. Pavel Hluska

KLÍČOVÁ SLOVA

AFIS, analýza, bezpečnost, České Budějovice, doporučení, dráha, ICAO, implementace, informace, letadlo, letiště, modernizace, nařízení, predikce, provoz, předpis, riziko, řízení, služba, systém

ABSTRAKT

Diplomová práce „Analýza implementace IFR/AFIS na letišti v Českých Budějovicích se zabývá implementací letové letištní informační služby AFIS na bývalém vojenském letišti v Plané u Českých Budějovic. Práce je rozdělena na teoretickou a praktickou část, přičemž v části teoretické je analyzováno samotné letiště, další česká letiště podobná letiště v Českých Budějovicích a zahraniční letiště, na kterých je AFIS již implementován. Praktická část je zaměřena na řízení rizik spojených s projektem implementace, predikci provozu po zavedení služby AFIS a na ekonomickou analýzu této služby. V samotném závěru práce je uvedeno doporučení letišti.

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KEYWORDS

AFIS, Airport, Analysis, Control, České Budějovice, ICAO, implementation, Information, Modernization, Plane, Prediction, Recommendation, Regulation, Risk, Safety, Service, System, Traffic, Way

ABSTRACT

The master thesis „Analysis of IFR/AFIS implementation at the airport in České Budějovice deals with the implementation of the AFIS flight information service at the former military airport in Planá near České Budějovice. The work is divided into theoretical part and practical part. The theoretical part analyses the airport itself, other Czech airports in České Budějovice and foreign airports, where AFIS is already implemented. The practical part is focused on the risk management associated with the implementation project, traffic prediction after the introduction of the AFIS service and the economic analysis of this service. At the very end of the work there is a recommendation to the airport.

ACKNOWLEDGEMENT

I would like to express gratitude the supervisor Ing. Otta Hajzler and Ing. Jiří Růžička, then I would like to thank to Ing. Gustav Sysel, Mgr. Martina Vodičková, Karel Bartoň a Josef Fošum from České Budějovice Airport for providing data and answers to questions concerning the elaboration of this diploma thesis. I would also like to thank Mr. Christian Fog Jensen from the Danish company Integra, whom I consulted throughout the processing of the project. I would also like to thank to Mrs. Heidi Rosa Nielsen from Odense Airport, who provided me data on traffic. Last but not least, I would like to thank to my parents, siblings and my girlfriend Martina for their support in my studies.

DECLARATION

I declare that I have prepared the submitted work independently and that I have listed ale the information sources which were used in accordance with the Methodical instructions of the ethical preparation of university final theses.

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In Prague, 3rd June 2020 ……

Content

Introduction **10**
1 České Budějovice Airport **12**
1.1 Technical information 13
Movement area 15
Runway 15
Taxiway 15
Apron 16
1.2 Modernisation 17
1.3 Test operation after modernization 18
1.4 Airport equipment 19
1.5 Fire brigade at LKCS 19
1.6 Movement statistics 21
1.7 Airport fees 22
2 Czech airport analysis **24**
2.1 Chosen airport 24
2.1.1 Hradec Králové 24
2.1.2 Mnichovo Hradiště 27
2.1.3 Plzeň/Líně 30
2.2 Comparison of parameters among airports 34
3 Analysis of foreign airports **36**
3.1 Esbjerg Airport 36
3.2 Sønderborg Airport 37
3.3 Odense Airport 40
3.4 Kolding Airport 42
3.5 Summary 44
4 Air traffic services **46**
4.1 Air Traffic Control 46
4.1.1 Area Control Service 47
4.1.2 Approach Control Service 47
4.1.3 Aerodrome Control Service 48
4.2 Alerting Service 48
4.3 Flight Information Service 48
4.3.1 Aerodrome Flight Information Service 49
AFIS equipment 52
4.4 Providing information to known traffic at airports 54
5 Implementation of AFIS at České Budějovice airport **55**
5.1 Safety risk analysis 55
5.1.1 Matrix of risks 55

5.1.2 Managing criteria ... 55
6 Risk mitigation means ... 65
6.1 Proposal of risk mitigation means ... 65
6.2 Time slot analysis ... 68
6.3 Questionnaire ... 70
6.3.1 Questionnaire questions ... 70
6.3.2 Questionnaire results ... 73
7 Intensity prediction ... 74
7.1 Conservative scenario ... 74
7.1.1 Conservative scenario results ... 76
7.2 Progressive scenario ... 77
7.2.1 Progressive scenario results ... 79
7.3 Dynamic scenario ... 80
7.3.1 Dynamic scenario results ... 82
7.4 Summary ... 83
8 Economic analysis of AFIS implementation at LKCS airport ... 85
8.1 Denmark ... 85
8.2 The Czech Republic ... 86
8.3 Simulation of services provided at LKCS ... 87
8.3.1 Boeing 737 arrival ... 87
8.3.2 Cessna 172 arrival ... 87
8.4 Summary ... 88
9 Airport recommendations ... 90
9.1 Conservative scenario ... 90
9.1.1 Fire brigade ... 90
9.1.2 Proposed risk mitigation means ... 90
9.2 Progressive scenario ... 91
9.2.1 Fire brigade ... 91
9.2.2 Proposed risk mitigation means ... 91
9.3 General measures ... 92
Conclusion ... 94
References ... 97
List of figures ... 100
List of tables ... 101
List of graphs ... 103
List of appendixes ... 104

List of abbreviations

ACC	-	Area Control Centre
AFIS	-	Aerodrome Flight Information Service
AGE	-	Aeronautical Ground Equipment
AIP	-	Aeronautical Information Publication
AM	-	Anemometer
AMSL	-	Above Mean Sea Level
APN	-	Apron
APP	-	Approach
ASDA	-	Accelerate Stop Distance Available
ATC	-	Air Traffic Control
ATS	-	Air Traffic Services
ATZ	-	Aerodrome Traffic Zone
CM	-	Ceilometer
DME	-	Distance Measuring Equipment
EKEB	-	ICAO code of Esbjerg Airport
EKOD	-	ICAO code of Odense Airport
EKSB	-	ICAO code of Sonderborg Airport
EKVD	-	ICAO code of Kolding Airport
ELEV	-	Elevation
FIC	-	Flight Information Centre
FIR	-	Flight Information Region
FIS	-	Flight Information Service
FT	-	Feet
GA	-	General Aviation
GPU	-	Ground Power Unit
IATCC	-	Integrated Air Traffic Control Centre
ICAO	-	International Civil Aviation Organization
IFR	-	Instrument Flight Rules
ILS	-	Instrument Landing System
LDA	-	Landing Distance Available
LKCS	-	ICAO code of České Budějovice Airport
LKHK	-	ICAO code of Hradec Králové Airport
LKLN	-	ICAO code of Plzeň/Líně Airport

LKMH	-	ICAO code of Mnichovo Hradiště Airport
LLZ	-	Localizer
LT	-	Local Time
MTOW	-	Maximum Take-Off Weight
NM	-	Nautical Mile
PWD	-	Present Weather Detector
QNH	-	Pressure at the airport converted to sea level
RMM	-	Risk Mitigation Means
RMZ	-	Radio Mandatory Zone
RWY	-	Runway
SAR	-	Search and Rescue
SZZ	-	Light Security Devices
TMZ	-	Transponder Mandatory Zone
TODA	-	Take-Off Distance Available
TORA	-	Take-Off Run Available
TWR	-	Tower
TWY	-	Taxiway
UTC	-	Universal Time Coordinated
VFR	-	Visual Flight Rules
VR	-	Wind Sleeve
VW	-	Volkswagen

Introduction

České Budějovice Airport used to be a military airport and became an international airport after the leaving of the Czech Army. The Czech Army left České Budějovice Airport in 2005 and since then the airport has undergone several phases of modernization thanks to which one day there will be a connection with the whole world.

The airport is equipped with a long runway, even longer than they have in Karlovy Vary. Thus, both Boeing 737 and Airbus 320 can arrive at the airport. However, these aircraft will not be seen here, at least not until good information service is provided. The Aerodrome Flight Information Service had been operating here for several years, but with the new EU regulation 2017/373 it had to be cancelled at the airport in České Budějovice. And not just here. Currently, the AFIS service is not provided at any of the airports in the Czech Republic. The operation of the AFIS service has become an expensive matter with that regulation which regional airports, whose main customers are sport aviation operators, cannot afford. According to EU Regulation 2017/373 the operator of the AFIS service is obliged to have a certified station and certified dispatchers. All airports where the AFIS service was operated have switched to the Radio service which is considerably cheaper as it is not subject to certification of meteorological equipment and personnel certification. The Radio service also does not have operational safety management system documentation prepared etc. In addition, the AFIS dispatcher must be able to provide traffic information even when there is a technological failure.

In Scandinavia, the AFIS service is relatively widespread and due to the many years of experience of Scandinavian airports with this provided airport service, these airports should lead Czech airports. Czech airports are serious about operating larger aircraft, but they do not have enough money and traffic to provide air traffic control services. AFIS is a good compromise between air traffic control services and the provision of information to known traffic. This will certainly be appreciated by pilots who do not want to fly to uncontrolled airports.

This work is divided into theoretical and practical part. The theoretical part analyses the České Budějovice airport which includes technical parameters of the airport the phase of modernization statistics of movements at the airport between 2010 and 2019. It also mentions the fees collected for using the airport and its services. Furthermore, three other airports with similar parameters as the airport in České Budějovice are analysed and it can be assumed that these airports would also be suitable for the implementation of the AFIS service. The third chapter analyses the foreign airports where they provide AFIS service and this analysis should outline the formula according to which the AFIS service is implemented at the airport. The

fourth chapter describes the current air traffic services. This description is intended to help readers from the ranks of the non-professional public to understand the issue.

In the practical part there is a safety risk analysis of the implementation of AFIS created, whose task is to define and understand the risks associated with the implementation of this project. Furthermore, a prediction of the number of movements at České Budějovice Airport is made based on data provided from the Danish Odense Airport. The prediction is developed in three proposed scenarios. The last task is, based on the information obtained to provide recommendations to České Budějovice Airport.

The aim of this work is to create a document that will not be beneficial only to the airport in České Budějovice which is devoted to a substantial part of this work and whose data is worked with and which is continuously consulted but it will be beneficial and usable for every airport in the Czech Republic that thinks about switching from the service Providing information to known traffic to the AFIS service.

1 České Budějovice Airport

The abbreviation of the airport according to ICAO is LKCS. [14]

České Budějovice Airport is located about 6.5 km southwest of the centre of České Budějovice in the village of Planá, directly on the 1st class road leading to Český Krumlov, to Kaplice and further to Austria. It is former military airport with surrounding land with an area of approximately 300 hectares. The founders of Jihočeské letiště České Budějovice a.s. is the South Bohemian Region and the Statutory City of České Budějovice and until recently these two bodies were also the owners of the company. It is now 100% owned by the South Bohemian Region which bought a half stake from the city of České Budějovice for 6.5 million crowns. [12]

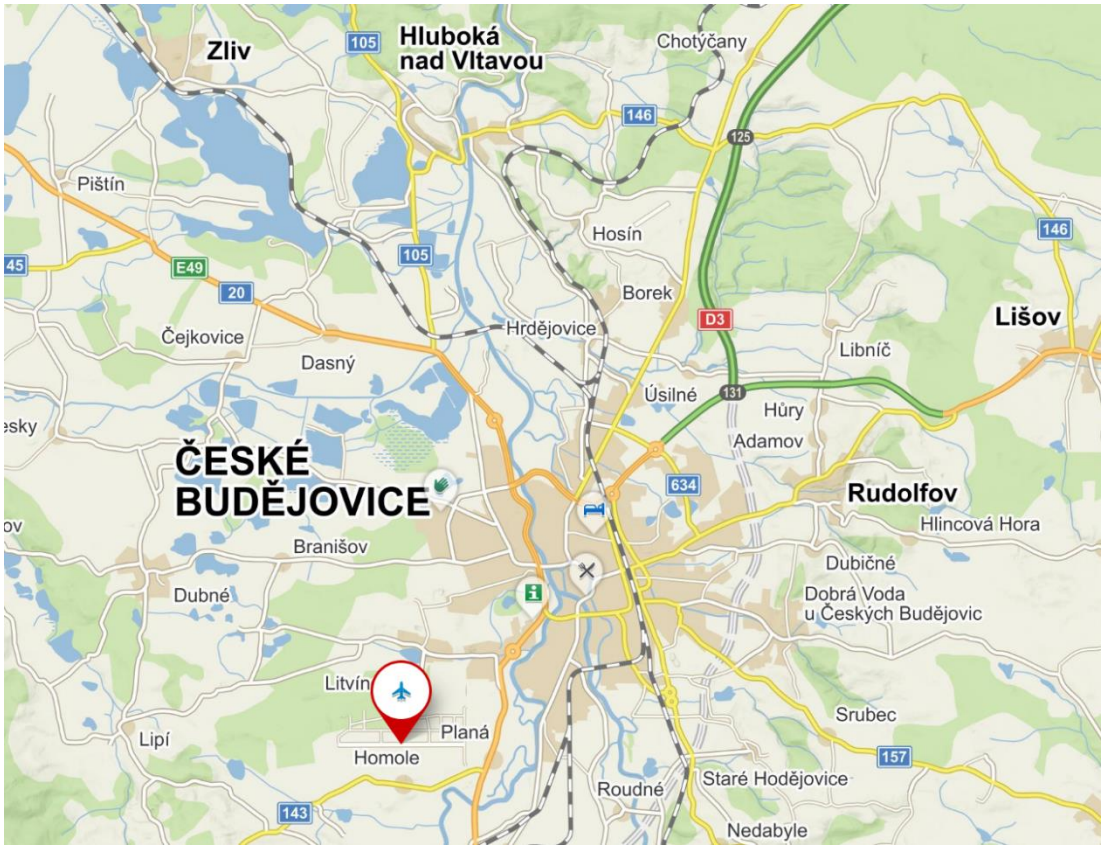


Figure 1: Location of České Budějovice Airport [25]

The airport is in 4 municipalities – Homole, Nové Homole, Litvínovice and Planá. From this point of view it is important that aircraft flying around the circuit, see Figure 2, do not fly over the inhabited areas of these municipalities in order to eliminate noise emissions. [14]

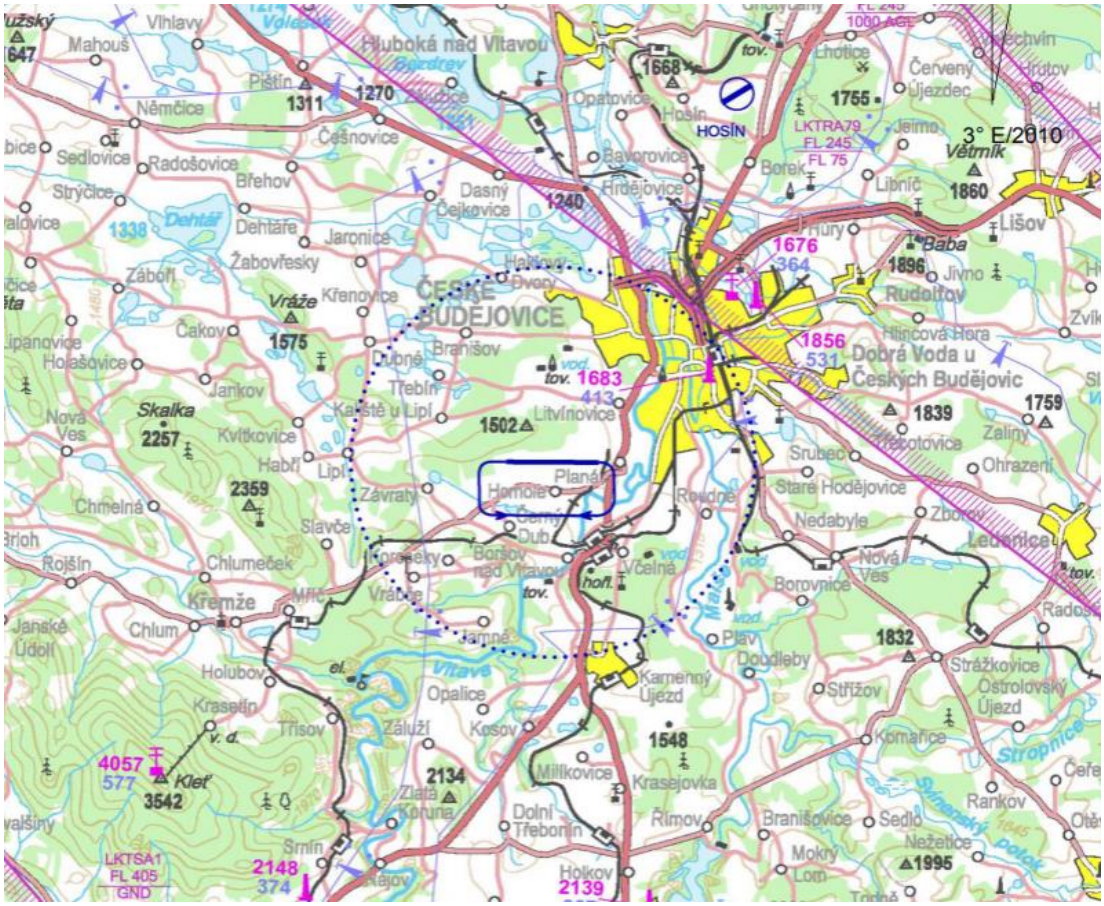


Figure 2: The circuit of České Budějovice Airport [14]

1.1 Technical information

The airport is a public domestic airport which means that the airport accepts all aircraft within its technical and operational capacity, and a non-public international airport with an external border which obliges the operator or commander to agree on whether it can be accepted at the airport. [39]

The airport in České Budějovice has the code 4C which is defined in the Aviation Regulation L 14. Looking at Tables 1 and 2, it is clear that the České Budějovice Airport has a 1800-meter long take-off run and aircraft moving at the airport must not have a wingspan greater than 36 meters. Another condition for aircraft is that the wheelbase of the main landing gear is from 6 meters up to, but not including 9 meters. [43] Theoretically, the airport should be able to land a Boeing 737 Max, but also more numerous Boeing 737 or Airbus 319, 320 or 321.

Code element 1	
Code number	**Nominal length of the airplane take-off run**
1	Less than 800 m
2	From 800 m up to, but not including 1,200 m
3	From 1,200 m up to but not including 1,800 m
4	1,800 m and more

Table 1: Code element 1 of airport categorization according to regulation L 14 [43]

Code element 2	
Code letter	**Wingspan**
A	Up to but not including 15 m
B	From 15 m up to but not including 24 m
C	From 24 m up to but not including 36 m
D	From 36 m up to but not including 52 m
E	From 52 m up to but not including 65 m
F	From 65 m up to but not including 80 m

Table 2: Code element 2 of airport categorization according to regulation L 14 [43]

The permitted type of operation at the airport is VFR during the day and from January 2020 a trial operation on VFR night takes place. According to the Aviation Regulation L 2, it is a way of conducting a flight enabling flight in suitable meteorological conditions i.e. for visibility. In this type of control the aircraft is guided and navigated by the pilot and it is only based on the view from the cockpit. Follow the rules for flight in visibility. [46]

The AFIS service was terminated at České Budějovice Airport on 31 December 2019. This decision is based on the decision of the airport itself, when LKCS requested the termination of AFIS due to the entry into force of European Commission Regulation 2017/373 on 2 January 2020 and threatened that the airport would continue to provide AFIS and the same time fail to meet staff certification requirements and equipment according to EU Regulation 2017/373, so there would be a risk that the airport would be completely closed by the Civil Aviation Authority.

Radio control is bounded by the ATZ horizontally by a circle of radius R=3 NM (5.5 km) from the aerodrome reference point and vertically by the ground and an altitude of 4000 ft (1,200 m). [14] České Budějovice Airport is assigned the call sign "Budějovice RADIO". This type of control only provides information to known operations, while the pilot of the aircraft remains responsible for the flight. The height of

the circuit at the Airport in České Budějovice in České Budějovice is 2400 ft / 730 m AMSL. [14]

The information provided to known traffic is available in Czech and English on the frequency channel 135,930. [14]

Further important information about the airport is given in Table 3, see below.

Airport reference point	ARP RWY 27/09 48°65'47" N 14°25'39" E
Airport altitude	1417 ft / 432 m AMSL
Airport reference temperature	21,9 °C (JUN)
Airport operating hours	Mon-Sun 07:00 (06:00) – 19:00 (18:00) UTC For arrivals outside of operating hours: Mon-Fri announce 24 hours in advance Sat-Sun + holidays announce 48 hours in advance
Seasonal applicability	In winter, the movement areas are maintained to a limited extent, depending on the weather conditions

Table 3: Further important information about the České Budějovice Airport [39]

Movement area

The movement area is defined in Aviation Regulation L 14 as a part of the airport used for take-offs, landings, and taxiing of aircraft, which consists of and operating area and an apron. [43]

Runway

"Demarcated rectangular area at a land aerodrome adapted for the landing and take-off of aircraft." [43]

České Budějovice Airport has one runway, which is marked 27/09, is 2500 meters long and 45 meters wide. This track is made of concrete. [14]

Taxiway

The taxiway is a lane at the airport that is used to taxi aircraft and connect one part of the airport with another. [43]

The taxiways are divided into 3 types according to their use:

1. An aircraft stand taxi lane is a part of the apron which is designated as a taxiway and allows aircraft access to stands. [43]
2. The apron taxiway allows the aircraft to pass through the apron. [43]
3. A rapid exit taxiway is a taxiway designed to allow landing aircraft to turn off at higher speeds, thereby reducing the time the aircraft blocks the main runway. [43]

České Budějovice Airport has 5 taxiways, which are marked A, B, C, D and T. Taxiways A, C, D and T have a concrete surface and a width of 18 meters. Runway B was extended from 18 meters to 26 meters during the reconstruction and it also has a concrete surface. [39]

Apron

Aprons are used for boarding and disembarking passengers, or in the case of freight transport for loading or unloading cargo. These areas are also used to prepare the aircraft for flight by activities such as refuelling, cleaning, etc. The areas are also used for aircraft parking. [43]

Aprons at the České Budějovice Airport are listed in Table 4, which is located below.

Designation	Positioning	Surface	Size
Apron M (Middle)	Southeast TWR – entrance from TWY B	Concrete	160x30 m
Apron W (West)	West TWR – entrance from TWY C and D	Concrete	150x30 m
Apron E (East)	East TWR – entrance from TWY A	Concrete	150x50 m

Table 4: List of aprons at České Budějovice Airport [39]

Figure 3 shows the situation plan of the airport, including all the RWY, TWY and APN described above.

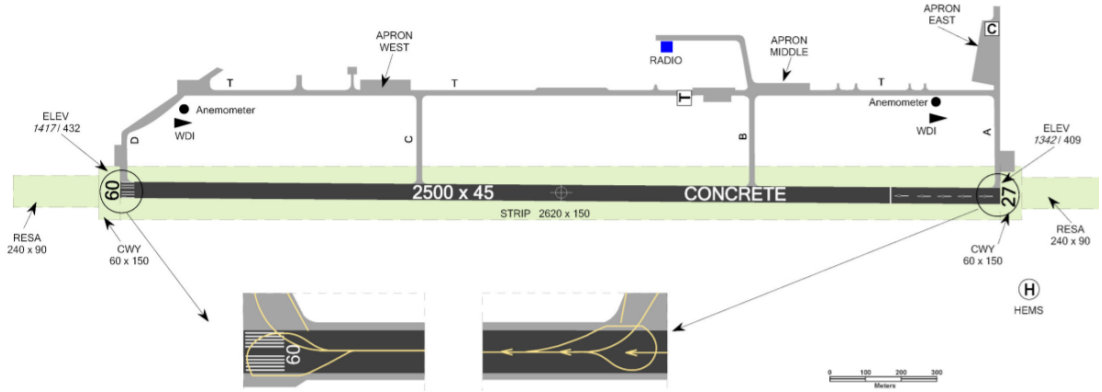


Figure 3: Situation layout of RWY, TWY and APN at LKCS [5]

1.2 Modernisation

In the past, two phases of modernization took place at České Budějovice Airport. In the first phase, which began in 2010, the control tower and the administrative building were reconstructed, and the complex was also networked with gas, electricity, and water.

