Czech University of Life Sciences Prague

Faculty of Engineering

Department for Quality and Dependability of Machines

OPTIMIZATION OF LOGISTIC PROCESSES IN TRAVEL SERVICE, A.S.

Diploma thesis

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DIPLOMA THESIS ASSIGNMENT

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Thesis title

Optimization of logistic processes in Travel Service, a. s.

Objectives of thesis

Analysis and optimization of logistic and planning processes in a selected organization

Methodology

1) Analysis of the situation – current state (logistic and planning process audit)
2) Identification of problems, inefficiencies and bottlenecks
3) Assessment of benefits, costs, needed resources and feasibility of identified problems' solution
4) Proposal of solution/optimization of selected problems supported with application of standard operations management methods
5) Economic evaluation of proposed solutions
6) Conclusion – summary of achieved results and economic evaluation (savings)

Outline of the structure

1) Introduction
2) Literature review
3) Project (thesis) objectives
4) Methodology
5) Analysis of current state
6) Proposed solution
7) Conclusion

The proposed extent of the thesis
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RUSSELL, R.S. – TAYLOR, B.W.: Operations management. Prentice Hall, Upper Saddle River, 2000, ISBN: 0-13-013092-3

GOULD, F.J. – EPPEN, G.D. – SCHMIDT, C.P.: Introductory management science. Prentice Hall, Singapore, 1997, ISBN: 981-3076-99-2

CHOPRA, S. – MEINDL, P: Supply Chain Management – Strategy, Planning and Operation. Pearson, 2013, ISBN 978-0-273-76522-6

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Declaration

I hereby declare that this thesis is my own work and that, it does not include any material published or written by another person, or has been submitted for the award of any other university degree and that all the sources I have used and quoted have been indicated and acknowledged by complete references.

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Prague, April 5, 2015 Irena Ambrožová

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Abstract

The aim of the MSc. thesis is to characterise operational background of Travel Service airlines. It focuses primarily on the arrangement of logistic flow during the processes of crew planning and creating crew rosters. It deals with the issues of flight standards validation for crew, logistic transfers and implementation of specific procedures when creating rosters, whose implementation would lead significantly to more efficient company operation and to reducing operational costs. The thesis contains its analysis, economic calculation and implementation based on the data from real operation.

Key words

Logistics processes, optimization, commercial aviation, crew scheduling and rostering, duty legality

Abstrakt

Diplomová práce charakterizuje provozní prostředí letecké společnosti Travel Service, a.s. Zaměřuje se zejména na analýzu logistických toků během procesu plánování posádek. Cílem práce je analýza současného systému a navržení opatření vedoucích k jeho optimalizaci. Zaměřena je především na validaci norem leteckého personálu, ekonomickou analýzu rozvržení bází a zefektivnění procesů během vytváření rosterů.

Klíčová slova

Logistické procesy, optimalizace, letecká doprava, plánování posádek

Contents

1 Introduction

It has been more than hundred years when the first airplane heavier than air was invented by brothers Willbur and Orwille Wrights. Since that time the air transportation has acquired a big importance for the human society. Air transportation is the fastest and the safest way of travelling connecting people and business, therefore it is an important tool for the economic development. The benefits of air transportation are following: quickness of the transport, safety, regularity, comfort and capacity of transported people and goods.

Apart from economic advantages, air transportation means social benefits by facilitating communication among different parts of world and providing easier access to remote areas. It improves the quality of life with spreading the leisure and cultural experiences. Air transportation also provides jobs and growth of tax revenues. The use of commercial aviation has grown over the last decades and it is expected that the volume of passengers and cargo is going to grow.

An important player in air transportation is airline. There are more than 900 commercial airlines around the world, with a total fleet of 22 000 aircraft. Commercial airlines serve more than 1700 airports and transport close to 2 billion passengers and 40% of interregional transports of goods annually. Also more than 2 million people are employed by airlines or handling agents, for example, as flight crew, operation staff, maintenance crew or check-in staff. [1]

The increasing number of airline companies has put more importance and pressure on their management to demand profits, reduce costs and increase revenues. The main goals for an airline company to meet the profit are: stability, reduced number of delays and fluent traffic without any defects. It involves the cooperation of all interested parts as operations, crew, and maintenance staff and as well the management of the airline company.

This diploma thesis is focused on the crew logistics and crew rostering process in the Travel Service, a.s., which is currently the biggest privately owned airline company in the Czech Republic. My motivation for choosing this topic is that I was employed 18 months there as a crew dispatcher/scheduler and now I work as a navigator department assistant, who is responsible for flight planning. Due to this experience I realized how necessary the scheduling and logistics processes are to avoid additional delays, for minimizing the costs and maximizing the revenues for the company. Travel Service operates with various air fleet (including Boeings and Airbuses as well) on several bases around the world (as Toronto, Montreal, Prague, Muscat, Maldives, Warsaw etc.). It causes complicated and long

scheduling process which is usually carried out sequentially, so that the flight, aircraft, maintainers and crew schedules are created several weeks before the day of operation.

At the beginning, theoretical review of the methods used in the thesis is presented and also the methodology. Further there are defined objectives of this work. First one is to create Flight duty period counter that should serve as a supporting tool for calculating flight duty period legality. The Flight duty period counter is programmed in MATLAB language and attached to this thesis. The presentation of its processing during the various beginning conditions (as beginning of the flight duty with transportation, flight duty during the window of circadian low, rotations with more numbers of flight legs, rotations operated by augmented crew) is in chapter 6. Second objective is economic analysis and evaluation of Polish bases´ location and logistics of crew transport, which is presented in chapter 7. The last objective is optimizing of crew rostering process and it is task of chapter 8. Except the analysis of identified problems and their improvements, the basic information about the Travel Service is presented there. The provided service, fleet, company structure, comparison of the operational situation during the summer and winter season are described. Apart from this the crew scheduling and rostering process operational background is presented there.

2 Theoretical review

In this chapter, basic methods used for the analysis, description and solution of the problems are summarized. It provides a short description of Differential analysis method, Workflow and Ishikawa diagrams.

2.1 Differential analysis

Differential analysis is an analytical method of comparing two or more alternatives to each other in a way to decide which of them better choice are. It requires considering all potential solutions to determine those that are the most cost-effective. This analysis uses a numerical approach. It compares only the relevant costs of alternatives and resulting benefits each of them. Differential analysis takes all of the relevant numbers associated with the possible choice and gives an idea of where the owner of a business would stand with each possible decision. [2] It usually involves four steps:

- Description of the current state,
- Determining the objectives and description of the final state,
- Specification of the differences between the current and demanding final state,
- Proposal of possibilities leading to reach the final state,
- Assessment of the proposal solutions and choosing the most desirable one. [3]

2.2 Workflow

Workflow is used in situations where it can be difficult for management to know where to begin looking for opportunities to increase the productivity by optimizing processing. [4] Workflow presents a sequence of operations and representation of real work, declared as work for a person or group. It introduces a process or collection of processes in the context of work. Workflow defines them as a logical set of activities, required to accomplish a specific goal under certain conditions. In workflow a flow control represented by diagramming techniques showing the directed flows between processing steps should be applied. [5]