The second phase of the modernization of České Budějovice Airport included the modification of the runway, internal roads, and the terminal. Furthermore, the taxiway was widened from 18 m to 23 m, and the runway was supplied with lighting equipment. All installed equipment within the 2nd stage of modernization, which have been in test operation since June 26, 2019, are listed below:

- VAISALA meteorological system
- Windsleeve 09/27 illuminated, height 6 m
- Ultrasonic 09/27 anemometer, height 10 m
- Temperature, humidity, pressure sensors (all RWY 27)
- Combined device PWD current weather detector and measurement and calculation of visibility
- Ceilometer - measurement of basic cloud and layers

Currently out of order:

- ILS cat I precision approach system, which includes:
    - LOC – localizer for horizontal guidance of the aircraft (located at the end of RWY 27)
    - GP – Glide Path for vertical guidance of the aircraft (located in the direction of RWY 27 to the left of the runway)
    - DME – Distance Measuring Equipment rangefinder (located on the GP mast)

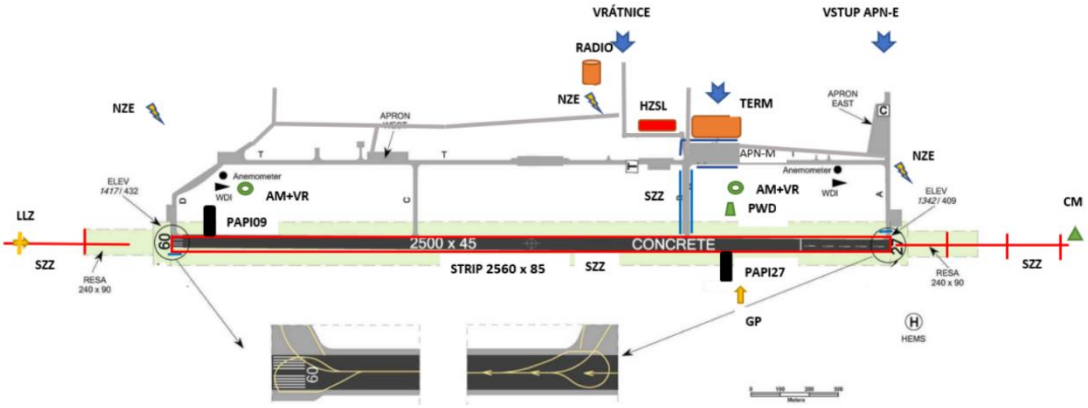


Figure 4: Situation layout of České Budějovice Airport with the location of AGE [5]

1.3 Test operation after modernization

The airport has been in the trial phase of VFR day since 26 June 2019, which regulates the conditions of the airport's operation. For example, the airport code was 1B due to various obstacles and construction work on the area. Aircraft landing during day could use all taxiways and aprons of the airport. [5]

The VFR night test operation, which complemented the VFR day and started in January 2020, was preceded by the installation of light safety devices. These are for example runway lights and lights at TWY B, APN M side lights, PAPI 09/27 descent light and approach lights at RWY 27 (900 m) and RWY 09 (shortened) system. Aircraft landing at night may only use TWY B and apron M. [5]

As mentioned above, information on known radio traffic in VFR day/night mode has been provided at České Budějovice Airport since 2 January 2020. It is clear from the consultations with České Budějovice Airport, that the airport is continuing to prepare for the implementations of EU Regulation 2017/373 and is striving to obtain the necessary certifications needed to provide the AFIS service. It is expected that AFIS will first operate in VFR mode and then be extended to IFR mode.

Figure 5: Night approach on RWY 27 [5]

Since July 2020, the Civil Aviation Authority has granted the airport a change in the conditions of test operation, where it is permitted to approach on RWY 27 and take-off from RWY 09 with code 4C. Code 2C applies when the aircraft approaches on RWY 09 and takes-off from RWY 27.

1.4 Airport equipment

České Budějovice Airport has the equipment needed to ensure the operation of the airport, both in point of operational and passenger handling view: [39]

- 2x pulled stairs for passengers (180 – 450 cm, 220-375 cm),
- 2x self-propelled stairs for passengers (245-580 cm, 200-410 cm),
- Fork-lift (2.5 t),
- NBL belt loader,
- Cabin service,
- Baggage tractor T135, T137,
- 6x luggage cart,
- GPU – Houchin,
- Car for the passenger transport (VW Crafter, VW Transporter),
- Fuel: AVGAS 100 LL, JET A1 – aircraft refuelling is possible on all aprons,
- Aircraft tractor Douglas – Kalmar TBL-180,
- Aircraft tractor JET 1800,
- Adhesive vehicle Saab 9-5 SARSYS.

1.5 Fire brigade at LKCS

An airport's fire brigade is governed by Act No. 49/1997 on Civil Aviation, Aviation Regulation L 14 and other related aviation regulations, EC Regulation No. 216/2008, the International Aviation Organization ICAO, and Act No. 133/1985 on the Fire and Rescue Service of the Czech Republic. [41] Aviation regulation L 14 specifies the category of the airport for the fire and rescue service, according to which the number of emergency vehicles, members of the intervention team, the amount of fire extinguisher, etc. are further defined. The airport's brigade must reach any part of the runway under optimal conditions of visibility and road condition until 3 minutes. [43] As part of the modernization, the České Budějovice Airport built a so-called branch station, which will reduce the intervention time to 2 minutes, as it is connected to the taxiways and is located approximately in the middle of the runway. The photo of the branch station is in Figure 6, see below.

The category of an airport for fire and rescue services is determined based on the size of the landing aircraft. According to L 14, it now falls into category 4, which is intended for airports where land aircraft from 18 to 24 meters (but not including) long with a maximum fuselage width of 4 meters. The obligation of each category 4 airport is to own one emergency vehicle, a certain amount of fire extinguishers defined in [43] and the minimum number of personnel per shift is 1 commander and 3 team members.

Figure 6: Newly built branch station of the Fire brigade LKCS

High demands are placed on the fire emergency truck. These demands include an acceleration from 0 to 80 km/h in 35 seconds, six-wheel drive, automatic transmission, or off-road capability. The emergency vehicle must have a high pump power, a large water supply, foaming agent, powder fire extinguisher, rescue equipment, medical equipment, chemical protection equipment and climbing equipment. [41] LKCS Airport has a Scania G 480 emergency vehicle.

Furthermore, this fire brigade has a fast emergency car and a command car. All these cars have the necessary firefighting equipment for leaving to less serious cases. The command car always leaves together with an emergency car or fast emergency car.

Figure 7: Vehicles of České Budějovice Airport's Fire brigade [41]

The airport fire brigade is established by the airport operator. [41]

1.6 Movement statistics

A movement is defined as the take-off or landing of an aircraft at an airport, with one take-off and one arrival being counted as two movements for airport operations. [22]

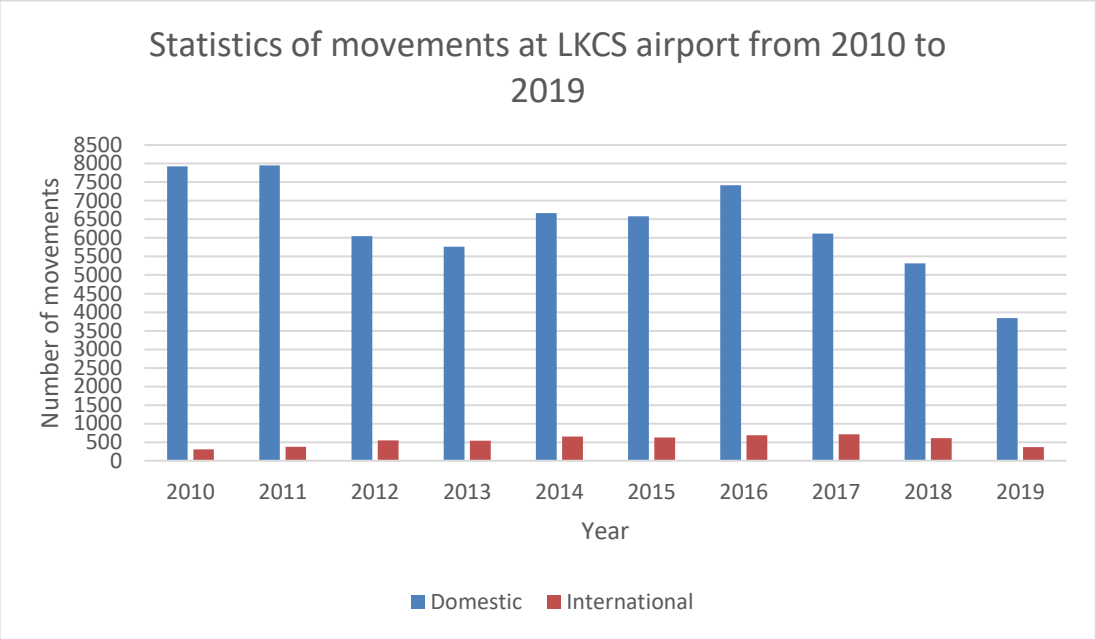
From 2010 to 2019, 69052 aircraft movements took place at the airport. Most of these movements were of a national nature, only a few hundred international movements per year. Table 5 below shows that during the period from 2010 to 2019, most movements took place in 2011, specifically 8323 movements. The second strongest year was 2010, when the České Budějovice Airport made 8238 movements. This represents a 1%-point increase. The largest percentage increase occurred between 2013 and 2014. In 2013, 6303 movements happened at the airport and 7318 took place in 2014. The decline in the number of movements in 2017 also included the end of the air rescue service allocated at the České Budějovice Airport. The largest percentage decrease occurred between 2018 and 2019, when there were 5929 movements in 2018 and 4214 movements in 2019 at the airport. The most important cause of the decrease in traffic was the restriction of the airport's operation due to the construction work when the modernization continued.

Year	Domestic	International	Total	Percentage change
2010	7929	309	8238	
2011	7948	375	8323	1,03
2012	6047	549	6596	-20,75
2013	5760	543	6303	-4,44
2014	6670	648	7318	16,10
2015	6580	622	7202	-1,59
2016	7419	686	8105	12,54
2017	6114	710	6824	-15,81
2018	5318	611	5929	-13,12
2019	3844	370	4214	-28,93

Table 5: Number of movements at LKCS airport from 2010 to 2019 [19]

An interesting statistic is also a comparison of the ratio of domestic and international movements at this airport. In 2010, the ratio of national to international movements was 3.9%. In the following years, this ratio decreased, and the geometric mean of all values is 8.38%. Most international movements took place in 2017, when there were 710 international movements at the airport and the ratio between domestic and international movements this year is 11.6%, which is an increase of 3.5%

points in international movements compared to the previous year 2016. However, in 2018, an almost 14%-point decrease followed, when 611 international movements took place at LKCS Airport. This decrease was because the airport was closed from September 2018 due to modernization.



Graph 1: Statistics of movements at České Budějovice Airport from 2010 to 2019 [19]

1.7 Airport fees

Airport fees are divided into 4 groups. These are landing fees, parking fees, passenger fees and other fees.

The basis for the calculation of landing fees is the maximum take-off weight of the aircraft. Landing fees at České Budějovice Airport are listed in Table 6.

Item	Price [CZK]
Aircraft up to 1 t MTOW and ultralight aircraft	150,00
Aircraft up to 2 t MTOW	200,00
Aircraft over 2 tons of MTOW – for each ton	250,00

Table 6: Landing fees at České Budějovice Airport [14]

Parking fees, which are again based on the MTOW of the aircraft and the parking time are listed in Table 7, see below.

Item	Price [CZK]
From 2 hours to 5 days (per hour and MTOW)	10,00
From 6 days to 10 days (per hour and MTOW)	5,00
From 11 days to 30 days (per hour and MTOW)	3,00

Table 7: Parking fees at České Budějovice Airport [14]

Fees for the use of the airport by passengers are paid by the carrier in scheduled and non-scheduled domestic and international flights. These fees are reflected in the final ticket price and are listed in Table 8, see below.

Item	Price [CZK]
Passenger	300,00
Passenger security check-in	200,00

Table 8: Passenger fees at České Budějovice Airport [14]

Other fees include customs and passport clearance and extension of airport operating hours, see Table 9 below.

Item	Price [CZK]
Ensuring customs and passport clearance	200,00
Extension of airport operating hours (each started hour)	3630,00

Table 9: Other fees at České Budějovice Airport [14]

2 Czech airport analysis

The chapter Czech airport analysis is divided into two parts. In the first part, 3 Czech airports are analysed – airports in Hradec Králové, Mnichovo Hradiště and Pilsen/Líně. All these airports have similar runway parameters and can therefore be considered as direct competitors of LKCS. These airports were selected for the analysis because they could be suitable for the provision of AFIS. In this chapter, these airports are technically described, the movements at these airports from 2010 to 2019 are listed, and a price list of services is also available for each airport, as this is also an important condition when selecting an airport by an airline.

In the second part, these analysed airports are compared with the LKCS airport according to two parameters. The first parameter are runways such as their dimensions and surface material. The second parameter are movements at the airport from 2010 to 2019.

2.1 Chosen airport

2.1.1 Hradec Králové

The abbreviation of the airport according to ICAO is LKHK. [14]

Hradec Králové Airport is located approximately 6 km north of the city centre between the local parts of Věkoše and Rusek. The airport is operated by Aviation Services Hradec Králové a.s. The airport can be reached by using public transport.

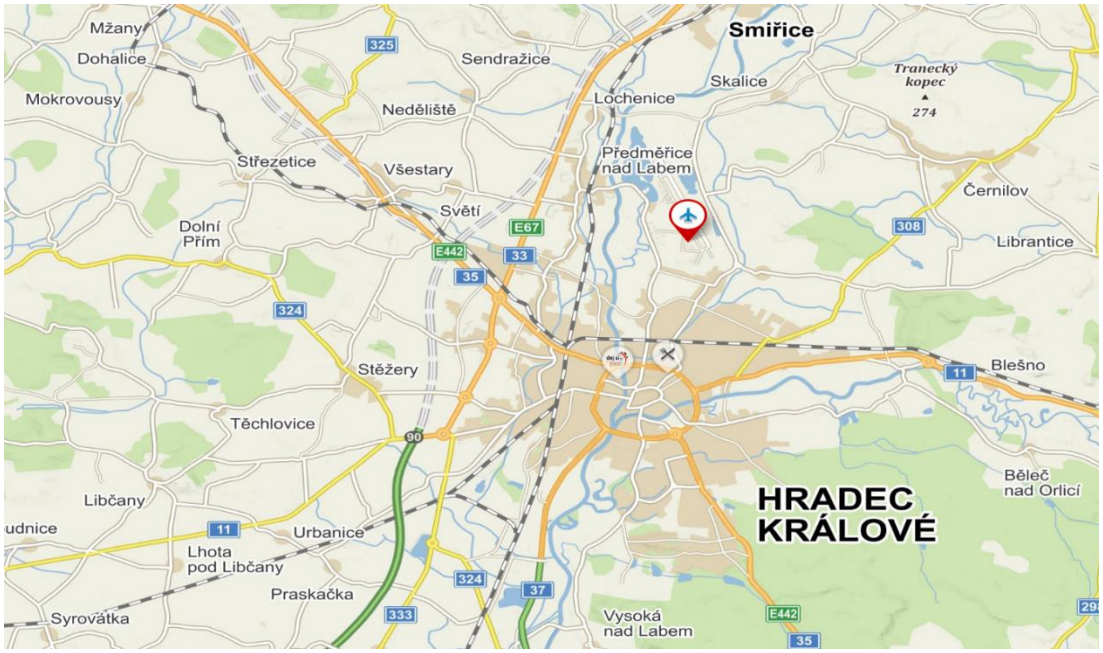


Figure 8: Location of Hradec Králové Airport [28]

The airport is a public domestic and a non-public international airport and belongs to category 2B. The airport therefore has a runway with a length of 800 m up to but not including 1200 m, and aircraft with a wingspan of 15 m up to but not including 24 m can land there. The airport has two runways, one of them is concrete and the other is grassed. The concrete runway is marked 33R/15L and is 2400 m long and 60 meters wide. The grass runway is marked as 33L/15R and is 800 meters long and 25 meters wide. The airport is equipped to operate VFR day/night flights. The airport is located at an altitude of 791 ft, which is 241 m. At the airport, it is possible to refuel AVGAS 100LL and JET A1 fuel during the airport's operating hours. [14]

Figure 9: Circuit of Hradec Králové Airport [14]

Hradec Králové Airport has frequency 122,005 and the airport code is "Kral RADIO". [14] The aerodrome chart of this airport is available in Appendix 2 of this document.

Airports circuits are divided according to the type of an aircraft. RWY 15L and 33L are intended for motorized aircraft mainly on the left side, RWY 15R and 33R mainly for the right side. RWY 15 is mainly intended for helicopters on the right side and RWY 33L is mainly for the left side. Gliders are assigned RWY 15R mostly right small and RWY 33L mostly left small. Even though the airport has two parallel runways, parallel operation, i.e. simultaneous take-off, or landing on both runways, is not possible. [14]

The altitude of the flight around the airport circuit is 1800 ft / 550 m AMSL, and it is forbidden to fly lower when flying over the surrounding villages during motorized

aircraft flights. To reduce noise, it is also possible to pass through the Airport operating zone only at an altitude of 2500 ft/830 m AMSL. When flying at night, the minimum circling altitude is 2100 ft/700 m AMSL, the minimum altitude is 2500 ft/830 m AMSL when flying above Hradec Králové town. [14]

Table 10 breaks down domestic and international movements from 2010 to 2019, including their year-on-year percentage change. The movement data were taken from the airport's annual reports, which can be found on the airport's website. It is important to note that jet aircraft also fly in the Hradec Králové Airport.

Year	Domestic	International	Total	Percentage change
2010	22111	513	22624	
2011	28046	657	28703	27,15
2012	27799	624	28423	-0,03
2013	28423	455	28878	0,64
2014	29383	630	30013	3,93
2015	41570	681	42251	40,74
2016	70168	790	70958	67,78
2017	76458	919	77377	9,18
2018	57910	1056	58966	-23,79
2019	46312	892	47204	-19,95

Table 10: Number of movements at Hradec Králové Airport from 2010 to 2019 [44]

As we can see from Table 10, the highest increase in traffic at LKHK occurred in 2016. Unfortunately, it was not possible to determine the cause of such a high increase from the annual report [16]. However, a significant part of the operation is generated by airlines stationed at the airport in Hradec Králové. For example, in 2014, these companies created 99% of traffic, remaining only 1% of traffic belongs to other users. [15]

Arrivals and departures outside operating hours are only possible by prior arrangement at least 24 hours in advance. The arrival form is completed online on the airport's website.

Table 11, see below, shows the landing fees at the airport in Hradec Králové.

Item	Price [CZK]
Aircraft up to 1 t MTOW	100,00
Aircraft up to 2 t MTOW	190,00
Aircraft over 2 tons of MTOW – for each t	220,00

Table 11: Landing fees at LKHK [14]

Parking fees charged to aircraft by Hradec Králové Airport are listed in Table 12.

Item	Price [CZK]
Parking area: Aircraft up to 2 t – for each day	200,00
Parking area: Aircraft over 2 t – for each day	150,00
Departure of a handling car on request to the airport area	120,00

Table 12: Parking fees at LKHK [14]

Table 13, see below, shows the fees for using the airport by passengers.

Item	Price [CZK]
Customs and passport clearance of crews and passengers for flights outside the EU and the Schengen area – per person	150,00
Safety check-in of crew and passengers – per person	250,00

Table 13: Passenger fees at LKHK [14]

Other fees relate to aircraft that intend to arrive beyond operating hours. These fees are shown in Table 14.

Item	Price [CZK]
Unauthorized use of the airport beyond operating hours	3000,00
Runway lighting (up to 3 aircraft) – for each started hour	2400,00
Runway lighting – each another aircraft	800,00
One-time lighting (for arrival/departure at 22:00-06:00 local time) – one movement	2500,00
Lights on request during operating hours – for each started hour	1000,00
Aircraft lighting on an apron on request – for each started night	300,00

Table 14: Other fees at LKHK [14]

2.1.2 Mnichovo Hradiště

The abbreviation of the airport according to ICAO is LKMH. [14]

The airport is located 3 km northeast of the town of Mnichovo Hradiště at an altitude of 801 ft/244 m AMSL. It is a public international airport with only VFR operation, as the airport is not equipped with a PAPI system. The airport is open from 07:00 to 15:00 UTC, i.e. from 08:00 to 16:00 in wintertime and from 09:00 to 17:00

in summertime. At the airport it is possible to check in airplanes, gliders, motor gliders, helicopters and ultralight aircraft. [29]

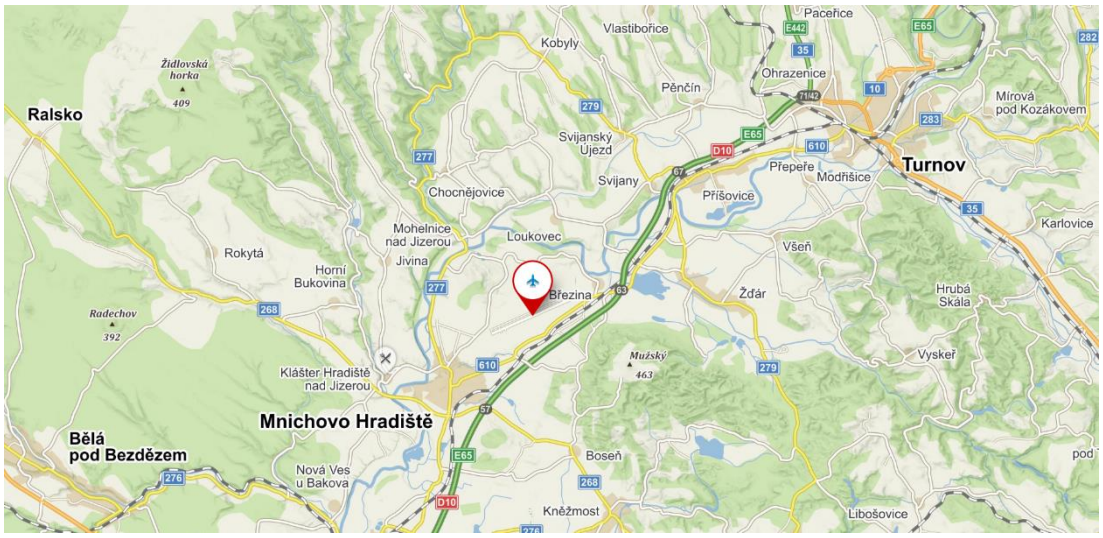


Figure 10: Location of Mnichovo Hradiště Airport [32]

The airport has two runways, one of them is grassed and the other one is concrete. The grassy runway is marked RWY 08/26 and is 1000 meters long and 60 meters wide. The concrete runway has dimensions of 1550x30 meters and is marked 07x25. On this paved runway, operation is permitted with code designation 2B and a maximum load of 25 t, but airplane heavier than 4 tonnes may only arrive at the airport based on request sent 24 hours before arrival. The altitude of the airport circuit is 1805 ft/550 m AMSL. [14] Anti-noise measures are implemented at the airport, which means that it is not allowed to fly over the surrounding villages – Březin, Podolí, Mnichovo Hradiště, Loukovec, Kruhy and Sychrov. [14] The aerodrome chart of this airport can be found in Appendix 3.

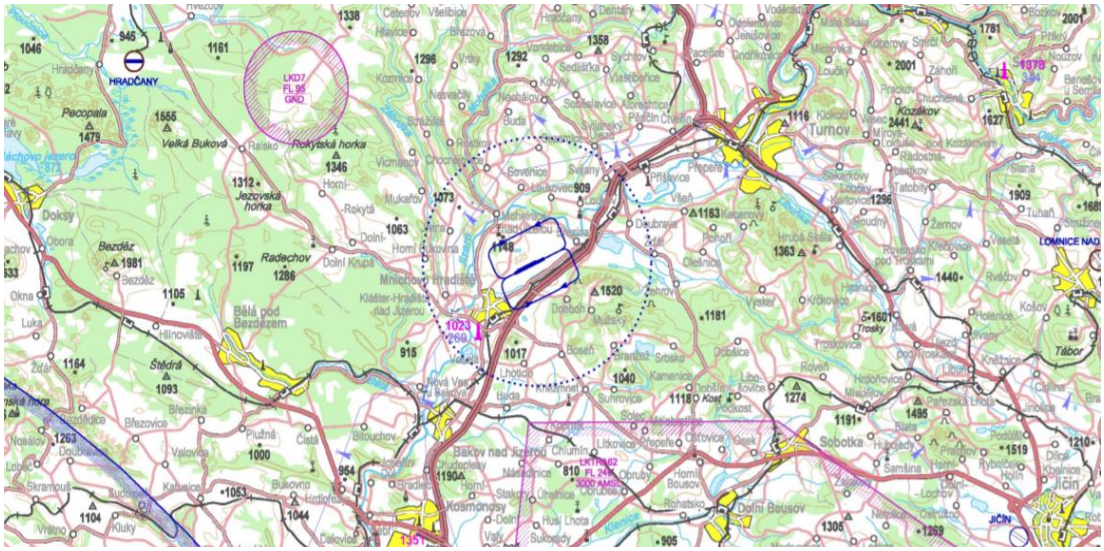


Figure 11: Circuit of Mnichovo Hradiště Airport [14]

It is possible to refuel AVGAS 100LL aviation gasoline and JET-A1 aviation kerosene at the airport during operating hours. Due to the absence of airport fencing, the pilot is encouraged to increased caution due to the possible occurrence of animals. The radio service is provided at the airport at the frequency 120,405 with the call code "Hradiště RADIO". The airport is operated by Aero-taxi OKR, a.s. [29]

Table 15 shows the domestic and international movements at the Mnichovo Hradiště airport. Data on movements were provided by Mnichovo Hradiště Airport.