Many operations professionals are documenting workflow processes with conventional flowcharts. However, in the thesis swim lane diagrams are used. Swim lane diagrams use symbols like boxes for activities and diamonds for decision points. Moreover, swim lane diagrams identify the participants involved in horizontal bands across the page. By aligning the activity boxes in swim lanes, participant groups are documented. [6]

2.3 Ishikawa diagrams

Ishikawa diagrams (also called Cause-and-Effect Diagram, Fishbone diagrams, Herring bone diagrams) identify possible causes of an effect or a problem. They sort ideas into useful categories. They can be used in product design, marketing or service industry. Causes are grouped into major categories to identify the source of the problem. These categories are usually following (but they can be different):

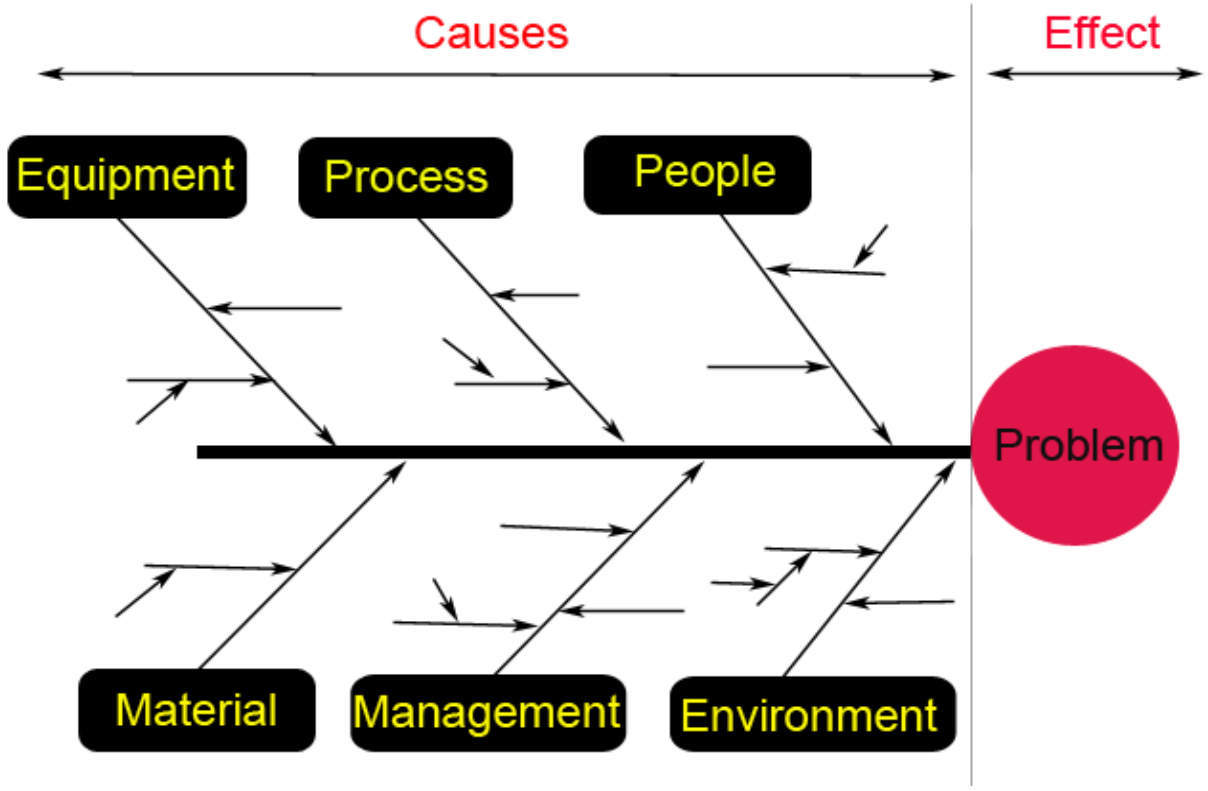
- Methods,
- Machines (equipment),
- People (manpower),
- Materials,
- Measurement,
- Environment. [7]

Creating Ishikawa diagram includes several steps:

1. Agree on a problem statement,
2. Brainstorm the main categories of causes of the problem,
3. Write the categories as branches from the main arrow,
4. Brainstorm all the possible causes. They can be written in several places if they relate to several categories. Then write possible sub-causes branching off the causes. Layers of branches indicate causal relationship.

An example of Fishbone diagram is presented on **Figure 1**.

Figure 1 – Example of Ishikawa diagram [8]



3 Thesis objectives

This chapter presents the particular objectives of the thesis which are the following:

1. **To create a Flight duty period counter** – a programme made in MATLAB language that is able to calculate the individual flight duty period, duty period and maximal limits of flight duty period under the various conditions and required rest. It is created only for Travel Service usage (each airline company has different regulations). It can be used on crew planning department as optimization tool leading to higher automation and human errors minimalizing. Flight duty period counter is described in the chapter 6.4 and attached to thesis as exe file.
2. **Economic analysis of Polish bases´ location** – calculation based on the data from the summer season 2014. In Poland there were just two bases – Warsaw and Poznan and the crews had to travel among other cities as Gdansk, Rzeszow, Krakow, Poznan, Katowice etc. The objective of this part is to compute and compare how the additional costs (for transfers, hotels, per diems) would be eliminated if the crews were based also in other cities. There is also included the possibility of the sickness and delay of the flight due to the crew transportation (the cases when the delays are longer than 2 hours and compensations to passengers have to be paid). In conclusion there is proposal which (if any) base would be the suitable one to open and how to optimize the crew transport logistics. (Description, economic evaluation and proposed solution is described in detail and evaluated in chapter 7.)
3. **Optimizing of crew rostering process** – the aim is to describe current methods and chronology used during creating rosters. Data from the new system, so called Bidding, are collected. The Bidding has been used since the November as a testing pilot system for flight deck planning. Moreover further improvements in Bidding system in the case of flight deck rostering are proposed and its possibility of implementation into the cabin crew rostering process.

The target date for the implementation of **Flight duty period counter** could be set as soon as possible. If we consider the fact that the preparations for the season last at least half a year, the possible time for implementation of proposed solution for the second objective could be the **summer season 2016.** And potential time for implementation steps leading to elimination crew rosters inefficiency could be at the beginning of the **summer season 2015.**

4 Methodology

The purpose of this work is to optimize the logistics processes, improve the main problems described as objectives in previous chapter and also assessment of the cost and feasibility of the proposed solutions. In the thesis following methodology was used:

1. Identification of the problems,
2. Analysis of the current and demanding state, considering potential solutions and choosing the most cost-effective and suitable one by Differential analysis.
3. Creating the **Flight duty period counter** in MATLAB language that serves as supporting tool for crew planners that eliminates human errors and prevent from duty illegalities and thus further complications.
4. Collecting data from AIMS software about the flights operated from Poland in summer season 2014:
    - Total number of the flights,
    - Number of flights operated from different cities (Katowice, Krakow, Gdansk, Rzeszow, Lodz, Wroclaw, Poznan, Warsaw, Lublin, Szczecin and Bydgoszcz),
    - Probability of the sickness,
    - Average capacity of the flights,
    - Number of the flights delayed more than 2 hours due to the transportation of the crew.
5. Evaluating the additional expenses (based on information obtained from crew support department in Travel Service)
    - Transportation costs,
    - Per-diems,
    - Accommodation costs,
    - Compensations to the passengers,
    - Costs on technical equipment.
6. Assessment the profitability for Travel Service to established another operational base/ bases in Poland and assessment of the logistics changes in crew transportation.
7. Description of the crew rostering process,
8. Collecting data (from EFA – Extranet Flight Application) from the Bidding system that was established at the beginning of the winter season 2014/2015 as a helpful tool for the pilot rostering.

9. Data evaluation – statistical evaluation of data about pilots who took a part in Bidding system, evaluation of the successful/unsuccessful requests in each flight deck category.
10. Proposal of further improvements for creating pilot´s rosters and implementation for cabin crew rostering.
11. Conclusion and summary of the proposed solution and their benefits for the Travel Service.

5 Introduction into the problem

The purpose of this chapter is to introduce the Travel Service, a.s. and current process of crew scheduling. The information is split into the several main parts. At first the basic characteristics of the company are provided, including the description of provided service – focused on charter, regular and business flights. The evaluation of the economic situation and position of the airline company within the aviation branch is a theme of this chapter as well. Also the comparison of the winter and summer season operational situation is presented there.

Further the basic of the crew scheduling is described, the current methods and procedures how the crew rosters are created. A division of the Crew Planning Department in Travel Service can be found there and description of its main tasks. Also workflow that describes the operational background in Travel Service is presented.

5.1 Basics characteristics of the company

The company Travel Service, a.s is currently the biggest privately owned airline company in Czech Republic. It was founded in the year 1997 and since than it has experienced a huge expansion. Travel Service, a.s. is owned by:

- **Global Trade Opportunities (G. T. O.) , Stockholm** – 36.16% of the stocks,
- **Roman Vik, General Director of Travel Service, s.r.o**. – 36.16% of the stocks,
- **Canaria Travel, s.r.o.** – 27.68% of the stocks. [9]

Travel Service operates 70% of the charters flights at the Czech market. Further from the May 2004 was established new brand named **Smart Wings** as a low cost operator for scheduled flights. The main area of activity of Travel Service, a.s. is a regular and irregular, international and domestic commercial air transport of passengers, their baggage, animals, mail and goods (or cargo) by air. [10]

Travel Service, a.s. has subsidiary companies in the following countries:

- **Slovakia** – Travel Service Slovensko, s.r.o.,
- **Poland** – Travel Service Polska, sp.z.o.o,
- **Hungary** – Travel Service, KFT. [9]

More information about company structure and air fleet is presented in **Appendix 1** and **Appendix 2**.

5.2 Analysis of the services

The Travel Service, a.s operates regular air transportation (scheduled flights), charter flights and as well business jet flights under the Travel Service or Smart Wings brand. [9]

5.2.1 Scheduled flights

Scheduled or regular flight means a flight planned on a particular route and time on a regular basis (daily, weekly etc.) The price of a scheduled air-ticket is calculated throughout the year and depends on the season and demand. [11]

Travel Service/Smart Wings airline provides following scheduled flights to:

- **Italy** (Rome),
- **France** (Paris),
- **Israel** (Tel Aviv).

5.2.2 Charter flights

Under the term **charter flight** is understood a flight that takes place outside the normal schedule by a lease arrangement with a particular customer (very often with a travel agency). Charter flights are not operated under published scheduled timetables. What more, the tickets are not sold directly, but by travel agencies. Also many charter flights tickets are sold as a part of a holiday package when price includes flights, accommodation and other services as a transport from the airport etc. [11]

Travel Service provides charter flights in cooperation with Exim Tours, Firo Tour, Canaria Travel and Blue Style to the following holiday destinations:

- **In summer season:**
    - **Greece** (Kos, Rhodes, Skiathos, Zakynthos, Corfu, Thessaloniki, etc.),
    - **Turkey** (Antalya, Izmir),
    - **Bulgaria** (Burghas, Varna),
    - **Spain** (Almeria, Malaga, Canary Islands),
    - **Morocco** (Agadir, Oujda).

- **In winter season:**
    - **Egypt** (Hurghada),
    - **Cuba** (Varadero),
    - **Mexico** (Cancun),
    - **Kenya** (Mombasa).

5.2.3 Business jet flights

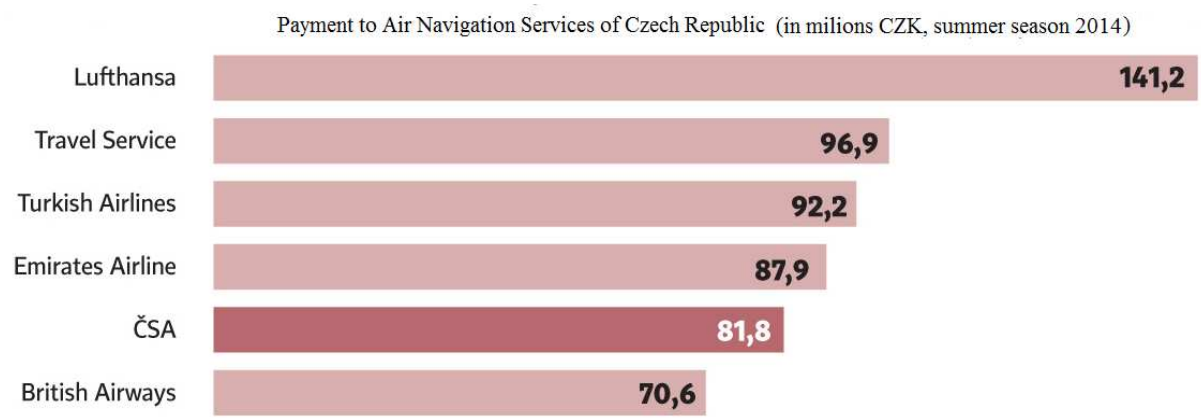
Beside the scheduled and charter flights since 2007 Travel Service offers private flights – Business jet Aerocab Service. These flights are provided by jet aircraft Cessna 680 Citation Sovereign designed for transporting up to 9 people. The most typical destinations include Europe, Middle East, Africa and Asia. [9]

5.3 Evaluation of the economic situation and position of the company within the branch

As was mentioned in the beginning, Travel Service is the biggest privately owned airline company. The only competitor in the Czech aviation branch is the Czech Airlines (CSA). However CSA are the form state company owned by Czech Aeroholding a.s, Ministry of the Finance of the Czech Republic, Czech Insurance Company, Prague and Bratislava cities. In 2013 the Korean Air bought 44% of the CSA´s stocks. Travel Service was willing to buy 34% of the Aeroholding part of the stocks. The agreement was signed in October 2013 and European Union confirmed in December 2014 that this step wouldn´t lead to disruption of the competition due to the connection of the two biggest airline companies on the Czech aviation market. In April 2015 Korean Air bought 34% of state stocks and sold them to Travel Service. [12]

If we could sum up the summer season 2014, Travel Service paid almost 20% more landing and over-flight taxes than CSA to the Air Navigation Services of Czech Republic. The exact value is presented on the following figure (**Figure 2**) and its 96.9 million of CZK. It was mainly caused by the providing of the charter flights for the travel agencies during the summer. [13]

Figure 2 – Payment to Air Navigation Services of Czech Republic (summer season 2014) [13]



Further the gross profit of Travel Service in the year 2013 was 219 million CZK. Compared with the year 2012, when the paid taxes were 64 million CZK, it increased almost four times. The number of passengers increased about 23% in the 2013 (approximately 4.3 million). The company spreads its activities at foreign markets within the year 2013 (contract with tour operator Hotelplan Suisse in Switzerland). From the October 2014 six times per week flights do Dubai International Airport are provided and from March 2015 to London Gatwick Airport. Nevertheless Travel Service requested for the traffic rights for the flights between Prague and Moscow (which is nowadays available only for CSA and Aeroflot). The permission will be granted from April 2015. [13]

5.4 Operational situation: winter and summer season

Travel Service, a.s. is placed in Prague. However we can find subsidiary companies in Slovakia, Poland or Hungary as well.