Year	Domestic	International	Total	Percentage change
2010	6014	273	6287	-
2011	6010	365	6376	1,41
2012	8320	300	8620	32,20
2013	2674	35	2709	-68,57
2014	5394	428	5822	114,91
2015	3387	470	3857	-33,75
2016	4118	434	4552	18,02
2017	4294	389	4683	2,88
2018	9670	450	10120	116,10
2019	10221	509	10730	6,03

Table 15: Movements at Mnichovo Hradiště Airport from 2010 to 2019

Mnichovo Hradiště Airport charges 4 types of fees, which are landing fees, parking fees, passenger fees and other fees. Landing fees are listed in Table 16, see below.

Item	Price [CZK]
Aircraft up to 2 t MTOW	150,00
Aircraft up to 3 t MTOW	280,00
Aircraft over 3 tons MTOW – for each ton	250,00

Table 16: Landing fees at LKMH airport [14]

Parking fees are listed in Table 17 below.

Item	Price [CZK]
Each ton and hour	10,00
Long-term parking (more than 2 days) – t/d	70,00
Aircraft guarding – per hour	500,00
Aircraft guarding – per day	1000,00

Table 17: Parking fees at LKMH airport [14]

Fees for the use of the airport by passengers are listed in Table 18, see below.

Item	Price [CZK]
Per person	150,00
Customs and passport clearance per person	150,00

Table 18: Passenger fees at LKMH airport [14]

The fourth category of fees charged by the airport in Mnichovo Hradiště are other fees, which are listed in Table 19, see below.

Item	Price [CZK]
Extension of airport operating hours –per hour	500,00
Increasing the category of fire safety	6000,00

Table 19: Other fees at LKMH airport [14]

2.1.3 Plzeň/Líně

The abbreviation of the airport according to ICAO is LKLN. [14]

Plzeň/Líně Airport is located 11 km southwest of the city centre of Plzeň at an altitude of 1188 ft/362 m AMSL. The type of VFR operation during the day is permitted at the airport. The airport belongs to category 4C, but currently it is limited to category 2B. As in the case of the České Budějovice Airport, it is a public domestic airport and a non-public international airport. Airport operating hours are from 06:00 to 17:00 UTC. [40]

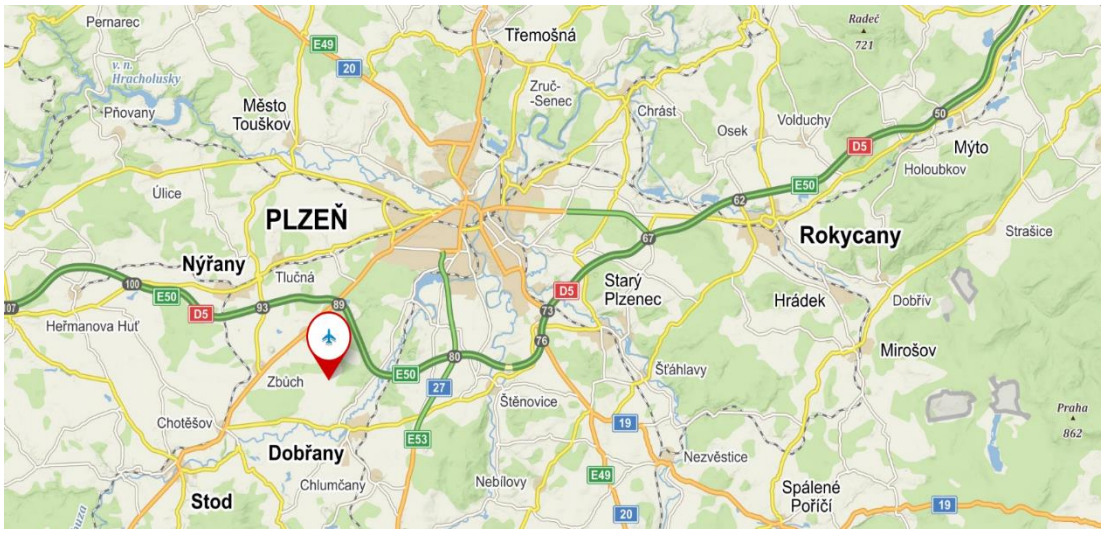


Figure 12: Plzeň/Líně Airport location [36]

The airport has one runway made of concrete surface with dimensions of 1450x60 m and marked 06x45, five concrete taxiways marked A, B, C, F and T, and 3 aprons

marked APN E, APN M and APN F. [40] The Aerodrome chart can be found in Appendix 4.

The altitude of the flight around the circuit is 2200 ft/670 m AMSL. According to the VFR guide, it is forbidden to fly over the villages of Dobřany, Vodní Újezd, Chotěšov, Zbůch, Líně, Sulkov and Lhota below 2200 ft /670 m AMSL. It is also forbidden to conduct training flights over densely populated areas. It is possible to refuel AVGAS 100LL at the airport, but only during operating hours. [14]

The airport is operated by PlaneStation Pilsen s.r.o. The airport is currently controlled by the Radio service on the frequency channel 129,005 and with the call sign "Line RADIO". [14]

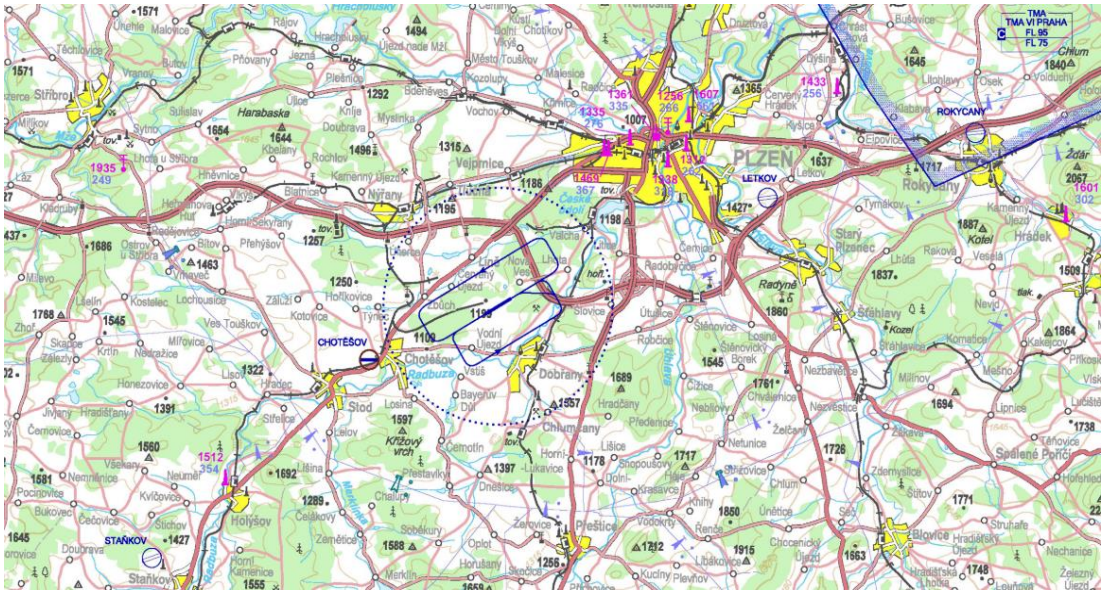


Figure 13: Circuit of Plzeň/Líně Airport [14]

Table 20 shows the number of domestic and international movements at Pilsen/Líně Airport from 2010 to 2019. Data was provided by Pilsen/Líně Airport.

Year	Domestic	International	Total	Percentage change
2010	7428	127	7555	
2011	9084	138	9222	22,06
2012	10450	178	10628	15,25
2013	10943	92	11035	3,83
2014	9143	218	9361	-15,17
2015	8922	251	9173	-2,01
2016	6333	157	6490	-29,25
2017	12014	303	12317	89,78
2018	16384	481	16865	36,92
2019	19286	405	19691	16,76

Table 20: Number of domestic and international movements at LKLN Airport from 2010 to 2019

Table 20 shows the annual increase since 2010, which, according to a telephone consultation with the airport, the company attributes to the gradual opening of hangar areas to aviation users. Moreover, the airport began providing AVGAS 100LL aviation gasoline in the same year. Between 2015 and 2016, there was a noticeable decrease in traffic intensity, which was caused by the rapid reduction in airport operating hours due to economic measures. In 2018, the operating hours were extended again from 08:00 to 20:00 every day in summer months, from 08:00 to civil twilight due to the absence of SSZ in winter. In 2019, the airport was also used by flight schools, and on weekends, German and Austrian tourists flew to the airport.

In the future, the airport would like to expand the airport code from the existing 2B to a higher one, as well as considering the implementation of lightening, which could be VFR night at the airport, and the introduction of instrument approach. The airport could find new clients among business passengers who will fly to the IFR airport thanks to these measurements.

As in the case of the Mnichovo Hradiště Airport 4 types of fees are charged – landing fees, parking fees, passenger fees and other fees. Landing fees are listed in Table 21, see below.

Item	Price [CZK]
Ultralight aircraft	68,00
Glider, balloon	85,00
Aircraft up to 1 t MTOW	85,00
Aircraft up to 2 t MTOW	170,00
Aircraft over 2 t MTOW – per each ton	230,00

Table 21: Landing fees at LKLN Airport [14]

In Table 22, see below, there are parking fees charged by LKLN.

Item	Price [CZK]
Parking area: Aircraft up to 2 t – per each day	100,00
Parking area: Aircraft over 2 t – per each day	100,00
Hangar – per each ton and day	250,00

Table 22: Parking fees at LKLN Airport [14]

The airport charges fees for the use of the airport by passengers, see Table 23.

Item	Price [CZK]
Customs and passport clearance of passengers for flights outside the EU and the Schengen area (per passenger)	120,00
Security clearance of crew, passengers, and luggage (physical check) for flights outside the EU and the Schengen area (per person)	250,00

Table 23: Passengers fees at LKLN Airport [14]

The last category of charged fees are other fees, which are listed in Table 24, see below.

Item	Price [CZK]
Extension of airport operating hours –30 min	450,00
Extension of airport operating hours – 60 min	900,00
Extension of fire assistance to cat. 3 and higher	3500,00
Use of a handling vehicle	120,00
Cargo transport up to 100 kg	120,00
Cargo transport over 100 kg – per each 100 kg	150,00
Parachute jump – per person and jump	30,00

Table 24: Other fees at LKLN Airport [14]

2.2 Comparison of parameters among airports

This chapter compares two parameters, which are the total movements, i.e. domestic and international movements at the airports in České Budějovice, Hradec Králové, Mnichovo Hradiště and Plzeň/Líně from 2010 to 2019.

Looking at Table 25 below, we can see that the airport in Hradec Králové is an airport with very heavy traffic. For example, in 2017, 77,377 movements took place at the airport in Hradec Králové. However, it is necessary to realize that the source of 99% of movements were deployed aeroclubs or other long-term customers of the airport, which was mentioned earlier.

	LKCS	**LKHK**	**LKMH**	**LKLN**
2010	8238	22624	6287	7555
2011	8323	28703	6376	9222
2012	6596	28423	8620	10628
2013	6303	28878	2709	11035
2014	7318	30013	5822	9361
2015	7202	42251	3857	9173
2016	8105	70958	4552	6490
2017	6824	77377	4683	12317
2018	5929	58966	10120	16865
2019	4214	47204	10730	19691

Table 25: Total movements at the LKCS, LKHK, LKMH and LKLN from 2010 to 2019

Another aspect of these airports that is being compared is runway. Comparison Table 26 shows the dimensions, runway material and parameters TORA, TODA, ASFA, and LDA, which are decisive for the air carrier whether to fly to the airport or not.

It is evident from the Table 26 that České Budějovice Airport has the longest runway from the compared airports, which measures 2,500 meters and is 45 meters wide. In addition, it is made of concrete, so larger aircraft such as Boeing 737 or Airbus 320 can land on it. This runway is also longer and wider than it is at Karlovy Vary Airport for instance, which is one of the public international airports with IFR and VFR operation, and whose runway measures 2150x30 meters. [14]

Airbus 320 needs 2,190 meters for take-off with MTOW 73500 kg [24] and Boeing 737 needs even more, 2300 meters long runway to be specific, for take-off with MTOW 70530 kg. [23] It means that these two aircraft could land from the compared airports only in České Budějovice and Hradec Králové, see Table 26.

	RWY	Dimension [m]	Material	TORA [m]	TODA [m]	ASDA [m]	LDA [m]
LKCS	27	2500x45	Concrete	2500	2560	2500	2200
	09	2500x45	Concrete	2500	2560	2500	2500
LKHK	33L	800x25	Grass	800	830	800	800
	15R	800x25	Grass	800	830	800	800
	33R	2400x60	Concrete	2400	2460	2400	2400
	15L	2400x60	Concrete	2400	2460	2400	2400
LKMH	07	1550x30	Concrete	1970	2030	1970	1550
	25	1550x30	Concrete	1550	1970	1970	1550
	08	1000x60	Grass	1000	1200	1000	1000
	26	1000x60	Grass	1000	1060	1000	1000
LKLN	06	1450	Concrete	1450	1690	1450	1450
	24	1450	Concrete	1450	1690	1450	1450

Table 26: Comparison of runway parameters at the airports LKCS, LKHK, LKMH, and LKLN [14]

3 Analysis of foreign airports

In this chapter will be described four Danish airports providing AFIS service.

3.1 Esbjerg Airport

The abbreviation of the airport according to ICAO is EKEB. [13]

Esbjerg Airport is located 9.3 km northeast of Esbjerg at an altitude of 97 ft/29.5 meters AMSL. The airport is allowed VFR day/night. It is an international airport with operational hours from 06:00 to 20:00 Monday to Friday, Saturday from 08:00 to 17:00 and Sunday from 08:00 to 19:00. [13]

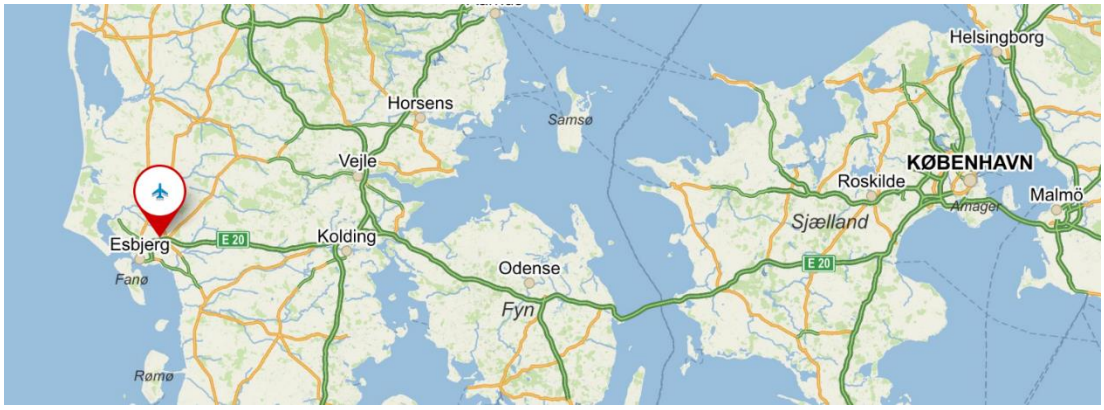


Figure 14: Esbjerg Airport location [26]

The airport is equipped with radar and one runway marked 08/26 with dimensions of 2599x45 m and an asphalt surface. The airport code is 4D. The consultation with this airport showed that the airport has a negotiated exception for the arrival of

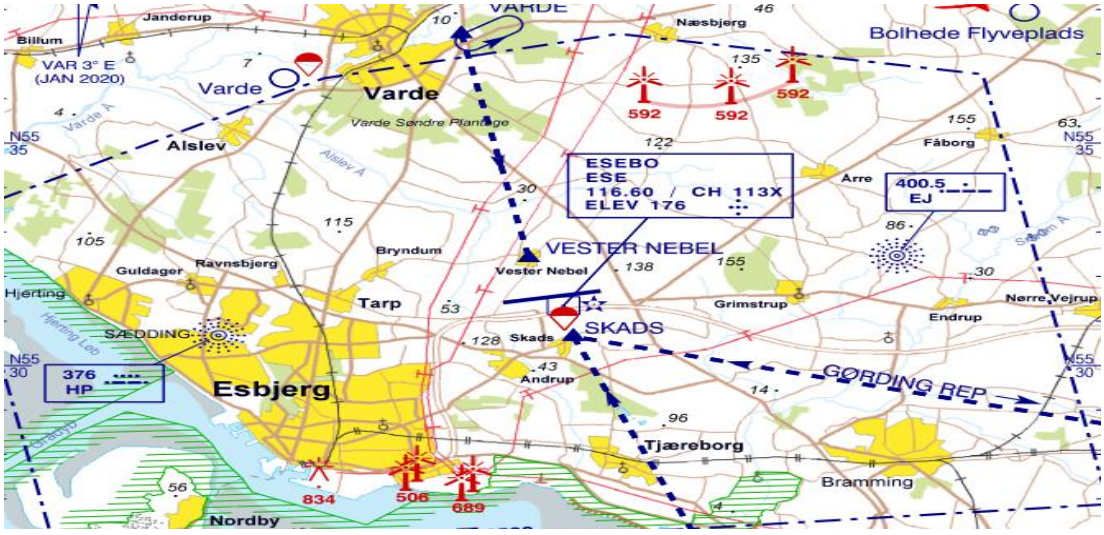


Figure 15: EKEB airport circuit [13]

aircraft with a wingspan of up to 52 meters, even though it has a runway only 45 meters wide. This exception was negotiated due to the arrival of some charter flights.

Both runways are equipped with a lighting device that allows the aircraft to land at night at a standard descent angle of 3 °. It is possible to refuel AVGAS 100LL aviation gasoline and JET-A1 aviation kerosene at the airport during operational hours.

The annual number of movements is approximately 7,500 aircraft. There are 5 regular operating airlines at the airport – DAT, Loganair, NHV, KN Helicopters and Bel Air. Flights to the city of Stavanger in Norway and Aberdeen in Scotland are operated daily from the airport. The airport is also a base for the operation of helicopters, which supply other facilities in the North Sea with oil and gas. TWR tuning is possible at a frequency of 120.15. [13] The Aerodrome chart of EKEB Airport can be found in Appendix 5.

The airport charges 4 types of fees, which are departure fees, passenger fees, which amount to DKK 120,00. Then there are parking fees and a handling fee. Departure fees are listed in the table below.

Type of fee	Item	Price [DKK]	DKK Exchange rate according to the CNB as of 21st July 2020	Price [CZK/EUR]
Departure fee	Aircraft up to 2 t MTOW	125,00	3,55	443,75/16,91
	Aircraft over 2 t MTOW per each ton	62,00		220,10/8,39
Passenger fee	Per person	120,00		426,00/16,24
Parking fee	per each ton and day	15,00		53,25/2,03
Handling fee	per each ton, aircraft 1-20 seats	151,00		536,05/20,44
	per each ton, aircraft 21-50 seats	149,00		528,95/20,17
	per each ton, aircraft 51-100 seats	144,00		511,20/19,49
	per each ton, aircraft 101 seats and more	135,00		479,25/18,27

Table 27: Fees charged at the EKEB Airport [11]

3.2 Sønderborg Airport

The abbreviation of the airport according to ICAO is EKSB. [34]

Sønderborg Airport is located 7.8 km north of Sønderborg at an altitude of 24 ft/7.32 m AMSL. The airport is authorized IFR/VFR. It is an international airport with the code 3C and with operating hours from 06:00 to 21:45 from Monday to Friday, from 06:30 to 16:00 on Saturday and from 14:00 to 19:15 on Sunday. The airport has one runway with the designation 14/32 with dimensions of 1797x30 meters. This runway has an asphalt surface. Furthermore, the airport has 5 taxiways marked A, B, C, D and E. The runway is equipped with lighting and a PAPI descent system with a standard descent angle of 3 °, so that it is possible to land on the runway in VFR night mode. [1]

The map with the marked airport is in Figure 16, see below.

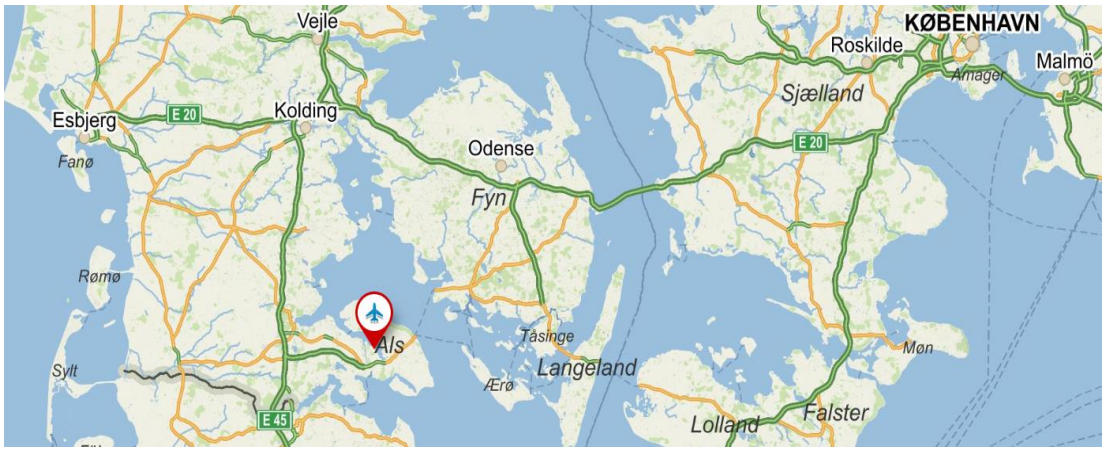


Figure 16: Sønderborg Airport Map [31]

Runway 32 is equipped with precision landing system cat.1. and radar. AFIS is available on the 126,40-frequency channel. It is possible to refuel AVGAS 100 LL aviation gasoline and JET-A1 aviation kerosene at the airport during operating hours. [1] The airport operates mainly charter flights and scheduled flights to the Danish capital Copenhagen. These are provided by Alsie Express, which was founded in 2013 and is based at EKSB Airport. Flights are organized with a frequency of 7 flights per week and the travel time is 35 minutes. [20] The airport has approximately 6,500 movements per year. [34] The Aerodrome chart of the EKSB Airport is in Appendix 6.

The consultation with the AFIS dispatcher from the EKSB Airport showed that since the airport has radar, staff have been trained to provide traffic information and navigation assistance if the pilot requires it. Aircraft often register with AFIS at the EKSB Airport outside the RMZ. With aircraft flying from the east, the tower has the first contact 15-35 NM from the airport. For aircraft flying from the north and west, the first check-in depends on whether the aircraft will land at the airport or if they

fly over the RMZ only. In the case of arrival at EKSB with such an aircraft, the tower usually makes the first contact 25 NM from the airport. Overlying VFR flights are usually reported at the RMZ airport.

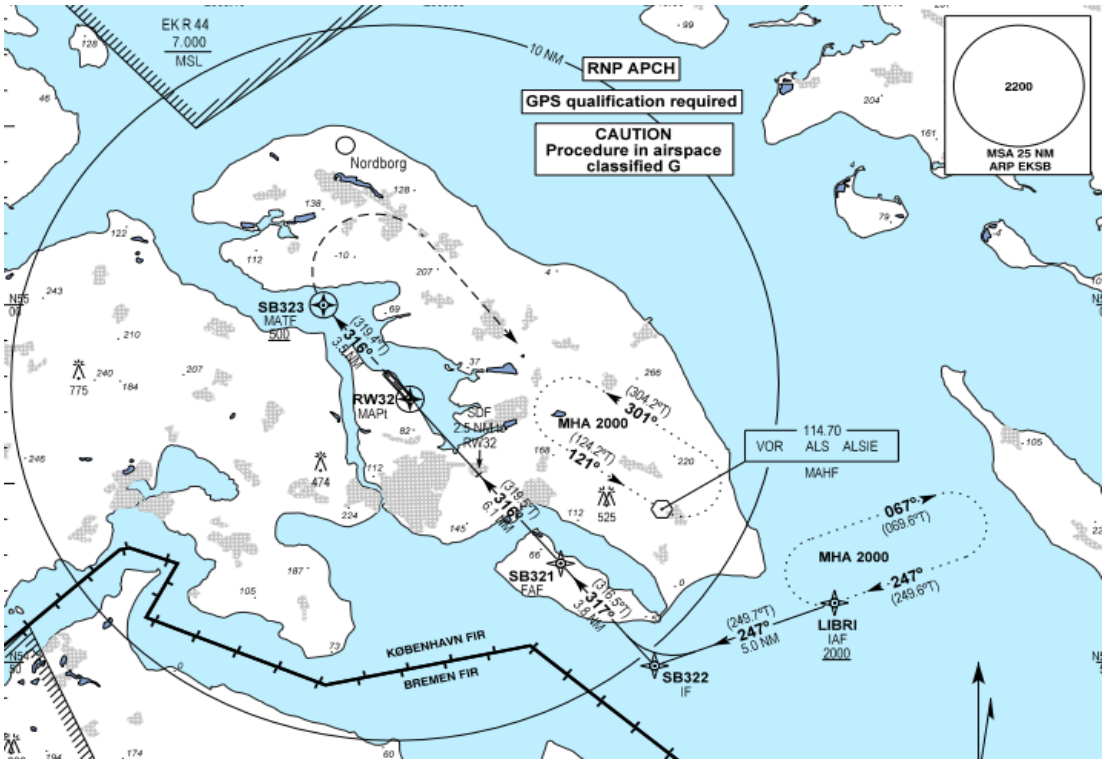


Figure 17: RMZ of EKSB Airport [1]

The table with the fees charged by ESKB is given below.