Travel Service´s Flight and Ground operational departments (with the support of Technical and Commercial Departments) are placed in Prague and control and regulate the operation of the aircraft on several bases. The number and location of the operational bases changes every season according to the wet or dry lease agreements and contracts with travel companies. The number of the aircraft is an important factor as well. The following text will be focused on the summer season 2014 and winter season 2015.

5.4.1 Summer season 2014

Travel Service operated **40 aircraft** on following operational bases during the **summer season 2014:**

- **Prague** – in Prague were 2x B737, 3x A320, 11x B738 and 1x B738 (wet leased from Spicejet). The destinations operated from Prague included scheduled and charter flights to: Spain, Portugal, Canary Islands, Balearic Islands, France, Italy, Montenegro, Croatia, Egypt, Israel, Switzerland, Morocco, Tunisia, Turkey, and Greece. And Travel Service also provided military flights to **Mazare Sharif** and **Kabul**. These flights are for troops of Finland, Norway and Sweden (**ISAF** contingent)[1].
- **Bratislava** – in Bratislava were based 3x A320 and 2x B738 that operated short-haul flights to Turkey, Italy and Greece.
- **Budapest** – short-haul flights based on travel agencies requests, 2x A320 wet leased from **Smartlynx** and 1x B738. The operated destinations were: **Israel, Jordan, Egypt** or **Kazakhstan**.
- **Brno/Ostrava** – 2x A320 that operated flights to Greece, Italy, Spain and Turkey.
- **Poznan** – 1x A320 wet leased from Hermes Airlines. Flights mainly operated to Greece, Egypt or Israel.
- **London (Heathrow) –** 1x B738 wet leased from **Sungwing Airlines**, flights operated mainly to the Greece.
- **Muscat (Sultanate of Oman)** – 2x B738 wet leased to **Oman Air**. Flights operated according the request of Oman Air to destinations as: **Dubai, Kuwait, Hyderabad (India), Cairo (Egypt), Sallalah (Sultanate of Oman)** and **Abu Dhabi (United Arab Emirates).**
- **Warsaw** – 1x B738 wet leased from **Sungwing Airlines**, 4x B738. The main destinations were: Tunisia, Greece, Egypt and Israel.

All the traffic was mainly focused on operating short-haul scheduled or charter flights in accordance the agreements with travel agencies and in Muscat according the Oman Air requests. (As it is shown on **Figure 3**)

[1] **ISAF -** International Security Assistance Force, military mission in Afghanistan led by NATO [15]

Figure 3 – Operational situation – summer season

5.4.2 Winter season 2014/2015

There were **31 aircraft** and following operational bases during the **winter season 2014 – 2015:**

- **Prague** – in Prague there were: 2x B737, 4x B738 and 2x A320. The operated flights were based on travel agencies requests. Short-haul as **Egypt, Israel** or **Morocco**. Or long-haul – **Kenya, Caribbean** aerodromes (**Cuba** and **Mexico)** or flights to **South America** (Venezuela, Jamaica). From Prague were operated flights requested by **Smart Wings**: to Italy and France (especially Rome and Paris).
- **Warsaw** – in Warsaw operated 3x B737 mainly short-haul flights to **Canarias islands** or destinations as **Madeira, Israel** or **Egypt**.
- **Budapest** – short-haul flights based on travel agencies requests, only 1x A320 wet leased from **Smartlynx**. The operated destinations were: **Israel, Jordan** or **Kazakhstan**.
- **Paris –** 3x B737. Flights between France and Canarias Islands.
- **Muscat (Sultanate of Oman)** – the same operational situation as in summer season.
- **Maldives** – 1x B738 wet leased to **Mega Maldives Airlines**. Flights were operated to **Hongkong, Male (Maldives)** and **Koror Island (Republic of Palau).**

- **The rest of the aircraft were:**
    - **Wet leased to Sungwing Airlines** – 5x B738 to Ottawa and Montreal bases. There were operated flights to Mexico and Caribbean destinations.
    - **Dry leased to Sungwing Airlines** – 6x B738 without the crew and other operational staff.
    - **Dry leased to Air Transat** – 2x B738 without the crew and other operational staff.

Operational situation during the winter season 2015 in presented on **Figure 4**.

Figure 4 – Operational situation – winter season

It can be assumed that the traffic during the summer and winter season is different. In summer period 2014 scheduled and charter flights were operated mainly to Europe and few other destinations as Turkey, Israel, Egypt or Morocco. On the other hand the winter season has different specifics. The short-haul flights are in the minority and the operation is focused on long-haul charter flights on travel agencies requests as well as on the wet leased agreements. The operational bases were changed and included new ones: Canada or Maldives. That means a lot of flexibility for the flight deck and cabin crew, as well for the ground staff. As it is obvious, the logistics of crew scheduling is influenced as well, because there have to be considered many factors while creating the crew rosters.

The crew (especially flight deck) is limited by the following:

- **Aircraft type –** crews operating on Boeing need different training and type rating than the Airbus ones.
- **Route competency** – it is required to have a special qualification trainings and simulators for operating flights to far east, middle east, west Africa, also to some destinations is NAT/ETOPS[2] qualification required. (Regions are defined in Operations Manual part A.)
- **Airport category vs. pilot category –** special list distinguishing the aerodromes according to their category (A, B or C) is provided, as well as the captains and first officers are divided according to their experiences (more about the categories and qualifications will be presented in the chapter 8.2).

The crew is also limited by other factors:

- **Duty limitation** – based on the Labour Code of the Czech Republic and Annex 6 of Convention on International Civil Aviation is also defined in Operations Manual part A.
- **Seniority** – during the procedure of crew scheduling is taken in account the seniority **–** the crew with higher seniority have privileges.
- **Vacations and requested day offs** – crews are limited by the ROFF (requested days off) requests. Each crew member could have 4 ROFFs per month, except the women with children up to the age of 2 years (10 ROFFs and 80% of the full contract). And also the RVACs (Requested Vacation day) could be applied according the Labour Code. However ROFF and RVAC are confirmed only when it could be allowed by the operational situation. That means that crew scheduling is complicated logistic procedure that have to take in account all the necessary factors when the rosters are made.

[2] **ETOPS –** Extended Twin-Engine operations. Refers to a type of operation in which air carriers are allowed to fly over places where aerodromes and landing area are sparse, for example a long routes over the ocean. ETOPS can be 75/90/120/138/180/207/240 min [16]

5.5 The content of crew scheduling

Travel Service usually uses following procedures to plan the operations. At first the problem of a flight scheduling is solved (means creating a schedule that defines each flight leg). Then the fleet assignment is performed to allocate an aircraft type for each flight leg (according to the demand for the destination, passengers capacity, performance and number of available aircraft) to maximize the profits. Further for each aircraft type, an aircraft routing problem is solved. Aircraft routing tends to determine the sequence of flight legs to be operated by individual aircraft, so that each leg is covered exactly ensuring maintenance. And the last step is solving the crew scheduling/rostering problem. [17]

The construction of airline crew rosters has been important in airline operations. It doesn´t influence only the level of service but also its profitability. Because a feasible cabin crew schedule has to satisfy the flight schedule, agreements with labour unions and government regulations, the crew scheduling is complicated. Generally it is separated into two problems:

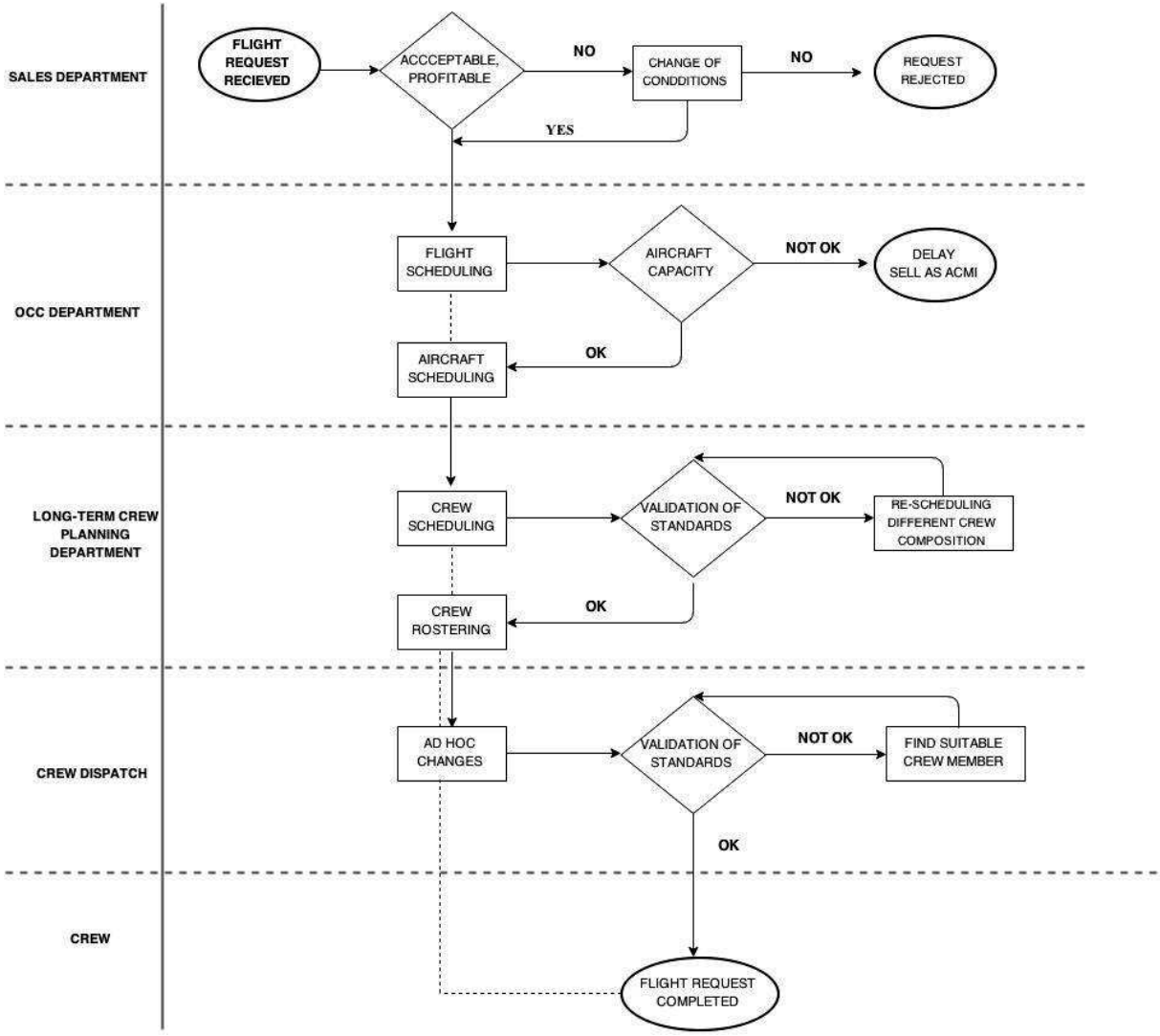
- **Crew scheduling –** it means the construction of pairings, each legal sequence of duties performed by the same crew, which starts and ends at the home base. A duty contains of one or more connected flights. The flight schedule, the fleet routes and the related crew costs involve the construction of a set of pairings and the cost of these pairings should be minimized. The planned pairings or rotations are not allocated to individual crew members at this stage. [17]
- **Crew rostering** – the crew rostering problem means linking pairings together into work schedules that are allocated to crew rosters over the period of time (usually two weeks or month in Travel Service). This usually leads to a conflict between management and crew requests: management forces to minimize the number of crew members required and crew are willing to maximize the satisfaction with the roster. [18]

The centre of crew scheduling is in Prague and it handles the operations for all bases. The crew scheduling procedure has to meet requirements that are defined in Operations Manual Part A and related regulations and rules. The Crew Planning Department is divided into the:

- **Crew Dispatch** – solves actual operations and problems in scope of 5 days,
    - **Crew Dispatch for pilots** – solves operational problems for the flight deck only.
    - **Crew Dispatch for stewards –** solves operational problems for cabin crew only.
- **Crew Planning** – the aim is to process long-term requirements starting 5 days ahead and more. Crew planning has to schedule the rosters for all crew members in accordance with ROFF and RVAC requests and limitations. The Crew Planning can be contacted only by email.
- **Crew Planning Supervisor** – person responsible for the day to day running of the Crew Planning Department, ensuring a safe and efficient operation. The Crew Planning Supervisor is also responsible for the communication with other departments, especially with Operations Control Centre (OCC). [19]

Following workflow (**Figure 5**) represents the operational background in Travel Service. It begins from the flight request receiving by Sales Department and shows the linkage with the Operations Control Centre (OCC), Long-term Crew Planning and Crew Dispatch with the crew.

Figure 5 – Workflow of the operational background in Travel Service



6 Flight duty period counter and crew legality

The aim of this chapter is to present the AIMS software, which is used during the crew rostering procedure. The emphasis is put on the flight duty period legality checking and definition of the current situation in context with the AIMS. The main pros and cons of the system are identified there and based on it proposed the solution. As well the general information about the flight time and flight duty limitations is presented, based on TVS Operations Manual Part A, and Labour Code of the Czech Republic. As a conclusion of this part, the Flight duty period counter is introduced there. It is programmed in MATLAB and it could serve as an additional tool supporting the validation of the individual flight standards. The functionality of the programme during various initial conditions and inputs is shown.