Type of fee	Item	Price [DKK]	DKK Exchange rate according to the CNB as of 21st July 2020	Price [CZK/EUR]
Departure fee	Aircraft up to 2 t MTOW	91,00	3,55	323,05/12,32
	Aircraft over 2 t MTOW – per each ton	44,00		156,20/5,96
Passenger fee	Per person	117,00		415,35/15,83
Parking fee	per each ton and day	9,00		31,95/1,22
Handling fee	per an aircraft exceeding 5 t MTOW	730,00		2591,50/98,80
	Minimum service fee	610,00		2165,50/82,56

Table 28: Fees charged by EKSB [38]

3.3 Odense Airport

The abbreviation of the airport according to ICAO is EKOD. [3]

Odense Airport is an international airport located 17 km northwest of the city of Odense at an altitude of 56 ft/17.07 meters AMSL. The airport has IFR/VFR mode of operation permitted. The airport has one runway with the designation 06/24 with dimensions of 2000x45 meters and with the code 4C. The runway of the EKOD has an asphalt surface. [3]

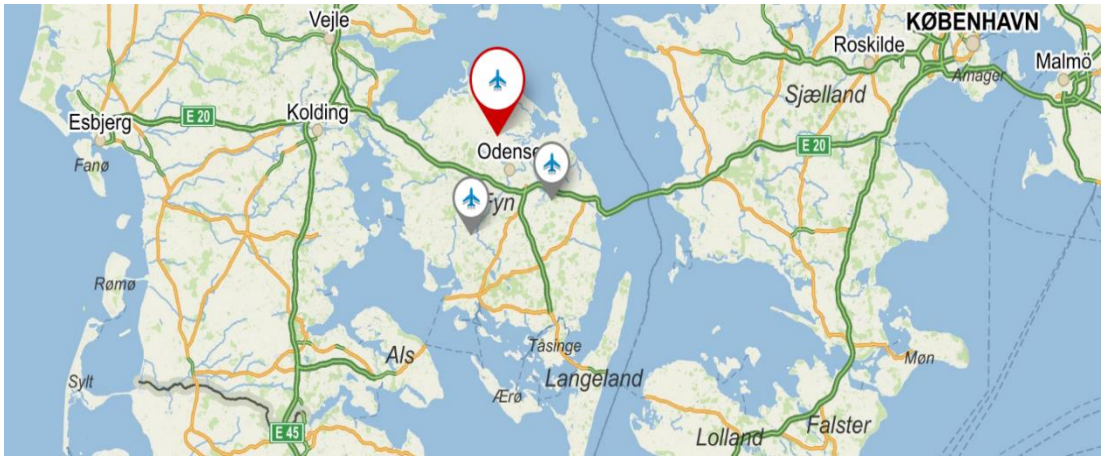


Figure 18: Odense Airport location [33]

The airport is open from 07:00 to 16:00 on Monday to Friday, from 08:00 to 14:00 then on Saturday and from 08:00 to 14:00 on Sunday. It is possible to refuel with AVGAS 100LL aviation gasoline and JET-A1 aviation kerosene at the airport during the airport's operating hours. The service AFIS at EKOD is available on frequency 119,525 under the call sign "Odense AFIS". It is also possible to land the airport in VFR night mode, as the airport is equipped with appropriate lighting. [3]

For the purposes of processing the diploma thesis, Odense Airport provided data on movements for 2018. These data show that in 2018, 7,116 movements were processed there, which the airport classifies into several groups. These are groups of charter and business flights, private flights, ambulance flights, school and training flights, military flights, and local operations, which also include parachuting flights, sightseeing flights, banner flights, calibration squadron and photographic flights.

	Domestic	International	Total
Charter and business	469	341	810
Private	2391	295	2686
Ambulance	145	60	205
School and training	2063	12	2075
Military	130	1	131
Local operations	1209	-	1209

Table 29: Number of movements at EKOD airport

Figure 19 shows the RMZ of Odense Airport. Aerodrome chart of EKOD is in Appendix 7.

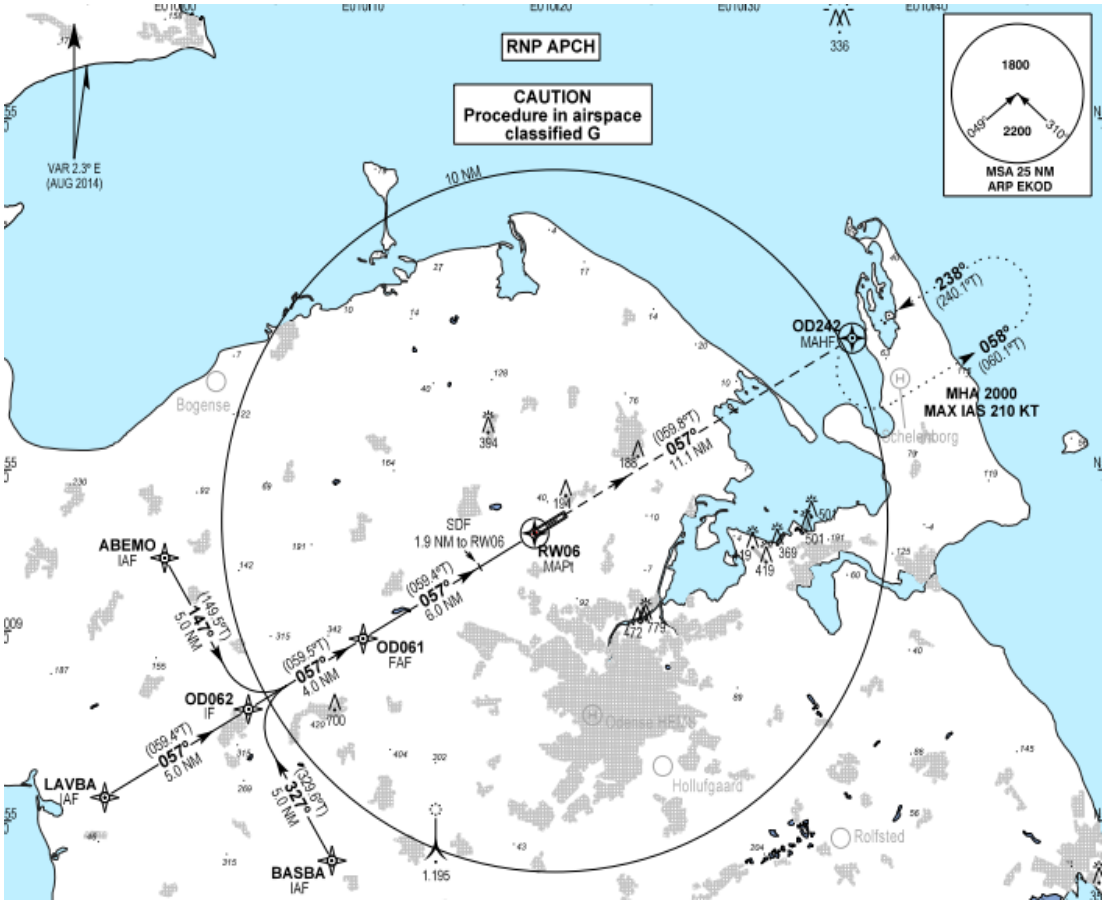


Figure 19: RMZ of EKOD airport [3]

The fees charged by Odense Airport are listed in Table 30, see below.

Type of fee	Item	Price [DKK]	DKK Exchange rate according to the CNB as of 21st July 2020	Price [CZK/EUR]
Depar-ture fee	Aircraft up to 2 t MTOW	76,00	3,55	269,80/10,29
	Aircraft over 2 t MTOW – per each ton	42,00		149,10/5,68
Passen-ger fee	Per person	116,00		411,80/15,70
Parking fee	peer each ton and day	13,00		46,15/1,76
Han-dling fee	Aircraft 0-20 t MTOW	333,00		1182,15/45,10
	Aircraft 21-40 t MTOW	733,00		2602,15/99,21
	Aircraft 41-60 t MTOW	867,00		3077,85/117,34
	Aircraft 61-80 t MTOW	1.000,00		3550,00/135,34
	Aircraft over 81 t MTOW	1.133,00		4022,15/153,34

Table 30: Fees charged by EKOD airport [9]

3.4 Kolding Airport

The abbreviation of the airport according to ICAO is EKVD. [2]

Kolding Airport is an international airport located 10 km southwest of the city of Kolding at an altitude of 147 ft/43.59 meters AMSL. [2] The airport is permitted IFR/VFR mode of operation. [2] EKVD has two runways, the parameters of them are given in Table 31, see below.

RWY	Dimensions	Surface
01	1006x23	Asphalt
19	1006x23	Asphalt
07	704x23	Grass
25	704x23	Grass

Table 31: Runway parameters at Kolding Airport [2]

The map with the airport location is shown in Figure 20, see below.

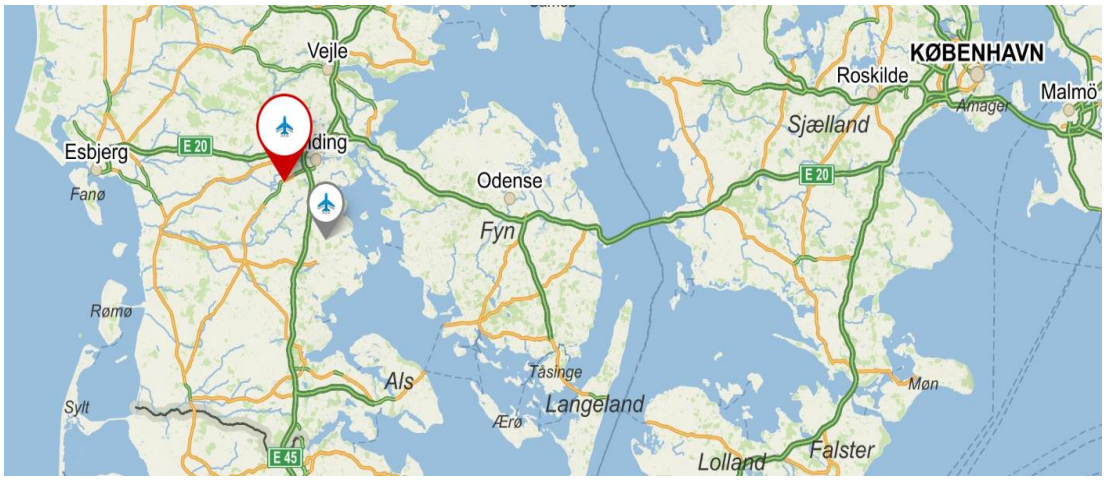


Figure 20: Kolding Airport location [45]

RWY 01/19 is designated by code 2B and RWY 07/25 has a code 1C. The runway 01/19 is equipped with lighting and a PAPI landing system with a standard descent angle of 3 °, so that it is possible to land on this runway in the VFR night mode. [2] The airport has 4 taxiways – TWY A, B, C and D. EKVD is open every day of the week from 06:00 to 21:00. It is possible to refuel with AVGAS 100LL aviation gasoline and JET-A1 aviation kerosene at the airport during the airport's operating hours. When flying in IFR mode, part of the airspace is classified as G below 3500 ft. Kolding Airport's AFIS service is provided at frequency 120.50. [2] The Aerodrome chart can be found in Appendix 8.

As for the number of movements, this airport is the largest of all the described Danish airports. It handles about 11,000 movements a year. The structure of these movements is mainly GA and flight schools. [30] Due to the absence of the Kolding Airport website, it was not possible to find out what types of fees are charged by airport.

The figure 21 below shows the RMZ of Kolding Airport.

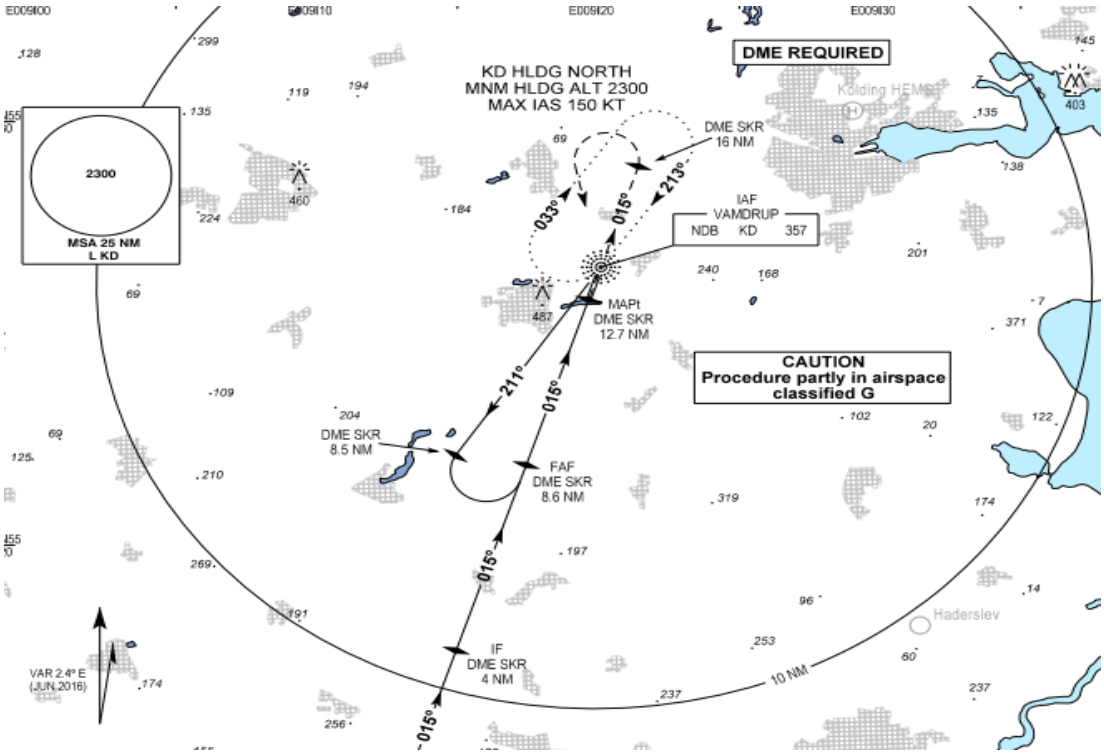


Figure 21: RMZ of the Kolding Airport [2]

3.5 Summary

In this chapter, 4 Danish airports that provide AFIS service are being analysed. These airports are in Kolding, Odense, Sønderborg and Esbjerg. From the collected data we can say that no more than 15000 aircraft movements per year will take place at any of these airports, which is a necessary condition for the provision of AFIS. However, this condition does not need to be met if the aerodrome handles less than 7500 IFR movements per year. If the airport handled more than 7500 IFR flights, it should switch to providing air traffic control.

The analysis also shows that all 4 airports have different runway dimensions. If only paved runways are considered, then the airport in Kolding has the smallest runway, which measures 1006x23 meters, while the airport in Esbjerg has the largest one, which measures 2599x45 meters.

It is especially important to mention that the assessed airports are close to each other, see Figure 22. This is beneficial if we want to compare them to airports in the Czech Republic, where the frequency of airports is extremely high and there is often overlap and necessary coordination among them. If, for example, the analysed Danish airports were 400 km apart, it would not be possible to reproduce the analysis for airports in the Czech Republic, because the passengers could land in Ostrava and

reach České Budějovice by car within the Czech Republic, which is about 390 km. It is therefore still possible to assume that an airport with an AFIS service could be back-up airport to a controlled airport, for example Prague-Ruzyně. On the contrary, the positive phenomenon that we can see from the analysis of this factor is that the assessed airports are close to each other and they have quite strong operation. In comparison with Czech airports such as Prague, Karlovy Vary, Ostrava, Brno, Pardubice and České Budějovice, the Danish assessed airport are much closer than these listed Czech airports.

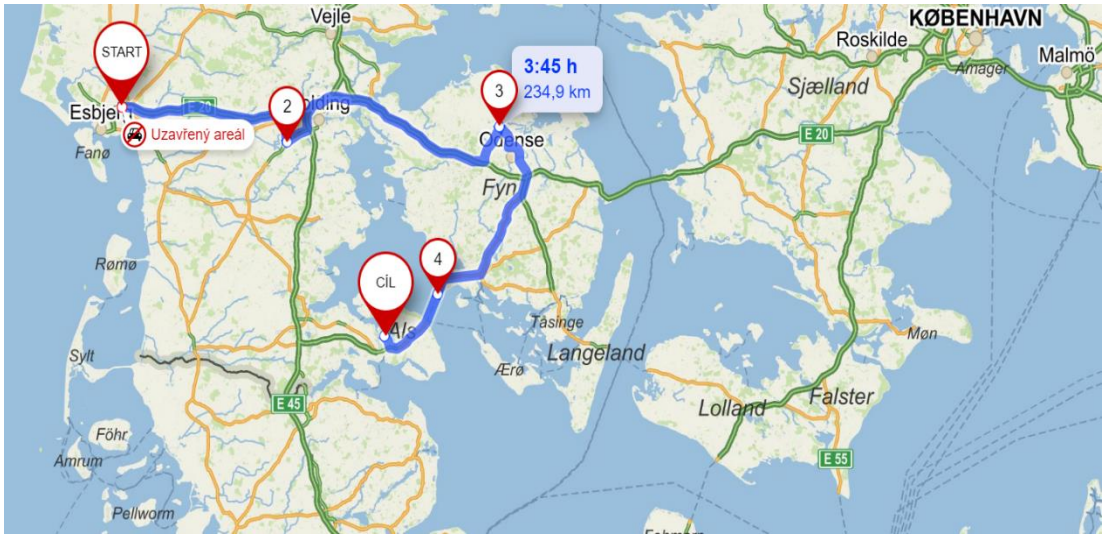


Figure 22: Map with the assessed Danish airports [37]

4 Air traffic services

AFIS is one of the air traffic services described in this chapter. Their basic tasks are to prevent aircraft collisions, to manage the flow of air traffic efficiently, to provide advice and information to ensure a safe flight, and to inform the relevant organizations and authorities of aircraft in need of assistance or an aircraft that needs to be sought. [10] Air traffic services include Air Traffic Control (ATC), Flight Information Service (FIS) and Alerting Services (ALRS). [18] All provided services are described here for a better understanding of air traffic service issues.

Air traffic services are provided in designated areas and at airports. The airspace is made for FIR flight information areas, which are determined according to the size of the territorial unit, or according to other special criteria. [18] In the Czech Republic, there is only one flight information area, which is called FIR Prague. [27]

The Air Traffic Control of the Czech Republic based in Jeneč near Prague is responsible for providing air traffic services in FIR Prague except of those that belong into exception. The mentioned exceptions include military airports, for which the Army of the Czech Republic is responsible. Furthermore, the airport operator is responsible for providing air traffic services at Kunovice and Praha Vodochody airports. As no air traffic control service is provided at AFIS airports, the airport operator is also responsible for providing information to known traffic at the airport. [7]

Air traffic control provides instructions to the aircraft which then follow and must execute those instructions. The operation of this type of control is very financially and technologically demanding, and therefore only large airports can afford it. For smaller regional airports, the AFIS service could be a good compromise between ATS and Radio. AFIS only provides information that the pilot can follow but does not give instructions. The AFIS dispatcher needs to be trained. Emphasis is also placed on the equipment of AFIS stations, including manuals and issued procedures. This fact could persuade potential carriers to provide regular flights to uncontrolled airports, but with particularly good information.

Even though the air traffic control service does not seem to be related to the issue of the České Budějovice Airport, it is important that the reader is aware of all air traffic services that are provided at Czech airports.

4.1 Air Traffic Control

"The Air Traffic Control" (ATC) service prevents aircraft collisions by providing prescribed distance among aircraft and transmitting traffic information." [10]

This service is provided in controlled airspace and at controlled airports. The air traffic control service is divided into 3 parts according to the controlled area. The first part is an area control service provided by an area control centre. The second part is the approach control service, which is provided by the approach control station, and the third part is the airport control service, which is provided only at the controlled airports and in their vicinity it is provided by the airport control tower. [18]

4.1.1 Area Control Service

The Area Control Service Centre is located at IATCC Jeneč and provides air traffic control service to controlled flights. The service is provided continuously. The area in this case means the territory of the Czech Republic, which is divided into sectors created in the horizontal and vertical levels, the use of which depends on the current intensity of air traffic. [35] In addition, the Area Control Service Centre must consider the strategically important objectives for which the no-fly zone applies. Such targets include, for example, the Temelín nuclear power plant, Prague Castle, or military training facilities. The Area Control Service Centre shall control the flight until it is taken over by the Approach Control Centre. [35]

The Area Control uses the guidance of aircraft on predetermined flight routes located in the upper and lower airspace. The flight routes in the upper airspace are intended for flights in transit through the Czech Republic. On the contrary, the flight routes in the lower airspace are used for flights to Czech controlled airports. [35]

The airspace categories of air traffic services are called A-G. [18] In the Czech Republic, there are only 4 classes of airspace in use, which are C, D, E and G. [35] In each of the airspaces, there are rules set for aircraft equipment, flight speeds, safety distances, etc. [35]

This service is provided by Area Control Centre Prague in the Czech Republic. [35]

4.1.2 Approach Control Service

It consists of several end logical segments in which the arrival and departure routes are tracked. [18] This created space serves for the safe guidance of aircraft for landing.

This service is provided by APP Prague, APP Brno, APP Ostrava, and APP Karlovy Vary in the Czech Republic. [8]

4.1.3 Aerodrome Control Service

The takeover of an aircraft by an airport control tower from the ACC depends on the weather conditions. In case of bad weather, the aircraft is guided to the area control in close proximity to the airport, and then it is handed over to the Aerodrome Control Tower, which takes responsibility for the final phase of the flight. In case of good weather, the aircraft is guided by Area Control to the landing system, where it is then taken over by the Aerodrome Control Tower again. [49] After landing the aircraft, the Aerodrome Control Tower ensures the movement of the aircraft around the aerodrome to the apron.

This service is provided by TWR Prague, TWR Brno, TWR Ostrava and TWR Karlovy Vary in the Czech Republic. [49]

4.2 Alerting Service

An Alerting Service is provided by the relevant Air Traffic services unit, which may be the Area Control Centre, the Approach Control Centre, the Aerodrome Control Tower, the Flight Information Centre, or the Aerodrome Flight Information Service. [6] All these types of services are described in this chapter.

The task of this service is to announce a search for an aircraft and to pass on requests for assistance to the National Search and Rescue Service SAR. According to Annex No. 12 of the Chicago Convention, each state is obliged to provide this service to the aircraft of any state in the case of an emergency or accident. [50]

Alerting Service is provided throughout the FIR Prague. [6]

4.3 Flight Information Service

This service is provided by the appropriate Air Traffic Service Centre described in this chapter to all aircraft for which the information may be useful and to which the Air Traffic Control Service is provided. Furthermore, the Flight Information Service is provided to all known Air Traffic Control Centre and general aviation, i.e. aircraft which the Air Traffic Control Service is not provided to on request. [7]

The aim of the Flight Information Service is to give advice and information on the operation, weather and condition of airports at the operating frequency of the relevant ATS Centre in the entire FIR Prague area and at controlled airports in order to make the flight safe and efficient. [7]

Air traffic controllers provide Flight Information Service to controlled flights and near controlled airports together with ATC and ALRS services. FIS and ALRS services

are provided to uncontrolled flights in the VFR mode in FIR Prague Flight Information Centre. [27]

The FIC is an air traffic services centre that provides service without a time limit on a 24/7 basis and free of charge on the operating frequencies of the unit: [27]

- 126.100 PRAHA INFORMATION for the Bohemia West sector
- 136.175 PRAGUE INFORMATION for the Bohemia East sector
- 136.275 PRAGUE INFORMATION for the Moravia sector

These sectors are shown on the map, see Figure 23.