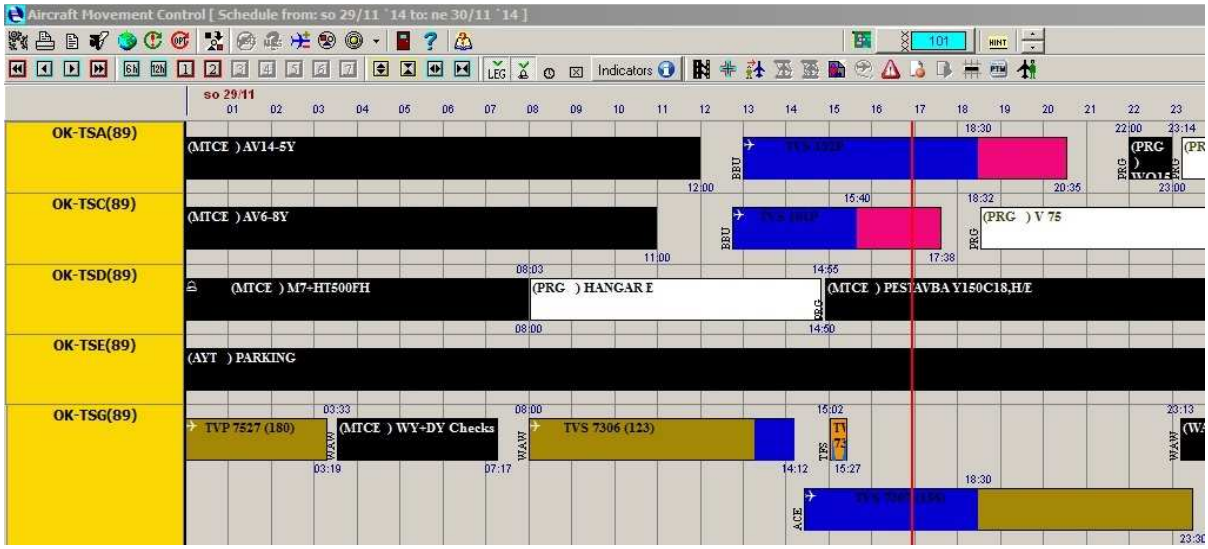
6.1 Scheduling software – AIMS

The process of the crew rostering is carried by the **AIMS** (Airline Information Management System) software. The planning is not done automatically, but mostly manually by adding the flight to the crew based on the qualifications and limitations. However the AIMS is used also in other departments in Travel Service as in Operations Control Centre, Slot Coordination Department or Navigation Department.

AIMS has been used by variously sized airlines since 1983 and its main functions are following:

- **Crew planning/scheduling** – operational and long term scheduling of the flights. It affords the ability to determine the minimum crew requirements for the scheduled seasonal plan.
- **Crew schedule production** – ability to produce and generate rosters for crews.
- **Crew tracking** – provides the crew legality – crew route legality checks, crew schedule legality checks, crew expiry dates. As well as the flight leg coverage control.
- **Operations control** – provides aircraft scheduling and movement control used also by OCC and Navigation Department. The Aircraft Movement Control is presented on the **Figure 6**.

Figure 6 – Screenshot of Aircraft Movement Control [22]



The brown colour presents charter flight, black colour maintenance or parking, pink colour technical rest, white colour means that the aircraft stay in the hangar and blue colour means delay of the flight.

- **Aircraft maintenance planning,**
- **Commercial planning** – includes flights schedule generator or changes, as well as additional information as airport slot management, flight cost analysis, PAX and cargo forecast or making reports.

AIMS has an ability to cover a wide range of company administrative, training and operational requirements, as well as individual requests and preferences. [23]

6.2 Flight duty legality checking

Crew rosters are created according to the legislative based on TVS Operations Manual Part A and Labour Code of the Czech Republic (more about duty time limitation is presented in chapter 6.3.2) However the supporting scheduling software AIMS is not able to calculate the maximum duty limitation and the rest requirements in many cases. The flight duty limitation calculations are very complex and it is quite easy to make a mistake. AIMS is able to control it to a certain extent of maximal FDP, appropriate rest of crew and determine the time of duty beginning. This applies only for planned long term flights. In case when the commercial department or OCC sells ACMI flight, or the planned rotation is changed due to operational changes (unexpected stopover, FDP extension due to a technical failure or

advanced over-routing), AIMS is not able to determine the FDP limitations for crew. Planners have to calculate the standards by themselves that can lead to inaccuracy and miscalculation, which can end in an illegally planned duty. Simple application, which would be able to determine basic parameters, such as FDP, FDP while un/expected duty extension and following rest would ease the work of both planners and crew. Planning department could also use this for the matters of standards verification and crew as a check back.

6.3 Flight time and duty limitation

The flight norm of crew has been issued to ensure the safety of flight operations. It defines the rules for standing maximal duty periods, flight duty periods, minimal rest requirements and rules for stating the standby of crew members. [24]

6.3.1 General information

While creating the crew rosters emphasis has to be put on the human factors as:

- Pregnancy,
- Illness, surgery, or usage of medications,
- Blood donation,
- Underwater diving,
- Cumulated fatigue,
- Age (pilot who reached 60 years age surplus can´t be planned with other pilot who is older than 60 years). [24]

6.3.2 Limitations of (Flight) duty period

If we want to describe the duty time and duty limitations, at first we have to define several terms that are necessary for it:

1. **Base** – the location nominated by the operator to the crew member from where normally a duty period or series of duty periods starts and ends and when the operator is not responsible for the accommodation of the crew members**.** [24]
2. **Flight Duty Period (FDP)** – each period when the crew member carries duties on board included 45/75/90 min before the flight as a briefing. If the crew members begin their duty on home base, the briefing time is 75 min before the flight. Out of the home

base it is 45 min, except Oman where the briefing is 90 min before the departure. When FDP begins with transportation, there is no briefing before the flight and the time of the transfer is calculated into the FDP. [24]

3. **Duty period (DP)** – time period including the briefing time + time on board + 30 minutes as a debriefing. Duty period also includes crews training and transportation to the home base. [24]
4. **Stand-by (SBY)** – flight reserve is defined as a period of time during which a crew member is required to be available to receive an assignment for flight operating. [24]
5. **Window of circadian low (WOCL)** – time interval from 2 am local time up to 5 am and 59 minutes local time (local time refers to the home base). [24]
6. **Basic crew –** the flight crew whose composition is specified according to the PAX capacity of the aircraft. Basic flight crew cannot have lower amount of members than a minimal flight crew (further in chapter 8.2 Crew qualifications). [24]
7. **Augmented crew –** the flight crew whose composition has more members than a basic crew for a given type of aircraft but less than double crew.[3] Its composition must permit that each flight crew member can be relieved by other member for a part of flight duty period. [24]

Limitations of duty period are following:

- 60 hours during consecutive 7 local days. [24]

Limitations of flight duty period are following:

- Maximal standard FDP is 13 hours.
- Maximal FDP 13 hours should be reduced by 30 minutes for each other leg[4] beginning with the third one. But the maximal reduction is 2 hours. If FDP starts by transportation, it is not considered as a flight leg.
- When the beginning of the FDP is in WOCL interval, then maximal limit assigned shall be reduced by the length of the time that interferes with the interval but maximal for 2 hours. If the FDP finishes or fully covers WOCL then maximal FDP shall be reduced by half of the length which interferes into the interval. (More information about the rules for FDP limitation during the WOCL is presented in **Appendix 3**.)

[3] **Travel Service** doesn´t use the double crew composition.

[4] **Leg (flight leg) –** means segment of a flight including stopover, also called flight segment. [24]

These limits are valid only for basic crew. Augmented crew is not influenced by WOCL interval.

- The maximum FDP for augmented crew[5] is 16 hours and 4 landings. There is no reduction of the FDP limitation due to the number of legs.
- The transportation after the flight is not considered as a flight duty period, it is included only in duty period. [24]

6.3.3 Planned extension

Maximal limits of flight duty period can be extended by 1 hour while meeting following conditions:

- Maximally 2 extended FDP are allowed in 7 consecutive days,
- If the extended FDP begins in interval from 10 pm local time up to 4 hours 59 minutes local time it is allowed in maximal length of 11 hours 45 minutes.
- Planned extension is not possible for augmented crew. [24]

6.3.4 Unplanned extension (Uncalculated circumstances)

If a delay arises after the beginning of the flight duty because of the uncalculated circumstances and it won´t be possible to complete the flight duty in the range of determined limits, based on the captain´s decision it is possible to modify the flight duty period, duty period and rest period in following way:

- Permitted limit of flight duty period must not be extended by more than 2 hours for the basic crew.
- More than 3 hours for the augmented crew (1 extra landing over the limit is possible). [24]

[5] **Augmented crew –** refers to the crew including 1 captain and 1-2 flight attendants over the basic crew due to the flight duty limitation. [24]

6.3.5 Rest requirements

Before the duty each crew member provides a basic rest as long as the previous duty or 12 hours, it depends on which equity is higher. If the duty begins out of the home base the crew member is provided with a basic rest as long as the previous duty minus 2 hours, or 10 hours according to which equity is higher. [24]

Rest in sequences of planned duties has to be 36 hours after maximal 168 hours of duty. The 36 hours has to include 2 local nights.[6] [22]

When the crew member crosses over 4 and more time zones in frame of one duty flight in one direction, minimal rest 14 hours plus 30 minutes per each time zone crossing over starting by fifth has to be provided. [24]

6.4 Proposed solution: Creating a Flight duty period time counter

In this subchapter the demonstration of the programme during the various situations and initial conditions is presented. The programme was created in MATLAB language using its graphical interface. (The source code of the programme is presented in **Appendix 4**). For starting the Flight duty time counter the **MATLAB Compiler Runtime** can be used**.** It is a standalone set of libraries than enables the execution of MATLAB files on computers without an installed version of MATLAB. It can be downloaded from the web **http://www.mathworks.com/products/compiler/mcr** for free. The version of MATLAB Compiler Runtime is tied to the version of MATLAB – in this case R2014a (8.3) 64-bit or 32-bit. Following figures present the Flight duty time counter operation under the different combinations of initial conditions:

1. Programme start – up,
2. After calculation – legal FDP for basic crew,
3. After calculation – legal FDP for augmented crew,
4. Demonstration of the programme during the WOCL period,
5. Error message with the reason of illegality.

[6] **Local night** – defined as a night that lasts minimal 8 hours and begins at 10 pm local time or ends at 4 am local time. [24]

6.4.1 Programme start – up

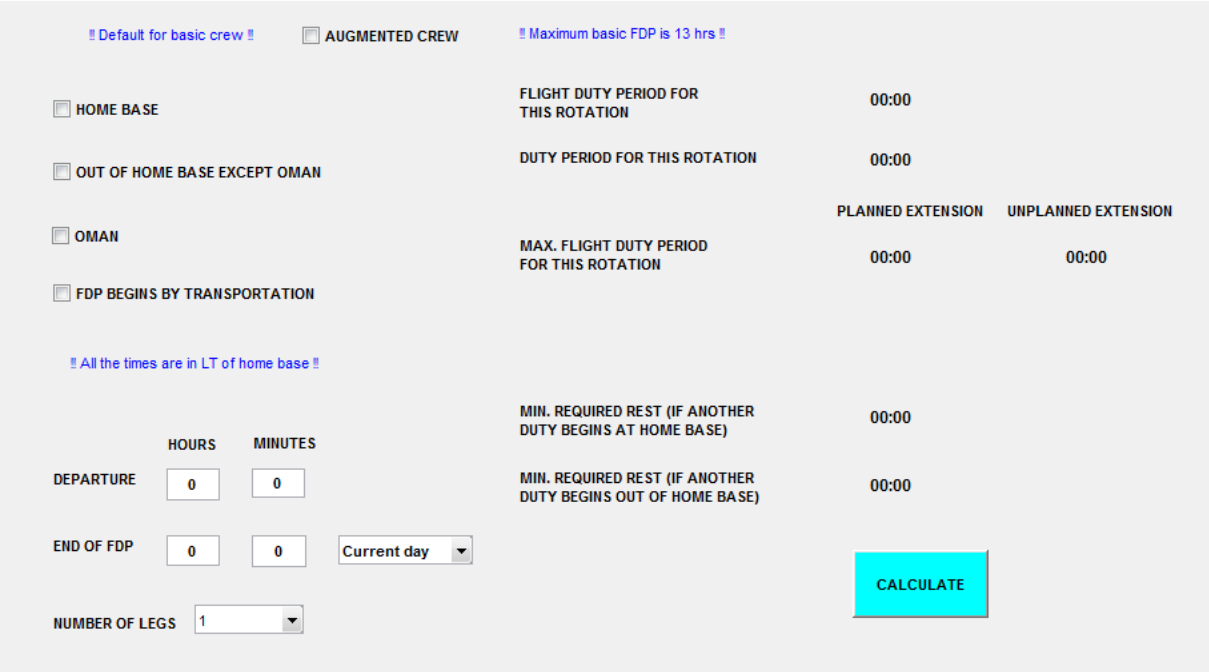
On the **Figure 7** the programme after start-up with the initial interface is presented. At first it should be defined, whether the crew member starts the flight duty at:

- Home base,
- Out of the home base (except Oman),
- Out of the home base,
- FDP begins by transportation.

Further it is necessary to insert the departure of the flight (or transportation) and the end of the FDP. All the values have to be in the local times of home base. And it can be chosen if for the basic crew composition it is calculated, which is initial setting, or for augmented crew. Finally the number of legs is necessary to insert. After calculation we obtain following information:

- Flight duty period for this rotation (if WOCL – maximal FDP for this rotation),
- Duty period for this rotation,
- Maximal FDP during the planned extension,
- Maximal FDP during the unplanned extension,
- Minimal required rest if another flight duty begins at home base,
- Minimal required rest if another duty begins out of home base.