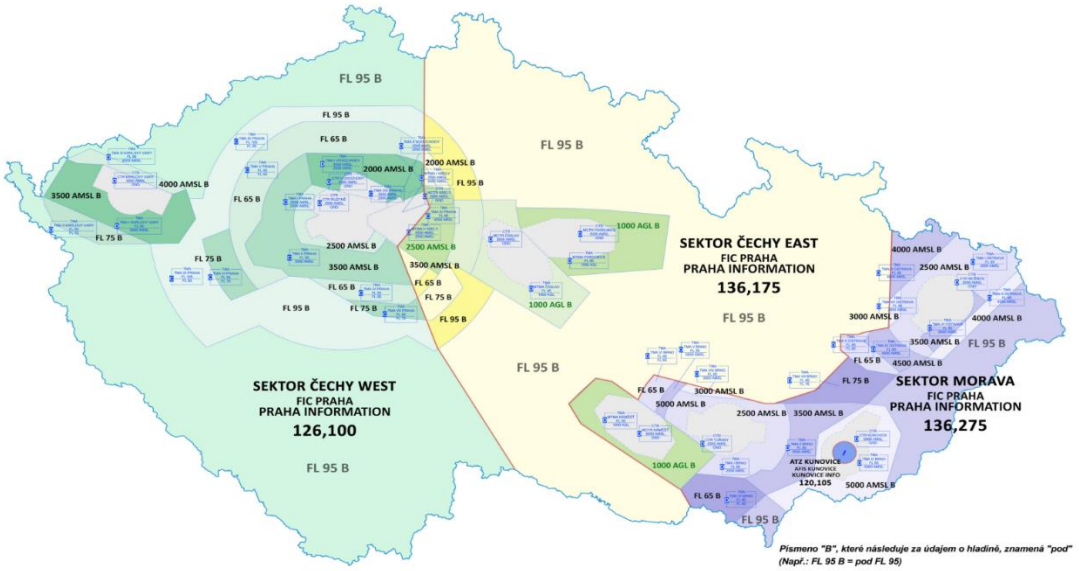


Figure 23: Allocation of ATS airspace by FIS and ALRS centres for uncontrolled flights [27]

After establishing a connection on the relevant frequency, FIC Prague provides information on traffic, information on reported meteorological conditions at the route and airport, information on the actual use of the sectors and any other information that could affect the safety of flight. [27]

4.3.1 Aerodrome Flight Information Service

The Aerodrome Flight Information Service is another category of Air Traffic Services. The provision is supervised by the by the National Supervisory Authority. [7] It is provided at uncontrolled aerodromes and its purpose is to inform the pilot about the aerodrome, about the condition of the movement area, about the type of traffic, and also about obstacles at and near the aerodrome. Additionally, it informs about meteorological conditions. [48]

AFIS is provided to all known aircraft that generate traffic at the airport and at ATZ or activated RMZ or TMZ. The area with mandatory radio communication is designed

so that the approached tract always occurs within this area, horizontally spaced from its borders by at least 1 NM, i.e. at least 1852 meters and vertically 500 ft. [48]

The operating hours of the AFIS station are clearly defined, however, there are certain circumstances in which this service may operate outside the published operating hours. These circumstances include, for example, ongoing flight license training at the airport, conducting airdrops at the airport, performing night aviation activities. Last but not least, organising an aeronautical public performance or air competition at the airport both belong to these circumstances. [48] The pilot may request extension of operating hours in advance because of reasons other than those mentioned above. Specifically, at LKCS, they have operating hours from 08:00 to 21:30 in July 2020. However, the extension of operating hours at this airport can go up to 22:00 due to night rest, so the extension of operating hours during summer season is not widely used by pilots. On the contrary, the extension of the winter operating hours is used more often. The operating hours are from 08:00 to 20:00 at LKCS in the winter period, so this period can be extended by up to 2 hours in this period, which costs approximately CZK 6,000 according to the valid price list. [4] Sending a request for an extension of operating hours is important, especially because of airport staff that must be present.

As mentioned above, the AFIS service is one of air traffic service categories, which is certified and supervised by the National Supervisory Authority, which is the Civil Aviation Authority in the Czech Republic. [48]

It is important that the AFIS centre is located so that the dispatcher can monitor the traffic on the operating area and near the airport. The AFIS centre must have information on ground wind pressure, direction and speed, air temperature, information on runway conditions, UTC time and meteorological conditions, including forecast. [48]

Within the AFIC centre, two functions are defined, which are the head of the AFIS centre and the AFIC dispatcher. The head of the AFIS centre is the responsible representative of the airport operator and he is responsible for the overall organization of AFIS. [48]

The task of the head of the AFIS centre is to prepare a guideline for the performance of the AFIS service for the given airport. The directive contains data on the AFIS centre, the scope of responsibilities, data on the technical equipment for the provision of AFIS, the telephone and other connections used, and the obligations of the AFIS controller and other people involved in ensuring air traffic. Furthermore, there are procedures for the provision of AFIS applicable to various types of

operation, procedures for the provision of emergency services, procedures for coordination with firefighters, rescue services, the Czech Police, etc. [48]

There are currently no airports with the AFIS service in the Czech Republic, as according to the European Commission Regulation 2017/373, AFIS falls under the ATC services. High demands are placed on these services. This regulation stipulates the need for certification of the AFIS centre, securing the site by a certified employee, etc. From a technical point of view, airports providing AFIS according to the new EU regulation 2017/373 must meet the same requirements as controlled airport, e.g. in Karlovy Vary or Brno. This is expensive, which is why the airport providing the AFIS service decided to switch to the Radio service until then.

In the case of providing the AFIS service, the obligation follows from the regulation to keep operational records in the so-called operating log of the AFIS centre. There is written information about start and end of the dispatcher shift and about people designated. This is done to ensure airport operations, important changes in the condition of the airport, used runway, are all recorded in case of obstacles, accidents or incidents. Also, it can be later be used as a proof that aviation regulations were violated. The operation log must be kept at the centre for at least three years from the date of its description. [48]

The AFIS dispatcher must be duly certified to perform this work, with a valid AFIS dispatcher license and a general aeronautical mobile radio operator's license and he must participate in training in order to provide AFIS each year. If the AFIS dispatcher performs his function at AFIS international airport, he must have language skills prescribed in Regulation L 1. The dispatcher's license is valid for 3 years. [48]

As mentioned above, there is currently no airport in the Czech Republic that provides AFIS service. However, it is suitable for smaller airports, where air traffic control is not needed due to less demanding infrastructure and operation. In Scandinavia, they have many years of experience with the AFIS service. Therefore, Integra company was consulted throughout elaboration of the diploma thesis. Integra trains and certifies AFIS dispatchers and other consulting services related to AFIS in Europe.

The Aerodrome Information Service provides information on the runway in use, the direction of the aerodrome circuit, the type of flight activity at the aerodrome, the condition of the aerodrome and obstacles located on it. It also informs about meteorological situation. Moreover, it transmits information to departing aircraft and arriving aircraft. [48]

Due to the higher demands placed on the certification of dispatchers and the AFIS centre, it can be assumed that this type of flight information provision could ensure new movements for airports, because the pilot would feel safer.

AFIS equipment

The dispatcher must have the following printed or approved electronic publications available at the AFIS station: [48]

- L 2 – Rules of flying
- L 3 – Meteorology
- L 11 – Air traffic services
- L 13 – Regulation on the professional investigation of the causes of accidents and incidents
- L 14 – Aerodrome
- L 15 – Aeronautical information service regulation
- L 4444 – Procedures for air navigation services
- Aviation information manual AIP CZ and VFR guide
- Air circulars (series A and C) according to the nature of the airport
- Valid NOTAMs that apply to the airport, ATZ or RMZ

The mandatory equipment of the AFIS station is listed in Table 32, see below.

The main radio station of the aeronautical mobile service	
Backup radio station of the aeronautical mobile service (in case of failure of the main radio station)	
Cell phone	
Meteorological equipment	Equipment for measuring the direction and speed of the ground wind
	Pressure measuring equipment
	Equipment for measuring the outdoor temperature
	Table for determining ground visibility
	Device for measuring the lower cloud base (for IFR)
Lighting control device (for VFR night)	
Equipment for recording radiotelephone communication and telephone calls	
Electronic equipment with access to non-aerodrome meteorological and other information, including electronic mail	
Time indicator	Clock showing UTC time in hours, minutes, and seconds

	Clock showing local time
Telescope	
Maps	ICAO Map 1:500 000
	Maps of restricted areas for the provision of Flight Information Service
	Aerodrome Chart
	Visual approach map of the airport
	IFR flight procedure maps (for IFR)
	Detailed map of the airport
Table of sunrises/sunsets	
Phone numbers	Public fire brigade
	Ambulance
	Police of the Czech Republic
	ATC providing ATS in the controlled airspace concerned (for IFR)
	Rescue coordination centre Prague
	Civilian or military ATS centre
	Cooperating meteorological service centre
	ATS reporting office
	Civil Aviation Authority
	Institute for professional investigation of the causes of aircraft accidents
	Responsible representative of the airport operator
	Responsible representatives of all organizations operating permanent aviation activities at the airport
AFIS centre operation log	
Airport regulations listed by the airport operator	
Guidelines for the performance of service at the AFIS centre	
Coordination directives and agreements, if not part of the airport regulations or guidelines for the provision of AFIS centre	

Operating instructions and regulations of the AFIS head

Table 32: Mandatory equipment of the AFIS centre [48]

4.4 Providing information to known traffic at airports

The provision of information to known traffic is defined in Regulation L 11, Appendix S. The aerodrome providing this service is uncontrolled and it has been decided that neither Air Traffic Control nor Aerodrome Flight Information Service is provided. Each such airport has been assigned a symbol consisting of the place of operation and the word RADIO (e.g. Budejovice RADIO). The information is provided in the airport operating zone. [47]

As in the case of the AFIS centre, the information centre must be in such a way that it is possible to monitor traffic at the operating area and in the vicinity of the airport as far as possible. The person providing the information is not authorized to issue any permit to the air traffic, on the contrary, he must provide information, maintain an overview of traffic at the airport and its vicinity, respond to unknown traffic and monitor the operability of the airport and its facilities. [47]

The obligation of the centre providing information to known traffic at airports is to keep operational records in the form of an operation log. It records similar information as with AFIS, i.e. when the shift was started and finished, important changes in the condition of the aerodrome used in the runway, the occurrence of obstacles, an accident, etc. Records must then be kept for at least three years from the description of the diary. [47]

The person must be trained to provide information but does not need to be certified as in the case of AFIS dispatcher. Known air traffic is provided with information about the runway in use, the direction of the airport circuit, the type of flight activity, the condition of the airport, obstacles at the airport and about meteorological conditions as well. It passes the information to known traffic during departure, arrival, and flying through the circuit. [47]

5 Implementation of AFIS at České Budějovice airport

This chapter presents a safety risk analysis of AFIS implementation at the airport in České Budějovice, which is an important milestone in the entire project. Furthermore, the mathematical model is used to predict traffic flow based on the construction of scenarios according to the affinity for risk of airlines.

5.1 Safety risk analysis

A safety risk analysis should be done for any project before its implementation. With the help of this analysis, owners, investors, and other stakeholders are acquainted with all the risks that the project brings, but also with the procedures that would eliminate these risks. It also says how to behave when the risks occur.

5.1.1 Matrix of risks

For safety risk analysis, it is necessary to design a risk matrix based on the severity of the hazard and the probability of its occurrence, see Table 33. This risk matrix was prepared after prior consultation with the safety specialist of the Air Navigation Services of the Czech Republic state enterprise.

		Probability				
		Frequent	Probable	Unusual	Infrequent	Improbable
Seriousness	Catastrophic	A1	B1	C1	D1	E1
	Dangerous	A2	B2	C2	D2	E2
	Serious	A3	B3	C3	D3	E3
	Low	A4	B4	C4	D4	E4
	Insignificant	A5	B5	C5	D5	E5

Table 33: Matrix of risks [42]

5.1.2 Managing criteria

The managing criteria are divided into unacceptable, tolerable, and acceptable, see Table 34. The defined risks can be found in Table 35, see below.

Risk index	**Managing criterium**
A1, A2, A3, B1, B2, C1	Unacceptable
A4, A5, B3, B4, B5, C2, C3, C4, D1, D2, D3, E1, E2	Tolerable
C5, D4, D5, E3, E4, E5	Acceptable

Table 34: Managing criteria

ID	Hazard	Consequences	Effect	Barriers	Probability	Seriousness	Risk	Risk mitigation means	Change of risk in case of RMM implement.
H01	AFIS dispatcher does not know about the plane in space	There is a VFR operation in the ATZ area, which the AFIS dispatcher does not know about, because he did not register	In case of simultaneous VFR and IFR operations, a dangerous convergence can occur	VFR flies by sight, sees around him	B	2	B2	-RMZ – all aircraft will have to report -IFR movements on defined time slots+take it down the AIP -overview information for the AFIS dispatcher	D4
H02	Handing wrong information over to the pilot								
H02.1	Meteorological								
H02.1.1	Ground wind direction and speed	The dispatcher hands wrong ground wind direction and speed information over to the pilot	The pilot expects a different wind speed, deviation from the RWY or other problems on landing manoeuvre can occur	-a meteorological equipment in the AFIS centre -the AFIS dispatcher is trained to prevent these situations	C	3	C3	-	-
H02.1.2	Significant weather (thunderstorm, hail)	The dispatcher hands wrong significant weather information over to the pilot	Lighting, icing, turbulence, wind shear	-a meteorological equipment in the AFIS centre -the AFIS dispatcher is trained to prevent these situations	C	2	C2	-	-
H02.1.3	Air temperature	The dispatcher hands wrong air temperature information over to the pilot	Possible worse start of the engine	-the pilot can verify himself -a meteorological equipment in the AFIS centre	D	4	D4	-	-

ID	Hazard	Consequences	Effect	Barriers	Probability	Seriousness	Risk	Risk mitigation means	Change of risk in case of RMM implement.
H02.1.4	Lower cloud base	The dispatcher hands wrong lower cloud base information over to the pilot	The pilot evaluates whether the RWY is visible. If the RWY is not visible, flight must be diverted to another airport	-the pilot can verify himself -a meteorological equipment in the AFIS centre	C	3	C3	-	-
H02.1.5	Pressure	The dispatcher hands wrong pressure information over to the pilot	Incorrect altitude adjustment, which can lead to an aircraft accident	-the pilot can verify himself -a meteorological equipment in the AFIS centre	C	2	C2	-	-
H02.2	Aircrafts in the space	There is another operation in the ATZ, which the AFIS dispatcher gave the pilot wrong information	The pilot does not expect the aircraft in the area where he is, a dangerous convergence can occur	VFR flies by sight, sees around him, the IFR pilot only to a limited extent due to instrument tracking	C	3	C3	-RMZ – all aircraft will have to report -overview information for the AFIS dispatcher	E4
H02.3	Airplane at the RWY and around the airport	The dispatcher hands wrong another operation information over to the pilot	The pilot does not expect the aircraft at RWY, dangerous convergence can occur	VFR flies by sight, sees around him, the IFR pilot only to a limited extent due to instrument tracking	C	3	C3	-overview information for the AFIS dispatcher	E4

ID	Hazard	Consequences	Effect	Barriers	Probability	Seriousness	Risk	Risk mitigation means	Change of risk in case of RMM implement.
H02.4	Information on the direction of the airport circuit	The aircraft flies against the direction of the airport circuit	Other traffic flies frontally against the aircraft with wrong information, dangerous convergence can occur	-the pilot has an information from the VFR guide and sees around him -AFIS dispatcher sees the circuit from the tower	D	2	D2	-overview information for the AFIS dispatcher	E4
H02.5	Contamination of the RWY (slippery RWY etc.)	The aircraft is approaching the RWY, which is in a different condition than the AFIS dispatcher announced	-preparation of the pilot for other conditions -longer braking distance	-a meteorological equipment in the AFIS centre	D	3	D3	-	-
H02.6	RWY is in use	The aircraft is approaching an RWY that is not in use	Approaching an RWY against an aircraft taking off, dangerous convergence can occur	-IFR approach only on RWY 27 -VFR flies by sight, sees around him	D	2	D2	-overview information for the AFIS dispatcher	E4
H03	Absence of weather information, see H02, H03	The system providing meteorological information is failing	The pilot cannot get meteorological information and there is a danger of misjudging the information	The pilot lands at the backup airport, where he is provided with information	C	3	C3	Backup source of information	E4

ID	Hazard	Consequences	Effect	Barriers	Probability	Seriousness	Risk	Risk mitigation means	Change of risk in case of RMM implement.
H04	Handing no information over to the pilot								
H04.1	Meteorological	If the pilot needs information, he asks the AFIS dispatcher	-increase the strain of the AFIS dispatcher -increase the strain of the pilot	-pilot asks -the AFIS dispatcher is trained to prevent these situations	D	4	D4	-	-
H04.1.1	Ground wind direction and speed	If the pilot needs information on ground wind direction and speed, he asks the AFIS dispatcher	-increase the strain of the AFIS dispatcher -increase the strain of the pilot	-pilot asks -the AFIS dispatcher is trained to prevent these situations	D	4	D4	-	-
H04.1.2	Significant weather (thunderstorm, hail)	If the pilot needs information on significant weather around the airport, he asks the AFIS dispatcher	-increase the strain of the AFIS dispatcher -increase the strain of the pilot	-pilot asks -the AFIS dispatcher is trained to prevent these situations	D	4	D4	-	-
H04.1.3	Turbulence	If the pilot needs information on turbulence, he asks the AFIS dispatcher	-increase the strain of the AFIS dispatcher -increase the strain of the pilot	-pilot asks -the AFIS dispatcher is trained to prevent these situations	D	4	D4	-	-
H04.1.4	Air temperature	If the pilot needs information on air temperature, he asks the AFIS dispatcher	-increase the strain of the AFIS dispatcher -increase the strain of the pilot	-pilot asks -the AFIS dispatcher is trained to prevent these situations	D	4	D4	-	-

ID	Hazard	Consequences	Effect	Barriers	Probability	Seriousness	Risk	Risk mitigation means	Change of risk in case of RMM implement.
H04.1.5	Lower cloud base	If the pilot needs information on lower cloud base, he asks the AFIS dispatcher	-increase the strain of the AFIS dispatcher -increase the strain of the pilot	-pilot asks -the AFIS dispatcher is trained to prevent these situations	D	4	D4	-	-
H04.1.6	Pressure	If the pilot needs information on pressure, he asks the AFIS dispatcher	-increase the strain of the AFIS dispatcher -increase the strain of the pilot	-pilot asks -the AFIS dispatcher is trained to prevent these situations	D	4	D4	-	-
H04.2	RWY in use	The AFIS dispatcher does not provide the pilot with information about the RWY in use	-pilot is preparing to approach another RWY, dangerous convergence can occur	-pilot asks -the pilot monitors the space around him	D	1	D1	-approach to one RWY only	E3
H04.3	Aircrafts in the space	The AFIS dispatcher does not provide the pilot with information about another aircrafts	The pilot does not expect the aircraft in the area where he is, a dangerous convergence can occur	-pilot asks -the pilot monitors the space around him	D	2	D2	-overview information for the AFIS dispatcher -the aircraft equipped with a transponder	E3
H04.4	Airplane at the RWY and around the airport	The AFIS dispatcher does not provide the pilot with information about aircraft on the RWY and around the airport	The pilot does not expect the aircraft on the RWY, a dangerous convergence can occur	-pilot asks -the pilot monitors the space around him	D	2	D2	-overview information for the AFIS dispatcher -the aircraft equipped with a transponder	E3

ID	Hazard	Consequences	Effect	Barriers	Probability	Seriousness	Risk	Risk mitigation means	Change of risk in case of RMM implement.
H04.5	Direction of the airport circuit	The AFIS dispatcher does not provide the pilot with information about the direction of the airport circuit	-increase the strain of the AFIS dispatcher -increase the strain of the pilot	-pilot asks -the AFIS dispatcher is trained to prevent these situations	D	4	D4	-	-
H04.6	Condition of the RWY (e.g. dead doe)	The AFIS dispatcher does not provide the pilot with information about the condition of the RWY	The pilot does not expect an obstacle on the RWY, a collision may occur	-the pilot monitors the space around him -pilot asks -the AFIS dispatcher monitors the entire RWY	D	2	D2	-monitoring of the RWY by the dispatcher and case of an obstacle sending a technical service	E3
H05	The pilot does not understand the information	-the pilot does not receive the information provided by the AFIS dispatcher -the pilot cannot take it into account in the subsequent behaviour	not receiving important information can lead to unexpected situations, dangerous convergence can occur	The AFIS dispatcher asks the pilot if he is receiving information	C	2	C2	-implementation of Datalink -repeat information twice	E4
H06	JET aircraft in ATZ	The AFIS dispatcher has an IFR aircraft in the ATZ with passengers on board, which moves 2.5 times faster than other traffic	In the case of simultaneous IFR and VFR traffic, dangerous convergence can occur	-the pilot monitors the space around him -AFIS dispatcher provides information on known traffic -the dispatcher assigns priority to approach of JET aircraft	B	2	B2	-IFR movements on defined time slots+take it down the AIP -overview information for the AFIS dispatcher -the aircraft equipped with a transponder -RMZ – all aircraft will have to report	D4

ID	Hazard	Consequences	Effect	Barriers	Probability	Seriousness	Risk	Risk mitigation means	Change of risk in case of RMM implement.
H07	IFR and VFR flights in the ATZ	There is both IFR and VFR operation in the ATZ	In the case of simultaneous IFR and VFR traffic, dangerous convergence can occur	-the pilot monitors the space around him -AFIS dispatcher provides information -the dispatcher assigns priority to approach of IFR	B	2	B2	-IFR movements on defined time slots+take it down the AIP -overview information for the AFIS dispatcher -the aircraft equipped with a transponder -RMZ – all aircraft will have to report	D4
H08	Lighting malfunction	Arrivals at the airport are only allowed during the day	Cancellation of all night flights	Redirection of aircraft to other airports	D	3	D3	-introduction of ILS cat. I also on RWY 09 -introduction of lighting also on RWY 09	E5
H09	IFR on departure and VFR in ATZ	THE IFR flight is going to depart and the VFR is in the airport area	In the case of simultaneous IFR and VFR traffic, dangerous convergence can occur	-AFIS dispatcher gives information to VFR traffic that IFR is going to depart -VFR clears ATZ -AFIS provides IFR information	B	2	B2	-IFR movements on defined time slots+take it down the AIP -overview information for the AFIS dispatcher -the aircraft equipped with a transponder -RMZ – all aircraft will have to report	D4
H10	The pilot overhears the information	-the pilot does not receive the information provided by the AFIS dispatcher -the pilot cannot take it into account in the subsequent behaviour	not receiving important information can lead to unexpected situations, dangerous convergence can occur	The AFIS dispatcher asks the pilot if he is receiving information	C	2	C2	-implementation of Datalink -repeat information twice	E4

ID	Hazard	Consequences	Effect	Barriers	Probability	Seriousness	Risk	Risk mitigation means	Change of risk in case of RMM implement.
H11	Emergency in VFR flight	There is a VFR flight in the ATZ, which has an emergency on board	VFR has a priority, but other traffic may not follow it, dangerous convergence can occur	-AFIS dispatcher give an information to other traffic -the dispatcher assigns priority to approach of emergency flight	D	2	D2	In this case, the AFIS dispatcher is given the authority to control the operation	E4
H12	Disobedience of the information	The pilot does not follow the information provided by the AFIS dispatcher	The pilot does not know important information, dangerous convergence can occur	-the pilot is trained -the pilot does not have to follow the information from the AFIS dispatcher	C	2	C2	Change of rules – the pilot is obliged to follow the information given to him by the AFIS dispatcher	D4
H13	The plane flies into the storm	The AFIS dispatcher provides information for safe taking the aircraft out of the storm	-increase the strain of the AFIS dispatcher -increase the strain of the pilot -possible damage to the aircraft	-VFR flies by sight, sees around him -the AFIS dispatcher is trained to prevent these situations	D	2	D2	-	-
H14	Technical issues	There is an aircraft in the ATZ that has technical problems	Aircraft with problems has a priority, but other traffic may not follow it, dangerous convergence can occur	-AFIS dispatcher give an information to other traffic -the dispatcher assigns priority to approach of affected aircraft	D	2	D2	In this case, the AFIS dispatcher is given the authority to control the operation	E4

ID	Hazard	Consequences	Effect	Barriers	Probability	Seriousness	Risk	Risk mitigation means	Change of risk in case of RMM implement.
H15	The plane flies into the storm	The AFIS dispatcher provides information for taking the aircraft out of the storm safely	-increase the strain of the AFIS dispatcher -increase the strain of the pilot -possible damage to the aircraft	-VFR flies by sight, sees around him -the AFIS dispatcher is trained to prevent these situations	D	2	D2	-	-
H16	Lack of fuel	There is an aircraft in the ATZ that has a lack of fuel	Aircraft with problems has a priority, but other traffic may not follow it, dangerous convergence can occur	-AFIS dispatcher give an information to other traffic -the dispatcher assigns priority to approach of affected aircraft	D	2	D2	In this case, the AFIS dispatcher is given the authority to control the operation	E4
H17	Wake turbulence	The aircraft gets into wake turbulence due to the plane flying in front of it	Loss of aircraft stability, which can lead to an accident	Keep a safe distance	C	2	C2	-overview information for the AFIS dispatcher	D4
H18	Disconnection between the TWR and the aircraft	The AFIS dispatcher does not give an information to aircraft in the ATZ	In the absence of traffic information, dangerous convergence can occur	-VFR flies by sight, sees around him	C	2	C2	-Backup radio, see Regulation L 11	D4

Table 35: Identified risks in safety risk analysis

6 Risk mitigation means

In this chapter will be proposed risk mitigation means and there will be analysed a suitable time slots for IFR traffic in LKCS according to EKOD traffic data.

6.1 Proposal of risk mitigation means

A description of the risk mitigation means is given in Table 36, see below. Each means has been assigned an ID, the means is briefly described, and the advantages and disadvantages of individual means are listed. The last column of this table provides an information on whether they have this means at AFIS airports in Denmark.

ID	Risk mitigation means	Description	Advantage	Disadvantage	Equipment at Danish airports
M.1	Implementation of RMZ	Upon entering the RMZ, all aircraft will have to report to the AFIS dispatcher via radio	The AFIS dispatcher will have an overview of the aircraft in the area	-Loss of aircraft at the airport, that will not be equipped with the necessary accessories -the need of certification -necessity of AFIS dispatcher training -expensive	Yes
M.2	IFR movements on defined time slots	During the day, there will be a dedicated slot at the airport for IFR traffic, which will be able to arrive at the airport only in this slot	-no collision with VFR traffic -no extra funds	-harder to coordinate -administrative difficulty -in case of flight delay or cancellation, the airport will be closed unnecessarily	No
M.3	Approach to only one RWY	In the case of the possibility to approach one RWY, the probability that the pilot will approach the other RWY is eliminated	-well memorable -no extra funds	-reduces airport flexibility -in adverse weather conditions, it will mean a reduction in traffic	No

ID	Risk mitigation means	Description	Advantage	Disadvantage	Equipment at Danish airports
M.4	Overview information for the AFIS dispatcher	Thanks to the overview information, the AFIS dispatcher will be well acquainted with what is happening in the airport area	Excellent overview of the operation	-the need of certification -necessity of AFIS dispatcher training -expensive -the aircraft must be equipped with a transponder	No
M.5	RWY monitoring by the dispatcher	The dispatcher constantly monitors the RWY and calls the airport technical service in the event of an obstacle	-operationality -no extra funds	Human factor risk (dispatcher does not notice the obstacle)	Yes
M.6	Backup source of information	AFIS centre has a backup source of information (e.g. meteorological)	The AFIS dispatcher transmits information even in the event of a failure of the primary source of information	-more expensive -the need for certification as with the primary source	Yes
M.7	Implementation of Datalink	Exchange of information between TWR and the pilot via text messages	-reliable information transfer -the AFIS dispatcher does not have to repeat the information	-the need for aircraft equipment to receive messages of this kind -the loss of aircraft at the airport that will not be equipped with the necessary accessories -expensive -the need of certification	No
M.8	Repeat information twice	If the pilot does not understand, the dispatcher must repeat the information	Assurance of receipt of information by the pilot -no extra funds	-increase the strain of the AFIS dispatcher	Yes
M.9	Authorization of the AFIS dispatcher to control the traffic	In emergency or other critical situations, the AFIS dispatcher is authorized to control the traffic	-ensuring the smooth operation -priority of flights with emergency or other problem	-very administratively demanding -AFIS dispatcher certification -dilemma: when is the right time for a dispatcher to start control traffic?	No
M.10	The pilot is obliged to follow the information	The pilot is obliged to receive information from the AFIS dispatcher and follow it	Higher reliability	-very administratively demanding -loss of the character of the information service	No

ID	Risk mitigation means	Description	Advantage	Disadvantage	Equipment at Danish airports
M.11	Implementation of ILS cat. I also on RWY 09	Implementation of an Instrument Landing System on the RWY 09	-improving airport facilities -possibility to approach at night on RWY 09 -improving the service provided	-the need of certification -necessity of AFIS dispatcher training -expensive -traffic restrictions during construction	No
M.12	Backup radio	In case of failure of the primary radio and loss of connections between the aircraft and the tower, the AFIS dispatcher will use a backup radio	-higher reliability -no connection is lost -the dispatcher can pass on information in the event of a failure of the primary radio	-the need of certification -expensive	Yes
M.13	The aircraft is equipped with a transponder	The aircraft is equipped with a transponder and can be seen in the overview information	Increased safety	-the loss of aircraft at the airport that will not be equipped with the necessary accessories -the need of certification -expensive	Yes
M.14	Implementation of TMZ	When aircraft entering TMZ, overview information is kept about all aircraft	The AFIS and FIR Prague dispatchers have an overview of the aircraft in the area	-loss of aircraft at the airport with the absence of appropriate equipment --the need of certification -expensive -necessity of AFIS dispatcher training	Yes

Table 36: Risk mitigation means, including their advantages and disadvantages

At the very least, all means need to be considered. Risk mitigation means M.2 – "IFR movements on defined time slots", will disadvantage airport in negotiations with airlines for the operation of flights to České Budějovice, but it eliminates the risk of mixed traffic in the area. As a result, this risk mitigation means will significantly

increase traffic, which most airlines will acknowledge. However, this means could be partially replaced by means M.1 – "Implementation of RMZ" or M.13 – "The aircraft is equipped with a transponder" and M.14 – "Implementation of TMZ". Means M.13 orders aircraft to be equipped with transponders, and both means M.1 and M.14 means that there is a designated area in the vicinity of the aerodrome for which airplanes report. However, these means will significantly reduce the operation of light aircraft, as not all aircraft are equipped with a transponder.

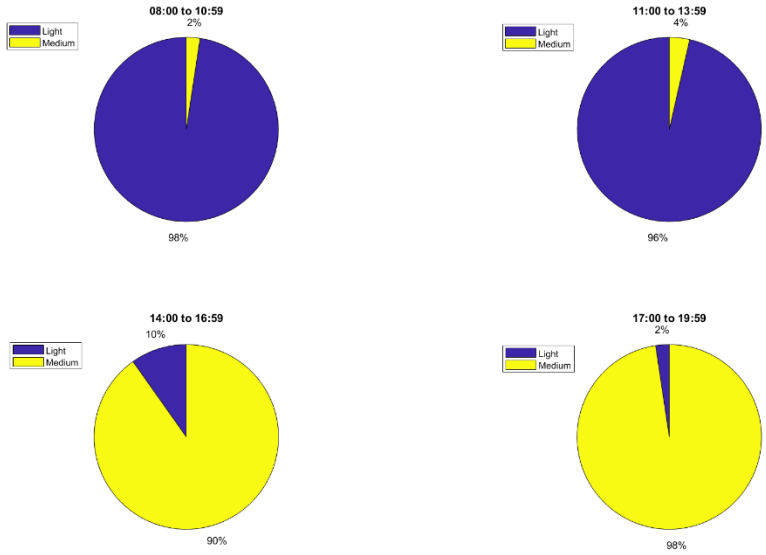
6.2 Time slot analysis

A part of the proposed risk mitigation means M.2, movements at the Danish EKOD Airport were analysed. In this analysis, traffic data from EKOD are examined. It will be possible to make a recommendation to České Budějovice Airport based on the results of the analysis. If the airport decides to introduce the risk mitigation means M.2, the results of this analysis will provide it with information on when to introduce this means. The analysis was performed in Matlab software and the script is shown below:

```
%% Timeslots
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4.
semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2018_EKOD po
AFIS');

num = num2cell(num);
txt(2:end,10)=num(:,8);

idx = strfind(txt(:,9), 'M');
idx = find(not(cellfun('isempty', idx)));
Medium = zeros(length(idx),2);
Medium = num2cell(Medium);

for i=1:length(idx)
Medium(i,:)=txt(idx(i),9:10);
end

idx = strfind(txt(:,9), 'L');
idx = find(not(cellfun('isempty', idx)));

for i=1:length(idx)
Light(i,:)=txt(idx(i),9:10);
end

Light = cell2mat(Light(:,2));
Medium = cell2mat(Medium(:,2));

numbers=unique(Medium);
count=hist(Medium,numbers);
numbers(:,2)=count;

Medium_Morning = 0;
Medium_Forenoon = 0;
Medium_Afternoon = 0;
Medium_Evening = 0;

for i = 1:length(numbers)
```

```
if numbers(i,1)<11
Medium_Morning = Medium_Morning + numbers(i,2);
elseif (numbers(i,1)>10 & numbers(i,1)<14)
Medium_Forenoon = Medium_Forenoon + numbers(i,2);
elseif (numbers(i,1)>13 & numbers(i,1)<17)
Medium_Afternoon = Medium_Afternoon + numbers(i,2);
else Medium_Evening = Medium_Evening + numbers(i,2);
end
end

numbers=unique(Light);
count=hist(Light,numbers);
numbers(:,2)=count;

Light_Morning = 0;
Light_Forenoon = 0;
Light_Afternoon = 0;
Light_Evening = 0;

for i = 1:length(numbers)
if numbers(i,1)<11
Light_Morning = Light_Morning + numbers(i,2);
elseif (numbers(i,1)>10 & numbers(i,1)<14)
Light_Forenoon = Light_Forenoon + numbers(i,2);
elseif (numbers(i,1)>13 & numbers(i,1)<17)
Light_Afternoon = Light_Afternoon + numbers(i,2);
else Light_Evening = Light_Evening + numbers(i,2);
end
end

Total(1,1) = Light_Morning;
Total(2,1) = Light_Forenoon;
Total(3,1) = Light_Afternoon;
Total(4,1) = Light_Evening;

Total(1,2) = Medium_Morning;
Total(2,2) = Medium_Forenoon;
Total(3,2) = Medium_Afternoon;
Total(4,2) = Medium_Evening;

pie(Total(1,:))
subplot(2,2,1)
pie(Total(1,:))
legend('Light','Medium')
title('08:00 to 10:59')
subplot(2,2,2)
pie(Total(2,:))
legend('Light','Medium')
title('11:00 to 13:59')
subplot(2,2,3)
pie(Total(3,:))
title('14:00 to 16:59')
legend('Light','Medium')
subplot(2,2,4)
pie(Total(4,:))
title('17:00 to 19:59')
legend('Light','Medium')
```

From this analysis, it can be concluded that medium aircraft arrived at Odense Airport in the afternoon, see Graph 2. Only 2% of all medium aircraft arrived at the airport in the 08:00-10:59 time slot, also called morning slot. A total of 4% of aircraft arrived in the midday slot from 11:00 to 13:59. In the afternoon, the trend was quite the opposite, with 90% of medium-sized aircraft arriving in the afternoon slot between 14:00 and 16:59, and even 98% of all aircraft in the evening slot between 17:00 and 19:59. If means M.2 was introduced, the airport could use the results of this analysis to create a time slot for IFR flight arrivals based on the experience from the EKOD airport.



Graph 2: Time slots at EKOD Airport

6.3 Questionnaire

A questionnaire was created to determine airline's risk aversion. This subchapter focuses on the questions of the questionnaire and its results.

The questionnaire was sent to 35 airlines, the list of which is in Table 38, including the column where it is written whether the company replied.

6.3.1 Questionnaire questions

. Airlines were asked 6 closed and 1 open question in this questionnaire, the list of the questions can be found in the table 37, see below.

Question number	Question
1	Does your company provide flights to airports with AFIS service?
2	Do you consider AFIS defined in EU Regulation 2017/373 to be a safe service providing information to pilots?
3	If there was a demand for a destination where only AFIS is provided, would you be willing to fly there?
4	What price of landing fees would be acceptable for you at an airport with AFIS service?
5	What price of passenger fees would be acceptable for you at an airport with AFIS service?
6	How many planes does your company have?
7	What is the name of your company?

Table 37: Questionnaire questions

The most important question in this case for creating prediction scenarios is number 3, which companies can answer with three possible answers – 1 (certainly not), 3 (probably) and 5 (certainly yes). Based on these answers, it is possible to compile a risk affinity coefficient that will provide an answer to the question of how the airline takes a stand on risk. The companies that correspond to number 1, i.e. that they will certainly not fly to these airports, show their caution and the fact that the safety of passengers and crew of plane comes first. On the contrary, companies corresponding to number 5 have very high propensity for risks, that the airport with the AFIS service compared to the airport with ATC, brings.

A list of company names and information on whether they completed the questionnaire is given in Table 38.

Airline	Answer	Airline	Answer
Aeroflot	No	Lauda Motion	Yes
Air Baltic	No	Level	Yes
Albawings	Yes	LoganAir	No
Alsie Express	Yes	Lufthansa	No
Condor Airlines	Yes	Malta Air	No
Corendon Airlines	No	Norwegian Air International	Yes
ČSA	No	Onur Air	Yes

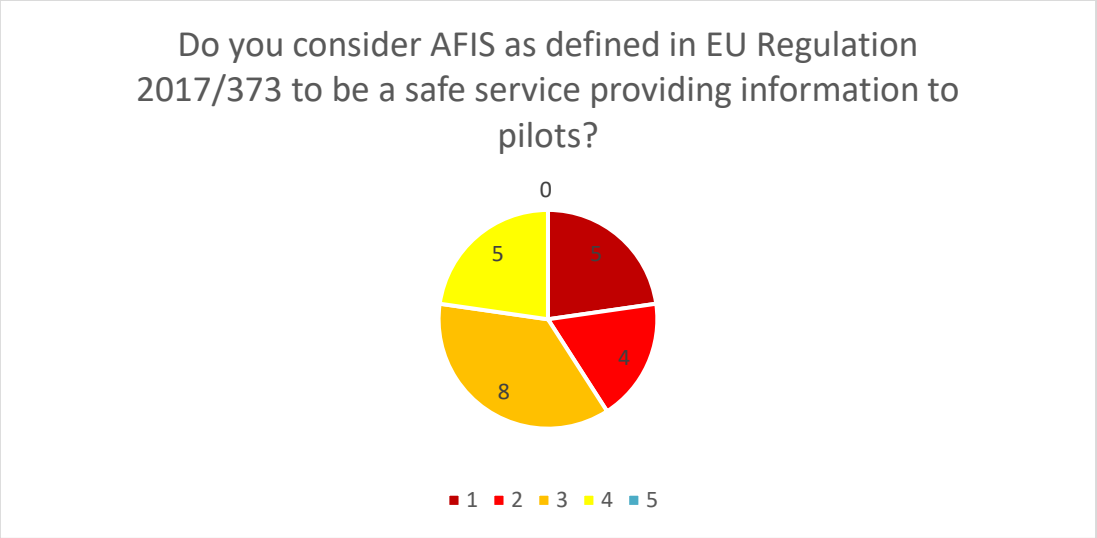
Airline	Answer	Airline	Answer
DAT (Danish Air Transport)	Yes	PLAY	No
EasyJet	Yes	Pobeda	Yes
Eurowings	Yes	Ryanair	Yes
FastJet	Yes	SkyUp	No
Finnair	No	Smartwings	Yes
Fly Dubai	No	SunExpress	Yes
FlyOne	Yes	Transavia France	Yes
Go	No	Turkish Airlines	Yes
Hopi	Yes	Volotea	No
Jet2.com	Yes	Wizz Air	Yes
KLM	Yes	-	-

Table 38: Company names with answers

Question 1 is a dichotomous question as it contains only 2 possible answers – yes, no. Question 2 aims to find out what relationship has the respondent to EU Regulation 2017/373 and whether he thinks that this regulation is written well. The answers to this question are formulated using the Likert scale, however, they do not have a direct impact on safety risk analysis. Questions 4 and 5 are indicative and their task is to find out at what maximum price airlines will be willing to fly to AFIS airport, which could help the airport to set a pricing policy. Questions 6 and 7 are among the analytical questions. Based on the answer to question 6, it will be possible to confirm or refute the hypothesis that smaller companies have a higher affinity for risk.

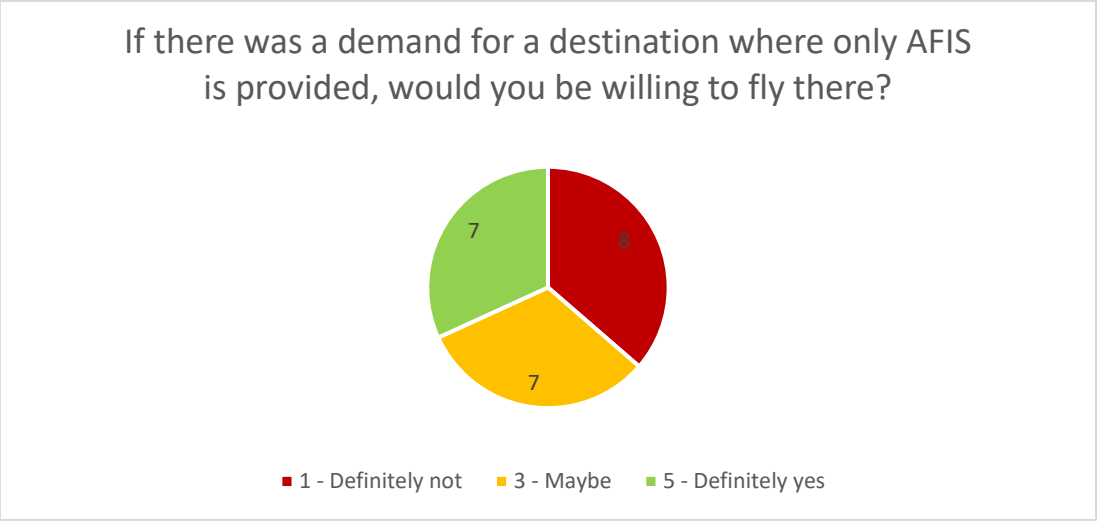
6.3.2 Questionnaire results

A total of 22 of the 35 airlines surveyed answered questions in the questionnaire. 16 of these airlines operate their flights to an AFIS airport. Interesting answers were provided by the companies to the 2nd question whether AFIS is considered a safe service according to EU Regulation 2017/373. The answers are in graph 3, see below, where 1 means no and 5 means yes. Chart 3 shows that none of the companies answered with number 5.



Graph 3: Answers to the 2nd questionnaire question

As already mentioned, the third question of the questionnaire is important for the creation of prediction scenarios. When asked if airlines would operate flights to AFIS airport if there was a demand, 8 companies said no, 7 said they might fly to such an airport, and 7 airlines said yes. The graph with the answers is given below.



Graph 4: Answers to the 3rd questionnaire question

7 Intensity prediction

There are 3 scenarios created according to the degree of affinity for risk. This is a conservative, progressive, and dynamic scenario. Based on the information from question 3 in the questionnaire sent to the airlines and the proposed means, 3 scenarios of predictions of air traffic intensities at the České Budějovice Airport were constructed.

The prediction is created in Matlab software and data provided by EKOD and LKCS airports were used. AFIS has been provided at EKOD for several years, and therefore provided data is from 2010, i.e. from the last year when the Radio service was provided at the airport. Data after the implementation of AFIS at this airport is from 2018.

The nature of movements according to individual weight categories at EKOD airport was analysed as a part of the individual prediction scenarios modelling.

7.1 Conservative scenario

The scenario is designed as the ratio of the number of aircraft before the implementation of AFIS and after the implementation of AFIS. This ratio is further divided as the ratio of individual categories according to data from České Budějovice Airport after the implementation of AFIS. The basis for calculating this scenario is the percentage increase in traffic from LKCS Airport. This is a scenario where the airport does not introduce any new means and at the same time fails to attract even those airlines that have a low risk affinity.

This scenario includes all airlines that answered 1 in the questionnaire to question 3, i.e. that they will not fly to uncontrolled airports, but with the AFIS service, under any circumstances. It can also be expected that airports with AFIS service will not be used by airlines other than low-cost ones, where their risk aversion is generally lower. Fulfilment of this scenario can be expected if none of the proposed means will be applied.

The script for this scenario is shown below:

```
%% EKOD pre AFIS
% Reading sheet
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4.
semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2010_EKOD před
AFIS');

% Finding specific data collumn
Types_pre_AFIS = txt(:,9);

% Counting number of Light planes
idx = strfind(Types_pre_AFIS, 'L');
```

```
idx = find(not(cellfun('isempty', idx)));
Number_of_Light_pre_AFIS = length(idx);

%Counting number of Medium planes
idx = strfind(Types_pre_AFIS, 'M');
idx = find(not(cellfun('isempty', idx)));
Number_of_Medium_pre_AFIS = length(idx);

% Computing percents of plane types pre AFIS
Number_of_Planes_pre_AFIS = Number_of_Light_pre_AFIS + Number_of_Me-
dium_pre_AFIS;
Percent_of_Light_pre_AFIS = (Num-
ber_of_Light_pre_AFIS/Number_of_Planes_pre_AFIS)*100;
Percent_of_Medium_pre_AFIS = (Number_of_Me-
dium_pre_AFIS/Number_of_Planes_pre_AFIS)*100;
%% EKOD post AFIS

% Reading sheet
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4.
semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2018_EKOD po
AFIS');

% Finding specific data collumn
Types_post_AFIS = txt(:,9);

% Counting number of Light planes
idx = strfind(Types_post_AFIS, 'L');
idx = find(not(cellfun('isempty', idx)));
Number_of_Light_post_AFIS = length(idx);

%Counting number of Medium planes
idx = strfind(Types_post_AFIS, 'M');
idx = find(not(cellfun('isempty', idx)));
Number_of_Medium_post_AFIS = length(idx);

% Computing percents of plane types pre AFIS
Number_of_Planes_post_AFIS = Number_of_Light_post_AFIS + Number_of_Me-
dium_post_AFIS;
Percent_of_Light_post_AFIS = (Num-
ber_of_Light_post_AFIS/Number_of_Planes_post_AFIS)*100;
Percent_of_Medium_post_AFIS = (Number_of_Me-
dium_post_AFIS/Number_of_Planes_post_AFIS)*100;

%% LKCS pre AFIS
% Reading sheet
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4.
semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2018_LKCS (starý
AFIS)');

% Finding specific data collumn
Types_pre_AFIS = txt(:,10);

% Counting number of Light planes
idx = strfind(Types_pre_AFIS, 'L');
idx = find(not(cellfun('isempty', idx)));
LKCS_Number_of_Light_pre_AFIS = length(idx);

%Counting number of Medium planes
idx = strfind(Types_pre_AFIS, 'M');
idx = find(not(cellfun('isempty', idx)));
LKCS_Number_of_Medium_pre_AFIS = length(idx);

% Computing percents of plane types pre AFIS
```

```
LKCS_Number_of_Planes_pre_AFIS = LKCS_Number_of_Light_pre_AFIS +
LKCS_Number_of_Medium_pre_AFIS;
LKCS_Percent_of_Light_pre_AFIS =
(LKCS_Number_of_Light_pre_AFIS/LKCS_Number_of_Planes_pre_AFIS)*100;
LKCS_Percent_of_Medium_pre_AFIS =
(LKCS_Number_of_Medium_pre_AFIS/LKCS_Number_of_Planes_pre_AFIS)*100;

%% Conservative scenario - coefficients of change based on pre and post AFIS
ratio of total volume and kept ratio of current volume

% Computing coefficients
Volume_coefficient = Number_of_Planes_post_AFIS/Number_of_Planes_pre_AFIS;

%Applying coefficients to LKCS numbers pre AFIS

Estimate_Volume_post_AFIS = LKCS_Number_of_Planes_pre_AFIS * Volume_coeffi-
cient
Estimate3_Light_post_AFIS = Estimate_Volume_post_AFIS *
(LKCS_Percent_of_Light_pre_AFIS/100)
Estimate3_Medium_post_AFIS = Estimate_Volume_post_AFIS *
(LKCS_Percent_of_Medium_pre_AFIS/100)
```

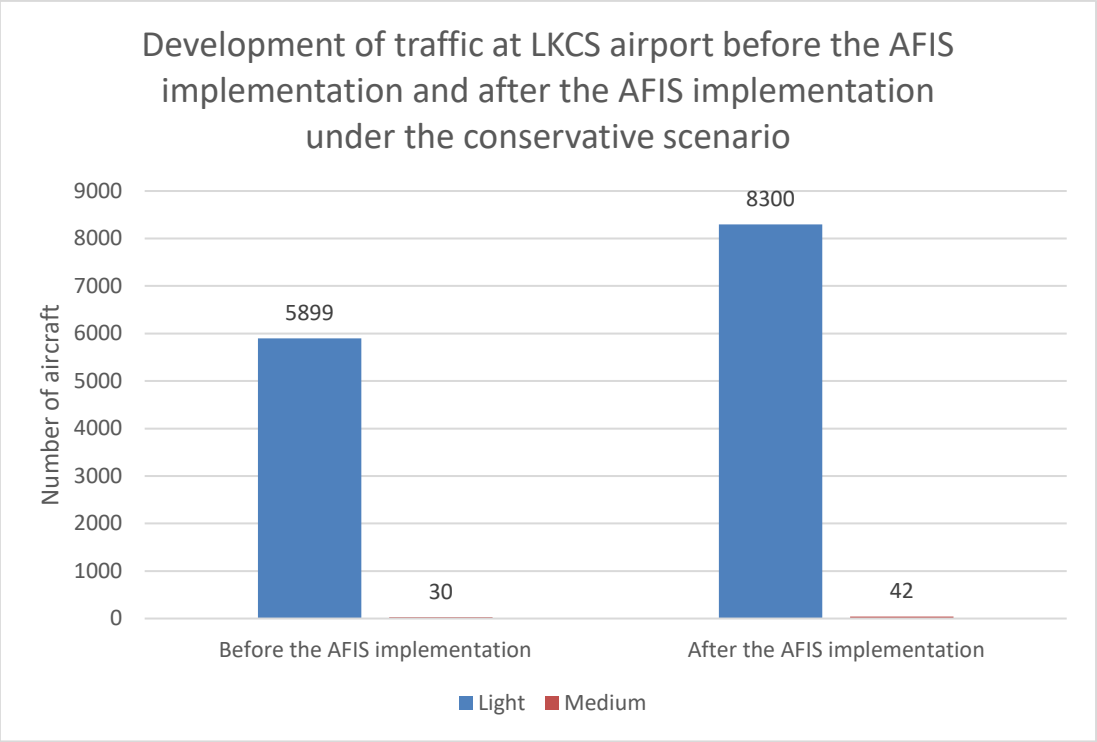
7.1.1 Conservative scenario results

It can be seen from Table 39 that there will be an increase in the intensities of light aircraft and a slight increase in the intensities of medium aircraft. Similar traffic behaviour is expected, in terms of year-on-year increases and decreases in traffic intensities, as up to now. This behaviour will increase the operation of medium aircraft due to the transition from radio to AFIS.

	Percentage of traffic increase at the EKOD airport after the implementation of AFIS	**Number of movements at the airport after the implementation of AFIS**	
		Light aircraft	**Medium aircraft**
České Budějovice Airport (LKCS)	1,41	8300	42

Table 39: Conservative scenario results

The graph of traffic development under the conservative scenario is shown below.



Graph 5: Development of traffic at LKCS airport before the AFIS implementation and after the AFIS implementation under the conservative scenario

7.2 Progressive scenario

This scenario is based on a prediction coefficient that arose as a ratio of the traffic intensity of each category at the EKOD airport after the AFIS implementation and the traffic intensity of each category at the EKOD airport before the AFIS implementation. This coefficient was created for light and medium aircraft. The individual intensities in 2018 at LKCS airport were subsequently multiplied by this coefficient.

The progressive scenario includes the companies answering the third question by number 3, which means that the airlines are not sure whether to operate flights to AFIS airport or not. Good arguments, the offer from the airport and the region implementation of some proposed means could convince them.

The script for this scenario is shown below:

```
%% EKOD pre AFIS
% Reading sheet
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4. semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2010_EKOD před AFIS');

% Finding specific data collumn
Types_pre_AFIS = txt(:,9);

% Counting number of Light planes
idx = strfind(Types_pre_AFIS, 'L');
```

```
idx = find(not(cellfun('isempty', idx)));
Number_of_Light_pre_AFIS = length(idx);

%Counting number of Medium planes
idx = strfind(Types_pre_AFIS, 'M');
idx = find(not(cellfun('isempty', idx)));
Number_of_Medium_pre_AFIS = length(idx);

% Computing percents of plane types pre AFIS
Number_of_Planes_pre_AFIS = Number_of_Light_pre_AFIS + Number_of_Me-
dium_pre_AFIS;
Percent_of_Light_pre_AFIS = (Num-
ber_of_Light_pre_AFIS/Number_of_Planes_pre_AFIS)*100;
Percent_of_Medium_pre_AFIS = (Number_of_Me-
dium_pre_AFIS/Number_of_Planes_pre_AFIS)*100;
%% EKOD post AFIS

% Reading sheet
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4.
semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2018_EKOD po
AFIS');

% Finding specific data collumn
Types_post_AFIS = txt(:,9);

% Counting number of Light planes
idx = strfind(Types_post_AFIS, 'L');
idx = find(not(cellfun('isempty', idx)));
Number_of_Light_post_AFIS = length(idx);

%Counting number of Medium planes
idx = strfind(Types_post_AFIS, 'M');
idx = find(not(cellfun('isempty', idx)));
Number_of_Medium_post_AFIS = length(idx);

% Computing percents of plane types pre AFIS
Number_of_Planes_post_AFIS = Number_of_Light_post_AFIS + Number_of_Me-
dium_post_AFIS;
Percent_of_Light_post_AFIS = (Num-
ber_of_Light_post_AFIS/Number_of_Planes_post_AFIS)*100;
Percent_of_Medium_post_AFIS = (Number_of_Me-
dium_post_AFIS/Number_of_Planes_post_AFIS)*100;

%% LKCS pre AFIS
% Reading sheet
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4.
semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2018_LKCS (starý
AFIS)');

% Finding specific data collumn
Types_pre_AFIS = txt(:,10);

% Counting number of Light planes
idx = strfind(Types_pre_AFIS, 'L');
idx = find(not(cellfun('isempty', idx)));
LKCS_Number_of_Light_pre_AFIS = length(idx);

%Counting number of Medium planes
idx = strfind(Types_pre_AFIS, 'M');
idx = find(not(cellfun('isempty', idx)));
LKCS_Number_of_Medium_pre_AFIS = length(idx);

% Computing percents of plane types pre AFIS
```

```
LKCS_Number_of_Planes_pre_AFIS = LKCS_Number_of_Light_pre_AFIS +
LKCS_Number_of_Medium_pre_AFIS;
LKCS_Percent_of_Light_pre_AFIS =
(LKCS_Number_of_Light_pre_AFIS/LKCS_Number_of_Planes_pre_AFIS)*100;
LKCS_Percent_of_Medium_pre_AFIS =
(LKCS_Number_of_Medium_pre_AFIS/LKCS_Number_of_Planes_pre_AFIS)*100;

%% Progressive scenario - coefficients of change based on pre and post AFIS
ratio of plane type volume

% Computing coefficients
Coefficient_Light = Percent_of_Light_post_AFIS/Percent_of_Light_pre_AFIS;
Coefficient_Medium = Percent_of_Medium_post_AFIS/Percent_of_Medium_pre_AFIS;

%Applying coefficients to LKCS numbers pre AFIS
Estimate1_Light_post_AFIS = LKCS_Number_of_Light_pre_AFIS * Coeffi-
cient_Light
Estimate1_Medium_post_AFIS = LKCS_Number_of_Medium_pre_AFIS * Coeffi-
cient_Medium
Estimate1_Volume_post_AFIS = Estimate1_Light_post_AFIS + Estimate1_Me-
dium_post_AFIS
```

7.2.1 Progressive scenario results

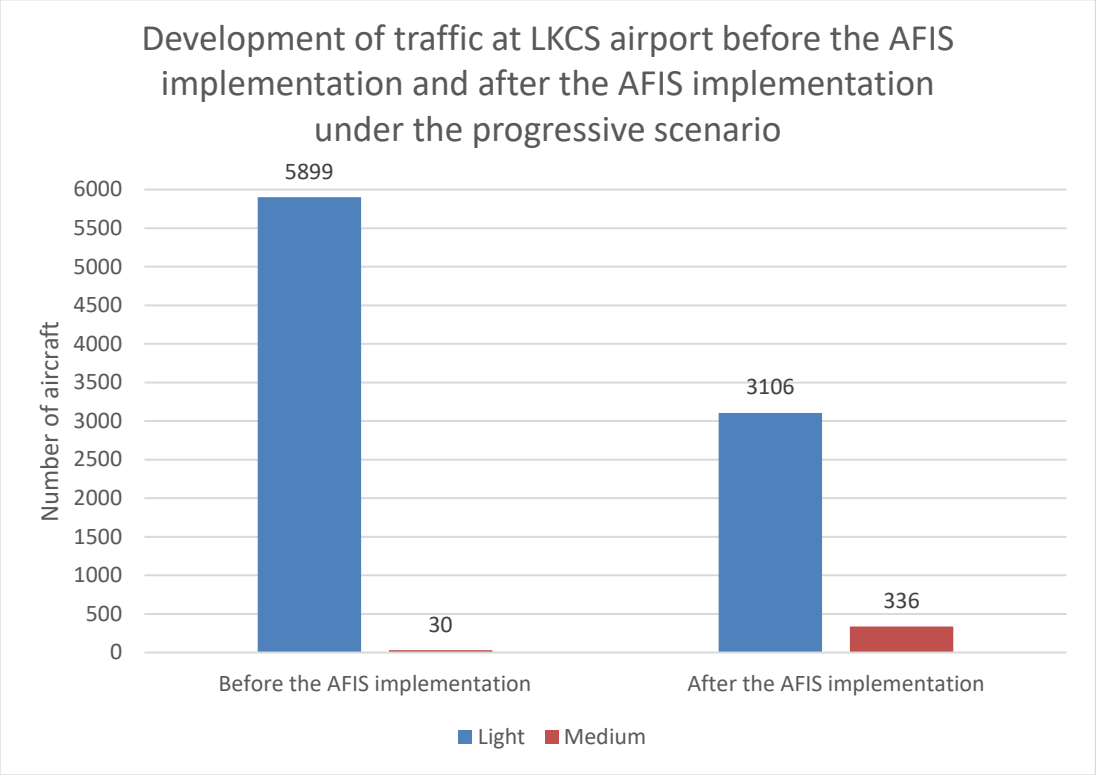
Table 40 shows that after the AFIS implementation in České Budějovice airport, the intensity of light aircraft will decrease by 47.3% points, while the intensity of medium aircraft will increase by up to 1020% points. The decrease in light aircraft traffic is because the airport accepts IFR traffic only in a certain time slot, which reduces the operating time of VFR traffic. Furthermore, this decrease may be due to the implementation RMZ or TMZ area around the airport, which will lead to a decrease in aircraft that do not have the necessary equipment for flights to this airport. However, the increase in the intensity of medium aircraft, such as Boeing 737 or the Airbus A320, will bring more funding to the airport and will mean an influx of more passengers for the region.

	Before the AFIS implementation		**After the AFIS implementation**	
	Light aircraft	**Medium aircraft**	**Light aircraft**	**Medium aircraft**
Odense Airport (EKOD)	4833	224	3581	3535
České Budějovice Airport (LKCS)	5899	30	3106	336

Table 40: Progressive scenario results

When the risk mitigation means M.2 is implemented, it is recommended to define a 3-hour time slot per day regarding the given intensities in this scenario. It would be advantageous to set this time slot in the early evening, ideally before the end of the airport's operating hours. Firstly, there was the strongest operation of medium aircraft of the day at EKOD airport in the early evening and secondly, in case of IFR aircraft delay, it is not a problem to extend the airport operating time, while if this

means was set to morning hours and flight delay would occur, it would limit further traffic.



Graph 6: Development of traffic at LKCS airport before the AFIS implementation and after the AFIS implementation under the progressive scenario

7.3 Dynamic scenario

The dynamic scenario is the least expected scenario that could be fulfilled if all the proposed means were implemented, which would increase the interest of airlines in operating flights to České Budějovice. If most of the proposed means were taken, the safety of traffic at České Budějovice Airport would also increase. A TMZ would have to be provided around the airport, which obliges aircraft to be equipped with a transponder, the airport would be equipped with overview information and the time of possible movement of IFR traffic would be ensured, thus avoiding combined IFR and VFR operations. The scenario appears to be the most expensive option for the implementation and subsequent operations, as it resembles the Air Traffic Control service in some aspects.

This scenario is intended for all companies that answer to question 3 by number 5 in the questionnaire, i.e. that in the event of a demand, they would certainly operate their flights to AFIS airports, even with all the resulting risks.

The scenario is designed as the ratio of the number of aircraft before the AFIS implementation and after the AFIS implementation. This ratio is further divided as the share of individual aircraft categories according to the data from the Danish airport after the AFIS implementation. The basis for calculating this scenario is the increase of percentage in traffic from the Odense Airport.

The script for this scenario is given below:

```
%% EKOD pre AFIS
% Reading sheet
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4.
semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2010_EKOD před
AFIS');

% Finding specific data collumn
Types_pre_AFIS = txt(:,9);

% Counting number of Light planes
idx = strfind(Types_pre_AFIS, 'L');
idx = find(not(cellfun('isempty', idx)));
Number_of_Light_pre_AFIS = length(idx);

%Counting number of Medium planes
idx = strfind(Types_pre_AFIS, 'M');
idx = find(not(cellfun('isempty', idx)));
Number_of_Medium_pre_AFIS = length(idx);

% Computing percents of plane types pre AFIS
Number_of_Planes_pre_AFIS = Number_of_Light_pre_AFIS + Number_of_Me-
dium_pre_AFIS;
Percent_of_Light_pre_AFIS = (Num-
ber_of_Light_pre_AFIS/Number_of_Planes_pre_AFIS)*100;
Percent_of_Medium_pre_AFIS = (Number_of_Me-
dium_pre_AFIS/Number_of_Planes_pre_AFIS)*100;
%% EKOD post AFIS

% Reading sheet
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4.
semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2018_EKOD po
AFIS');

% Finding specific data collumn
Types_post_AFIS = txt(:,9);

% Counting number of Light planes
idx = strfind(Types_post_AFIS, 'L');
idx = find(not(cellfun('isempty', idx)));
Number_of_Light_post_AFIS = length(idx);

%Counting number of Medium planes
idx = strfind(Types_post_AFIS, 'M');
idx = find(not(cellfun('isempty', idx)));
Number_of_Medium_post_AFIS = length(idx);

% Computing percents of plane types pre AFIS
```

```
Number_of_Planes_post_AFIS = Number_of_Light_post_AFIS + Number_of_Me-
dium_post_AFIS;
Percent_of_Light_post_AFIS = (Num-
ber_of_Light_post_AFIS/Number_of_Planes_post_AFIS)*100;
Percent_of_Medium_post_AFIS = (Number_of_Me-
dium_post_AFIS/Number_of_Planes_post_AFIS)*100;

%% LKCS pre AFIS
% Reading sheet
[num,txt] = xlsread('C:\Users\Acer\OneDrive\Pája\ČVUT\Magisterské studium\4.
semestr\Diplomová práce\5. kapitola - predikce\Data.xlsx','2018_LKCS (starý
AFIS)');

% Finding specific data collumn
Types_pre_AFIS = txt(:,10);

% Counting number of Light planes
idx = strfind(Types_pre_AFIS, 'L');
idx = find(not(cellfun('isempty', idx)));
LKCS_Number_of_Light_pre_AFIS = length(idx);

%Counting number of Medium planes
idx = strfind(Types_pre_AFIS, 'M');
idx = find(not(cellfun('isempty', idx)));
LKCS_Number_of_Medium_pre_AFIS = length(idx);

% Computing percents of plane types pre AFIS
LKCS_Number_of_Planes_pre_AFIS = LKCS_Number_of_Light_pre_AFIS +
LKCS_Number_of_Medium_pre_AFIS;
LKCS_Percent_of_Light_pre_AFIS =
(LKCS_Number_of_Light_pre_AFIS/LKCS_Number_of_Planes_pre_AFIS)*100;
LKCS_Percent_of_Medium_pre_AFIS =
(LKCS_Number_of_Medium_pre_AFIS/LKCS_Number_of_Planes_pre_AFIS)*100;
%% Dynamic scenario - coefficients of change based on pre and post AFIS ra-
tio of total volume and ratio of Light and Medium planes in pre AFIS volume

% Computing coefficients
Volume_coefficient = Number_of_Planes_post_AFIS/Number_of_Planes_pre_AFIS;

%Applying coefficients to LKCS numbers pre AFIS

Estimate_Volume_post_AFIS = LKCS_Number_of_Planes_pre_AFIS * Volume_coeffi-
cient
Estimate2_Light_post_AFIS = Estimate_Volume_post_AFIS * (Per-
cent_of_Light_post_AFIS/100)
Estimate2_Medium_post_AFIS = Estimate_Volume_post_AFIS * (Percent_of_Me-
dium_post_AFIS/100)
```

7.3.1 Dynamic scenario results

Given the results and the gradual decline of air traffic at controlled airports in the Czech Republic, this scenario seems to be the least likely to be met.

The input data for this scenario is listed in Table 41, see below.

	Number of movements at the airport before the AFIS implementation	Number of movements at the airport after the AFIS implementation	Percentage increase
Odense Airport (EKOD)	5057	7116	1,41

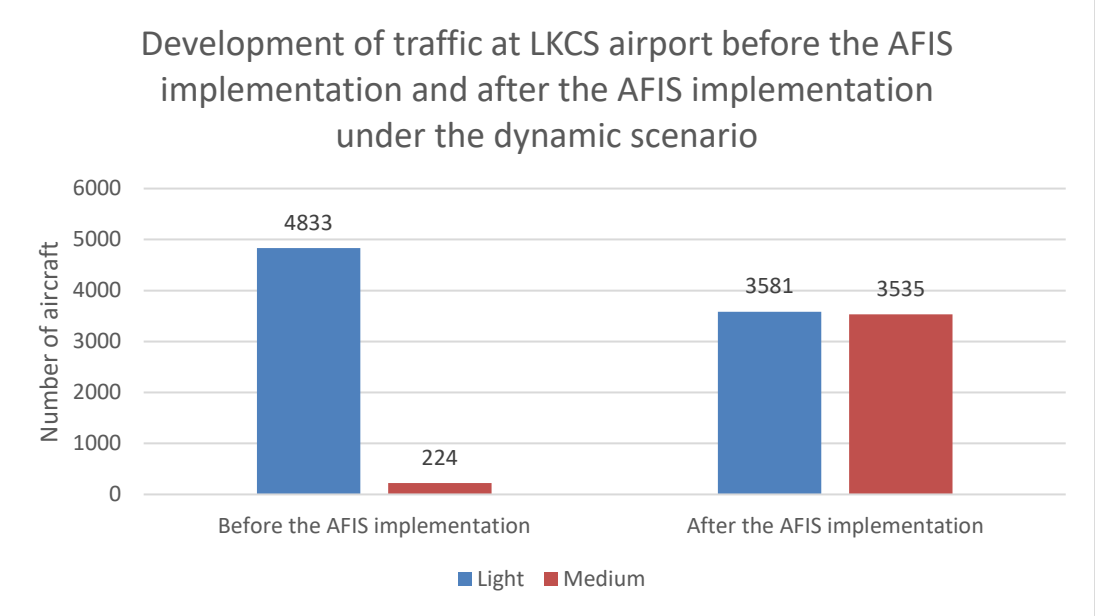
Table 41: Input data for the dynamic scenario

The result of the dynamic scenario prediction is shown in the Table 42, see below.

	Number of movements at LKCS after the AFIS implementation	
	Light aircraft	**Medium aircraft**
České Budějovice Airport (LKCS)	4198	4145

Table 42: Dynamic scenario results

Given intensities in this scenario and the time slot analysis performed at Odense Airport, it is recommended to set a time slot from 14:00 until the end of the airport's operating hours, as the light to medium aircraft ratio is approximately 50:50 in this slot. In the morning, the airport would only handle VFR flights and in the afternoon, it would handle only IFR flights. This fact would have to be recorded in the AIP.



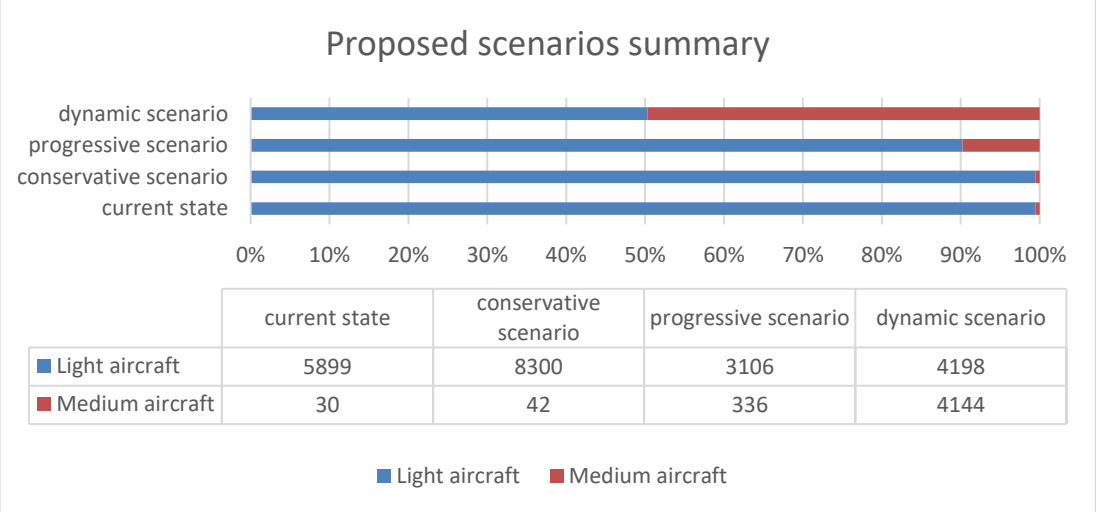
Graph 7: Development of traffic at LKCS airport before the AFIS implementation and after the AFIS implementation under the dynamic scenario

7.4 Summary

Three scenarios reflecting the AFIS implementation at the České Budějovice Airport were proposed. It is clear from Graph 8 that the difference between the conservative scenario and the current situation is not exceptionally large, and therefore does not correspond to the objectives of České Budějovice Airport. These are the increase in traffic and especially the increase in the operation of medium aircraft. The conservative scenario included all airlines that answered negatively to the question whether they will provide flights when securing the demand for flights to České Budějovice.

It is also likely that larger airlines will be included in this scenario, for which safety during flights is a priority.

The progressive scenario includes airlines that would be willing to fly to České Budějovice with current demand and the implementation of some proposed means. Among the proposed means that would have to be implemented for these airlines to fly to LKCS is the TMZ around the airport introduction. According to the forecast, this scenario will bring 336 aircraft of the medium category to České Budějovice, i.e. approximately one medium aircraft per day.



	current state	conservative scenario	progressive scenario	dynamic scenario
Light aircraft	5899	8300	3106	4198
Medium aircraft	30	42	336	4144

Graph 8: Proposed scenarios summary

The dynamic scenario is the least likely scenario, which includes all airlines that answered in the affirmative to the question of whether they will fly to the České Budějovice Airport in the questionnaire. At the same time, the scenario expects the implementation of all the proposed risk mitigation means, which are, however, expensive and, by their nature, more reminiscent of the Air Traffic Control service. The improbability of fulfilling this scenario also results from the development of air traffic in the Czech Republic, where most IFR flights are operated to a controlled airport in Prague and other controlled airports tend to lack traffic. Furthermore, it is envisaged to create a 6-hour slot every day, during which only IFR aircraft will be allowed to move in the airport area. However, this scenario predicts 4144 medium aircraft per year.

8 Economic analysis of AFIS implementation at LKCS airport

An economic analysis of the AFIS implementation is performed in this chapter. The chapter is divided into 4 parts. First the offer of Integra is analysed including the wages of AFIS employees in Denmark, then the analysis of the ANS of the Czech Republic state enterprise is performed and the wages of AFIS employees are recalculated after prior consultations with the České Budějovice Airport. A simulation of the arrivals of two aircraft belonging to different weight categories is performed in the third part. This modelling is intended to create an idea of how much will be charged by the airport in the case of a light aircraft or a medium aircraft.

8.1 Denmark

In consultation with Integra, a list of expenses was drawn up based on the experience and equipment listed in Table 43.

Item	Amount	Price [€]	Exchange rate € according to the CNB as of 20.7.2020	Price [CZK]
AFIS centre equipment (see Table 32)	1	200.000,00	26,62	5.324.200,00
AFIS dispatcher course	10	420.000,00		11.180.400,00
Recurrent course of AFIS dispatcher after 2 years	10	20.000,00		532.400,00,00
Total		640.000,00		17.037.000,00

Table 43: Expenses on equipment and AFIS dispatchers' courses according to the Integra company

Table 44 shows the wages of AFIS workers in Denmark.

Item	Amount	Unit price [€]	Exchange rate € according to the CNB as of 20.7.2020	Total price per month [CZK]	Total price for 2 years [CZK]
AFIS dispatcher's wage	4	5.200,00	26,62	553.696,00	13.288.704,00
AFIS head's wage	1	5.460,00		145,345,20	3.488.284,80
Total		10.660,00		699.041,20	16.776.988,80

Table 44: Wages of AFIS workers in Denmark

8.2 The Czech Republic

The state-owned company Air Navigation Service of the Czech Republic prepared an individual offer for the course of AFIS dispatchers to the České Budějovice Airport, which amounts to approximately CZK 1.2 million for the training of 5 dispatchers and 5 technicians. Expenses on equipment and courses for AFIS dispatchers is shown in Table 45.

Item	Amount	Price [€]	Exchange rate € according to the CNB as of 20.7.2020	Price [CZK]
AFIS centre equipment (see Table 32)	1	200.000,00	26,62	5.324.200,00
AFIS dispatcher course	10	4.507,89		1.200.000,00
Recurrent course of AFIS dispatcher after 2 years	10	2.000,00		532.420,00
Total		217.167,89		7.056.620,00

Table 45: Expenses on equipment and AFIS dispatchers' courses according to the ANS of the Czech Republic state enterprise

The most expensive item is the AFIS centre equipment. The AFIS dispatcher course costs approximately one tenth of the amount offered by Integra. If the Ministry of Transport were involved in AFIS issuers and more Czech airports were interested in this type of service provision, it would be possible to assume that the price of the AFIS dispatcher course provided by the state owned company ANS of the Czech Republic state enterprise would be reduced.

Table 44 shows that the expenses for the operation of AFIS according to the company ANS of the Czech Republic state enterprise, are 33% lower than in the case of the offer from the Danish company Integra.

Table 46 shows the wage expenses of AFIS employees in the Czech Republic. These are about a quarter of the wages received by AFIS workers in Denmark.

Item	Amount	Unit price [€]	Exchange rate € according to the CNB as of 20.7.2020	Total price per month [CZK]	Total price for 2 years [CZK]
AFIS dispatcher's wage	4	1.502,63	26,62	160.000,00	3.840.000,00
AFIS head's wage	1	1.690,46		45.000,00	1.080.000,00
Total		3.193,00		205.000,00	4.920.000,00

Table 46: Wages of AFIS workers in the Czech Republic

8.3 Simulation of services provided at LKCS

8.3.1 Boeing 737 arrival

Table 47 models the situation when a Boeing 737 arrives at the airport. All services are shown there that an aircraft of this type could use at the airport. The amount of over CZK 90,000 will be collected by the airport for the arrival of an aircraft of this type using all services.

Item	Billed by LKCS [CZK/unit]	Amount	Total price [CZK]	Exchange rate € according to the CNB as of 27.7.2020	Total price [€]
Landing fee according to MTOW	250,00	65	16.250,00	26,20	620,23
Passenger fee	300,00	128	38.400,00		1.465,65
Parking up to 2 hours	0,00	0	0,00		0,00
Passenger stairs	2260,00	2	4.520,00		172,52
Belt loader	600,00	2	1.200,00		45,80
Baggage tractor	360,00	1	720,00		27,48
Cabin service - toilet	1.070,00	1	1.070,00		40,84
GPU	1.070,00	1	1.070,00		40,84
Fuelling	26,00	1000	26.000,00		992,37
Push-back	1.190,00	1	1.190,00		45,42
Waste disposal	140,00	1	140		5,34
			90.560,00		**3.822,90**

Table 47: Boeing 737 arrival simulation according to the valid LKCS price list [4]

8.3.2 Cessna 172 arrival

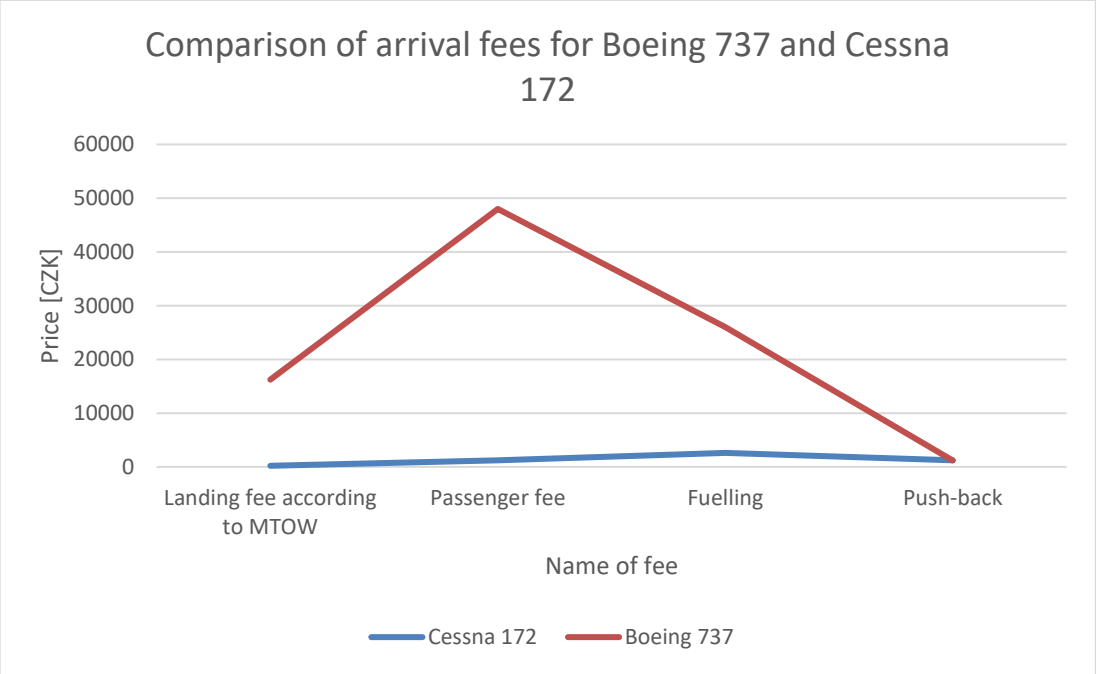
On the contrary, the Cessna 172 is a frequently used aircraft at LKCS. It belongs to the category of light aircraft. An aircraft of this type will bring approximately CZK 5,000 to the airport. It can be also seen from Table 48 that compared to the Boeing 737, this aircraft will use much less services at the airport.

Item	Billed by LKCS [CZK/unit]	Amount	Total price [CZK]	Exchange rate € according to the CNB as of 27.7.2020	Total price [€]
Landing fee according to MTOW	200,00	1	200,00	26,20	7,63
Passenger fee	300,00	4	1.200,00		45,80
Parking up to 2 hours	0	0	0		0,00
Fuelling	26,00	100	2.600,00		99,24
Push-back	1.190,00	1	1.190,00		45,42
			5.190,00		**198,09**

Table 48: Cessna 172 arrival simulation according to the valid LKCS price list [4]

8.4 Summary

The biggest financial differences between the arrivals of a medium aircraft and a light aircraft include landing fees, which are charged for MTOWs, but also passenger fees, see Graph 9. While the Boeing 737 brings 130 tourists to the region, the Cessna 172 only a maximum of 4. The only comparable charge, that is the same for both aircraft, is the parking fee. That is charged per each aircraft regardless of its weight.



Graph 9: Comparison of arrival fees for Boeing 737 and Cessna 172

Table 49 compares the revenues of České Budějovice Airport according to the proposed scenarios and current price list [4], see Chapter 7. The table shows the individual predicted intensities for light and medium aircraft, the average price for light aircraft movement was set at CZK 2,000 and the average medium aircraft was set at CZK 50,000. The most advantageous variant with the best utility value seems to be the progressive scenario, during which light aircraft are operated at the airport. But there is also a large increase in medium ones. The results of this comparison for the dynamic scenario should be taken with great caution, as the fulfilment of this scenario is rather unlikely.

	Light aircraft		**Medium aircraft**		**Total price [CZK]**	**Total price [€]**
	Amount	**The average price for movement at LKCS**	**Amount**	**The average price for movement at LKCS**		
Conservative scenario	8.300	2.000	42	50.000,00	18.700.000	713.903.95
Progressive scenario	3.442		336		23.684.000	904.175,53
Dynamic scenario	4.198		4.144		215.596.000	8.230.739,86

Table 49: Comparison of revenues of České Budějovice Airport according to scenarios

With the introduction of AFIS service, a slight increase in fee prices can be expected, as airports will increase the safety of operations and services provided.

9 Airport recommendations

For putting forward a recommendation, it is necessary to ask what policy the airport wants to have after the implementation of AFIS. Should the introduction of the provision of this service increase the intensity of VFR traffic to which it will only pass information? Or would the airport want to attract larger Boeing 737s or Airbus 320s, and is it therefore willing to pay for some of the proposed means, which will increase traffic safety?

These issues have been included in the considerations for creating prediction scenarios. While the conservative scenario does not anticipate the influx of many new medium aircraft to the airport, the progressive scenario predicts approximately 1 medium aircraft at the airport per day. For the purposes of this chapter, only these two scenarios are calculated due to the improbability of fulfilling the dynamic scenario.

For each of these two scenarios, this chapter provides recommendations on what the airport should do or implement to meet the scenarios.

9.1 Conservative scenario

According to the forecast, the number of light aircraft at the LKCS will increase from 5929 aircraft per year in 2018, to 8300 light aircraft after the AFIS implementation. The number of medium sized aircraft at the airport will increase from 30 aircraft per year in 2018, to 42 medium aircraft after the AFIS implementation.

9.1.1 Fire brigade

Under the conservative scenario, the Fire brigade of České Budějovice Airport will remain in the current category 4, which is given by the size of landing aircraft at the airport. In this scenario, the composition of the aircraft will not change, and therefore the airport does not have to move to a higher category according to [43].

9.1.2 Proposed risk mitigation means

Of the proposed means, České Budějovice Airport is recommended to implement means M.5 – RWY monitoring by the dispatcher, M.6 – Backup source of information, M.8 – Repeat information twice and M.12 – Backup radio, see Table 36.

It is not highly recommended to implement means M.1 – Implementation of RMZ and M.14 – Implementation of TMZ, see Table 36. These means would prevent the arrival of aircraft without radio or transponder equipment, which is not desirable, given the predicted traffic flow composition.

9.2 Progressive scenario

According to the forecast, the number of light aircraft at the LKCS will decrease from 5929 aircraft per year in 2018, to 3106 light aircraft after the AFIS implementation. The number of medium aircraft at the airport will increase from 30 aircraft per year in 2018, to 336 aircraft after the AFIS implementation. These figures will be obtained by taking the same risk mitigation means that were taken at the Danish airport of Odense, from which the input data used for the prediction comes.

9.2.1 Fire brigade

A fundamental change in the composition of traffic flows at the České Budějovice Airport is expected and there will be a strong increase in medium aircraft movements, of which most aircraft will be Boeing 737 or Airbus 320, because airlines have these types mostly. This means that it will be necessary to change the fire protection category from the current category 4 to category 6.

According to [43], certain obligations arise for the airport, including the establishment of a separate communication system connecting the fire station with the TWR, with any other fire station at the airport and with fire and rescue vehicles. Further changes are listed in Table 50, see below.

	Category 4 – current state	**Category 6 – after the AFIS implementation**
Number of emergency vehicles	1	2
Amount of water (category B) [l]	2400	7900
Extinguishing power of foam solution (category B) [l/min]	1800	4000
Amount of extinguishing powder [kg]	135	225
Powder extinguishing power [kg/s]	2,25	2,25
Number of firemen [people]	1+3	1+5

Table 50: Minimum applicable extinguishing quantities and other parameters necessary for the transition from category 4 to category 6 [43]

9.2.2 Proposed risk mitigation means

This scenario most closely corresponds to the change in traffic that occurred at the Danish EKOD airport, when even at this airport, after the AFIS implementation, there was a decrease in the operation of light aircraft and an increase in medium aircraft.

The implementation of the proposed means will therefore correspond to the means they have also introduced at Danish airports. The only discrepancy is between

the introduction of RMZ or TMZ around the airport, as some analysed Danish airports have introduced RMZ but some TMZ.

If we consider proposed means, it is recommended to implement either means M.1 – Implementation of RMZ or means M.14 – Implementation of TMZ. Means M.13 – The aircraft is equipped with a transponder and M.4 – Overview information for the AFIS dispatcher are also related to the implementation of means M.14. In the case of implementation of M.1, it will be necessary to equip the aircraft with a radio and report the aircraft to the AFIS dispatcher when entering the RMZ.

It is also recommended to implement the means M.2 – IFR movements on defined time slots, thanks to which there will be no possible collisions between IFR and VFR flights. However, this means was not taken by any of the analysed Danish airports and could put the airport at a disadvantage in negotiations with airlines to operate flights at LKCS. The fact about the operating time for IFR flights and for VFR flights must be reported to the AIP so that all pilots heading for LKCS can be acquainted with it. To maintain safety, it is also recommended to take means M.5 – RWY monitoring by the dispatcher, M.6 – Backup source of information, M.8 – Repeat information twice and M.12 – Backup radio.

9.3 General measures

The airport needs to answer the question written at the beginning of this chapter, whether the airport wants to increase the intensity of VFR flights with light aircraft since the AFIS implementation or whether this change will aim to attract medium aircraft.

If the airport wants to target medium aircraft available to larger airlines, it is necessary to devise a marketing campaign in which České Budějovice Airport and the owner of the airport, i.e. the South Bohemian Region, will participate. This marketing campaign will serve to attract airlines to the airport and tourists to the region. According to the questionnaire prepared for the purposes of this thesis, it is recommended to contact mainly low-cost airlines, as the answers provided showed that they would be willing to fly to an uncontrolled airport only with the AFIS service provided under the right conditions. Their affinity for risk is therefore significantly higher than that of traditional airlines. It is desirable for the airport to address those airlines that have answered the third question by numbers 3 or 5 of the questionnaire. These companies already have an experience in operating their flights to uncontrolled airports in Europe. Along with the marketing campaign, setting the pricing policy for airport fees will be especially important.

In the case of the implementation of the proposed means M.2 - IFR movements on defined time slots, it is appropriate to set aside rather the afternoon hours based on the performed analysis. If this time slot is introduced before the end of the airport's operating hours, there would be the problem with the IFR flight delay, which could occur in the case of a time slot in the morning. In the event of an IFR flight delay after the end of the aerodrome operating time would only be extended until the aircraft arrives at the airport.

Another of the given recommendation to České Budějovice Airport based on the performed analysis is that the airport would perform an analysis among other Czech airports of a similar nature as LKCS, which may include, for example, the analysed airports in this work. If more airports are interested in providing the AFIS service, the Ministry of Transport could be involved in this project in order to save money of Czech airports. Within the whole project, AFIS dispatcher courses could be organized by ANS of the Czech Republic state enterprise which would be cheaper than it is for one airport only.

The last important recommendation is that the operation of IFR flights does not exceed the above-mentioned 7500 movements per year. According to research by Integra, this number is ideal for the operation of the AFIS service. If this number is exceeded, then a switch to Air Traffic Control is desirable. According to the website of Karlovy Vary Airport, in the years 2012-2018, no more than 6000 movements took place there annually. [51] Given this trend, a downgrading from ATC service to AFIS service, which is cheaper, could be beneficial for airport.

Conclusion

The aim of the theoretical part of the work was to analyse the current state of the České Budějovice Airport and compare it with 3 other airports in the Czech Republic and 4 airports abroad. The airports in Mnichovo Hradiště, Plzeň/Líně and Hradec Králové were selected among the analysed Czech airports. These airports were selected because of the similarity of the technical parameters available to the České Budějovice Airport.

Then the condition of AFIS airports abroad was analysed. Following a prior consultation with Integra, which organizes AFIS dispatcher courses or assists airports with the transition from Radio or Air Traffic Control to AFIS, 4 Danish airports were selected. These were Esbjerg Airport, Sønderborg Airport, Odense Airport and Kolding Airport. All these airports provide AFIS service and are located close to each other, so they were ideal for the comparison with Czech airports. The Scandinavian airports were selected because of their many years of experience in operating the AFIS service.

In the last theoretical part, individual air traffic services were analysed. Even though České Budějovice Airport does not have such traffic and especially financial resources for the operation of the Air Traffic Control service, this service is also included in the analysis for a better understanding of the issue by the reader.

The aim of the practical part was to make an analysis of the risks of providing the AFIS service and to propose means for these risks (H1-H18). These risks were of a technical nature, transmission of incorrect information, etc. The risks were determined based on the probability of occurrence and severity. Subsequently, means have been proposed to mitigate the risks. 14 means were proposed (M.1-M.14). Some of these means have also been taken by Danish airports.

Furthermore, a prediction of traffic intensities was created according to the set scenarios based on a mathematical model. Data from the Odense Airport from 2010 were used for this prediction, when the airport provided the Radio service, and from 2018, when the AFIS service was already provided at the airport. Data from 2018 were used for a possible comparison with traffic at the České Budějovice Airport. As part of the development of the scenarios, a short questionnaire with 7 questions was sent to 35 airlines. The aim of the questionnaires was to find out the airline's approach to risks. This questionnaire was filled in by 22 companies, 7 of which would like to organize their flights to České Budějovice in case of the demand. Seven of these airlines would organize their flights to LKCS with 50% and 8 airlines answered the questionnaire that it was not interested in flights to an uncontrolled airport for them.

Based on the knowledge of the affinity for risk of several companies, it was possible to create scenarios for traffic prediction. A total of 3 scenarios were created – conservative, progressive, and dynamic. The conservative scenario does not include the implementation of any proposed means, and this scenario was approached in such a way that airlines would not be interested in flights with medium aircraft to the České Budějovice Airport. According to the prediction of this scenario, the composition of the traffic flow will not change significantly at the airport, but the intensity of light aircraft movement will increase. The mathematical model of this scenario is designed as the ration of the aircraft number before the AFIS implementation and after the AFIS implementation at Odense Airport. This ratio is further divided as the share of individual categories according to data from České Budějovice Airport before the AFIS implementation. This scenario corresponds to the low affinity for the risk of airlines, as they do not want to organize their flights to České Budějovice Airport. Prediction of the conservative scenario after the AFIS implementation expects 8300 light aircraft and 42 medium aircraft.

Another created scenario was a progressive scenario in which the composition of the traffic flow was changed. Although the intensity of light aircraft decreased, the intensity of medium aircraft increased. The mathematical model of this scenario is based on a prediction coefficient, which arose as the ratio of the traffic intensity of each category at Odense Airport after the implementation of AFIS and the traffic intensity of each category at Odense Airport before the service. And the subsequent multiplication of traffic intensities at LKCS Airport. Prediction of the conservative scenario after the AFIS implementation expects 3106 light aircraft and 336 medium aircraft.

The last scenario is a dynamic scenario, which predicts a large increase in medium aircraft at the České Budějovice Airport. This scenario is unrealistic in view of the aviation development in the Czech Republic and has not been processed further. The mathematical model of this scenario is designed as the ratio of the aircraft number before the AFIS implementation and after the AFIS implementation at Odense Airport. This ratio is further divided as the share of individual categories according to data from the Danish airport. Prediction of the conservative scenario after the AFIS implementation expects 4198 light aircraft and 4144 medium aircraft.

Another part of the thesis is the economic evaluation of the project. As part this evaluation, the offers for the AFIS implementation by Integra and Air Navigation Services of the Czech Republic were compared. Subsequently, simulations of the arrivals of the Boeing 737 and Cessna 172 were made to give a better imagine of how much the arrival of these aircraft costs. Subsequently, the average amounts for the arrival

of light and medium aircraft were fitted to the individual scenarios and the yield was calculated.

In the last part, recommendations were provided to the České Budějovice Airport, what steps should be taken and what measures should be implemented to the AFIS implementation.

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List of figures

Figure 1: Location of České Budějovice Airport [25] 12
Figure 2: The circuit of České Budějovice Airport [14] 13
Figure 3: Situation layout of RWY, TWY and APN at LKCS [5] 16
Figure 4: Situation layout of České Budějovice Airport with the location of AGE [5] 17
Figure 5: Night approach on RWY 27 [5] 18
Figure 6: Newly built branch station of the Fire brigade LKCS 20
Figure 7: Vehicles of České Budějovice Airport's Fire brigade [41] 20
Figure 8: Location of Hradec Králové Airport [28] 24
Figure 9: Circuit of Hradec Králové Airport [14] 25
Figure 10: Location of Mnichovo Hradiště Airport [32] 28
Figure 11: Circuit of Mnichovo Hradiště Airport [14] 28
Figure 12: Plzeň/Líně Airport location [36] 30
Figure 13: Circuit of Plzeň/Líně Airport [14] 31
Figure 14: Esbjerg Airport location [26] 36
Figure 15: EKEB airport circuit [13] 36
Figure 16: Sønderborg Airport Map [31] 38
Figure 17: RMZ of EKSB Airport [1] 39
Figure 18: Odense Airport location [33] 40
Figure 19: RMZ of EKOD airport [3] 41
Figure 20: Kolding Airport location [45] 43
Figure 21: RMZ of the Kolding Airport [2] 44
Figure 22: Map with the assessed Danish airports [37] 45
Figure 23: Allocation of ATS airspace by FIS and ALRS centres for uncontrolled flights [27] 49

List of tables

Table 1: Code element 1 of airport categorization according to regulation L 14 [43] 14
Table 2: Code element 2 of airport categorization according to regulation L 14 [43] 14
Table 3: Further important information about the České Budějovice Airport [39] 15
Table 4: List of aprons at České Budějovice Airport [39] 16
Table 5: Number of movements at LKCS airport from 2010 to 2019 [19] 21
Table 6: Landing fees at České Budějovice Airport [14] 22
Table 7: Parking fees at České Budějovice Airport [14] 23
Table 8: Passenger fees at České Budějovice Airport [14] 23
Table 9: Other fees at České Budějovice Airport [14] 23
Table 10: Number of movements at Hradec Králové Airport from 2010 to 2019 [44] 26
Table 11: Landing fees at LKHK [14] 26
Table 12: Parking fees at LKHK [14] 27
Table 13: Passenger fees at LKHK [14] 27
Table 14: Other fees at LKHK [14] 27
Table 15: Movements at Mnichovo Hradiště Airport from 2010 to 2019 29
Table 16: Landing fees at LKMH airport [14] 29
Table 17: Parking fees at LKMH airport [14] 29
Table 18: Passenger fees at LKMH airport [14] 30
Table 19: Other fees at LKMH airport [14] 30
Table 20: Number of domestic and international movements at LKLN Airport from 2010 to 2019 32
Table 21: Landing fees at LKLN Airport [14] 33
Table 22: Parking fees at LKLN Airport [14] 33
Table 23: Passengers fees at LKLN Airport [14] 33
Table 24: Other fees at LKLN Airport [14] 33
Table 25: Total movements at the LKCS, LKHK, LKMH and LKLN from 2010 to 2019 34
Table 26: Comparison of runway parameters at the airports LKCS, LKHK, LKMH, and LKLN [14] 35
Table 27: Fees charged at the EKEB Airport [11] 37
Table 28: Fees charged by EKSB [38] 39
Table 29: Number of movements at EKOD airport 41
Table 30: Fees charged by EKOD airport [9] 42
Table 31: Runway parameters at Kolding Airport [2] 42
Table 32: Mandatory equipment of the AFIS centre [48] 54
Table 33: Matrix of risks [42] 55
Table 34: Managing criteria 55
Table 35: Identified risks in safety risk analysis 64
Table 36: Risk mitigation means, including their advantages and disadvantages 67
Table 37: Questionnaire questions 71
Table 38: Company names with answers 72
Table 39: Conservative scenario results 76
Table 40: Progressive scenario results 79
Table 41: Input data for the dynamic scenario 82
Table 42: Dynamic scenario results 83
Table 43: Expenses on equipment and AFIS dispatchers' courses according to the Integra company 85
Table 44: Wages of AFIS workers in Denmark 85
Table 45: Expenses on equipment and AFIS dispatchers' courses according to the ANS of the Czech Republic state enterprise 86
Table 46: Wages of AFIS workers in the Czech Republic 86
Table 47: Boeing 737 arrival simulation according to the valid LKCS price list [4] 87
Table 48: Cessna 172 arrival simulation according to the valid LKCS price list [4] 88
Table 49: Comparison of revenues of České Budějovice Airport according to scenarios 89

Table 50: Minimum applicable extinguishing quantities and other parameters necessary for the transition from category 4 to category 6 [43]..... 91

List of graphs

Graph 1: Statistics of movements at České Budějovice Airport from 2010 to 2019 [19] 22
Graph 2: Time slots at EKOD Airport 70
Graph 3: Answers to the 2nd questionnaire question 73
Graph 4: Answers to the 3rd questionnaire question 73
Graph 5: Development of traffic at LKCS airport before the AFIS implementation and after the AFIS implementation under the conservative scenario 77
Graph 6: Development of traffic at LKCS airport before the AFIS implementation and after the AFIS implementation under the progressive scenario 80
Graph 7: Development of traffic at LKCS airport before the AFIS implementation and after the AFIS implementation under the dynamic scenario 83
Graph 8: Proposed scenarios summary 84
Graph 9: Comparison of arrival fees for Boeing 737 and Cessna 172 88

List of appendixes

Appendix 1 - Aerodrome chart LKCS
Appendix 2 - Aerodrome chart LKHK
Appendix 3 - Aerodrome chart LKMH
Appendix 4 - Aerodrome chart LKLN
Appendix 5 - Aerodrome chart EKEB
Appendix 6 - Aerodrome chart EKSB
Appendix 7 - Aerodrome chart EKOD
Appendix 8 - Aerodrome chart EKVD