Figure 7 – Programme start-up



6.4.2 After calculation – legal FDP for basic crew

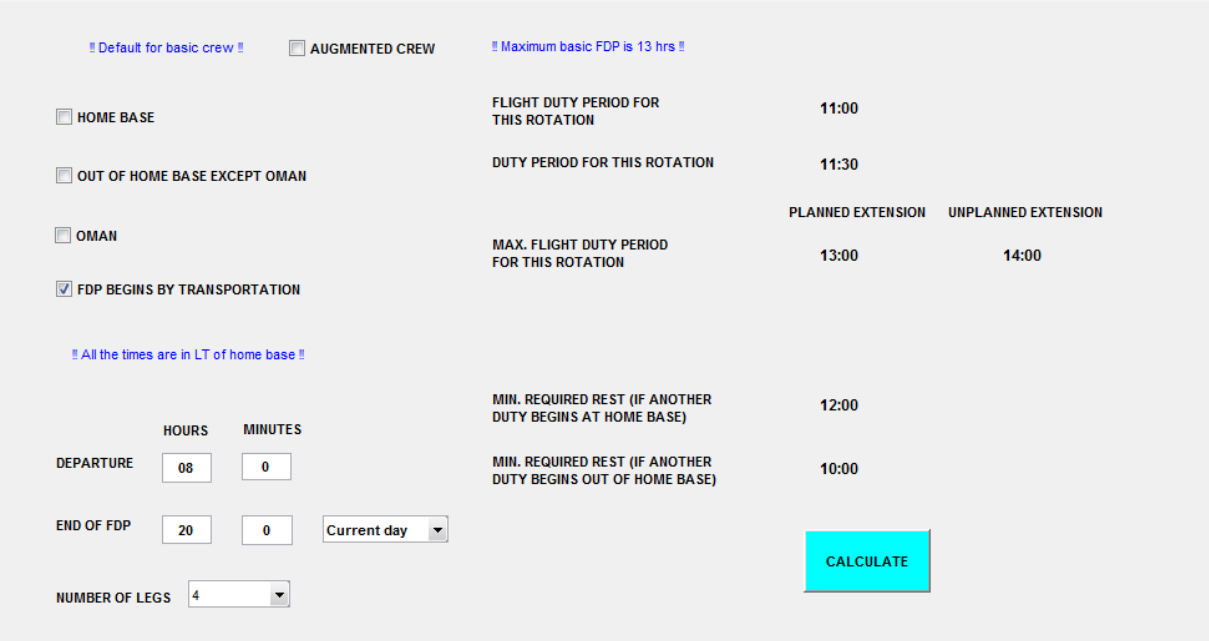
Figure 8 demonstrates the calculation for following initial conditions:

- Duty begins by transportation (means +0 min as briefing) (6.3.2),
- Departure: 08:00 LT,
- End of FDP: 20:00 LT,
- 4 legs (means 60 min reduction) (6.3.2).

The calculated results are:

- FDP for this rotation is 11 hours,
- DP for this rotation is 11 hours 30 min (6.3.2),
- Maximal FDP if planned extension occurs is 13 hours (Calculated from the maximum FDP for basic crew – 13 hours (6.3.2), adding 1 hour as a limit for planned extension (6.3.3) and subtracting 1 hour due to the number of legs (6.3.2).)
- Maximal FDP if unplanned extension occurs is 14 hours (Calculated from the maximum FDP for basic crew – 13 hours (6.3.4), adding 2 hours as a limit for unplanned extension (6.3.4) and subtracting 1 hour due to the number of legs (6.3.2).
- Minimal required rest if another duty begins at home base is 12 hours (6.3.5),
- Minimal required rest if another duty begins out of home base is 10 hours (6.3.5).

Figure 8 – After calculation (legal FDP for basic crew)



6.4.3 After calculation – legal FDP for augmented crew

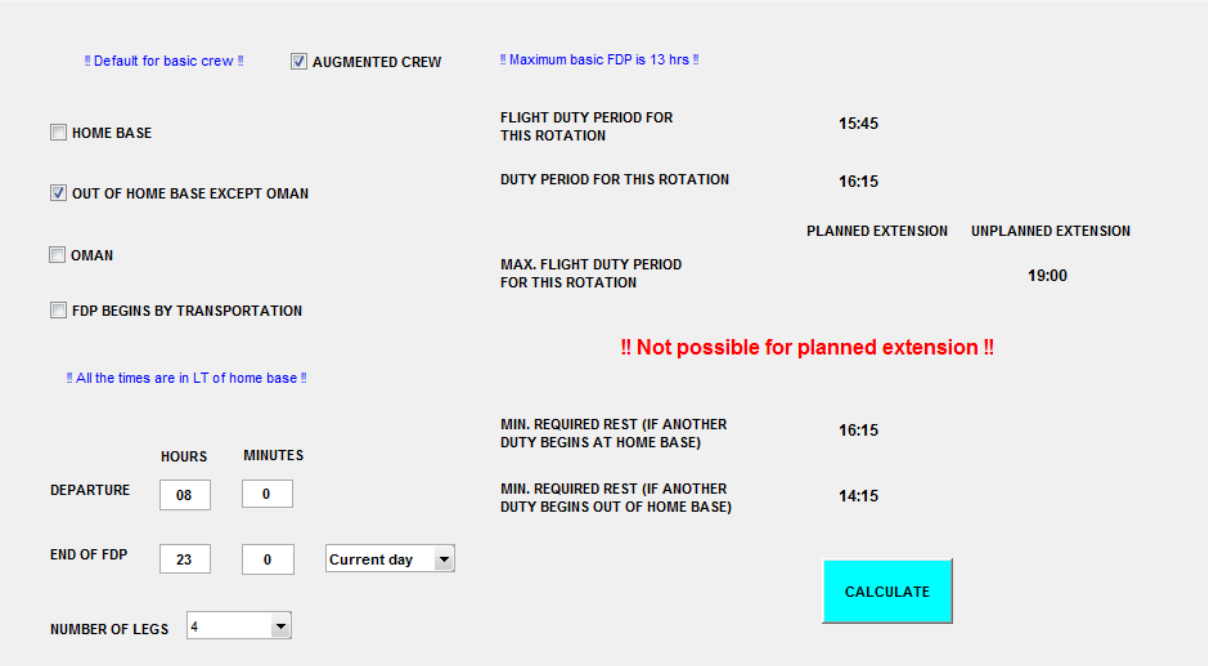
Figure 9 demonstrates the calculation for augmented crew with following initial conditions:

- Duty begins out of the home base except Oman (means + 45 min as briefing),
- Departure: 08:00 LT,
- End of FDP: 23:00 LT,
- 4 legs (means no reduction for augmented crew).

The calculated results are:

- FDP for this rotation is 15 hours 45 min,
- DP for this rotation is 16 hours 15 min (6.3.2),
- Maximal FDP if planned extension occurs is not possible for augmented crew (6.3.3),
- Maximal FDP if unplanned extension occurs is 19 hours (6.3.4)
- Minimal required rest if another duty begins at home base is 16 hours 15 min (6.3.4),
- Minimal required rest if another duty begins out of home base is 14 hours 15 min (6.3.4).

Figure 9 – After calculation (legal FDP for augmented crew)



6.4.4 Demonstration of the programme during the WOCL period

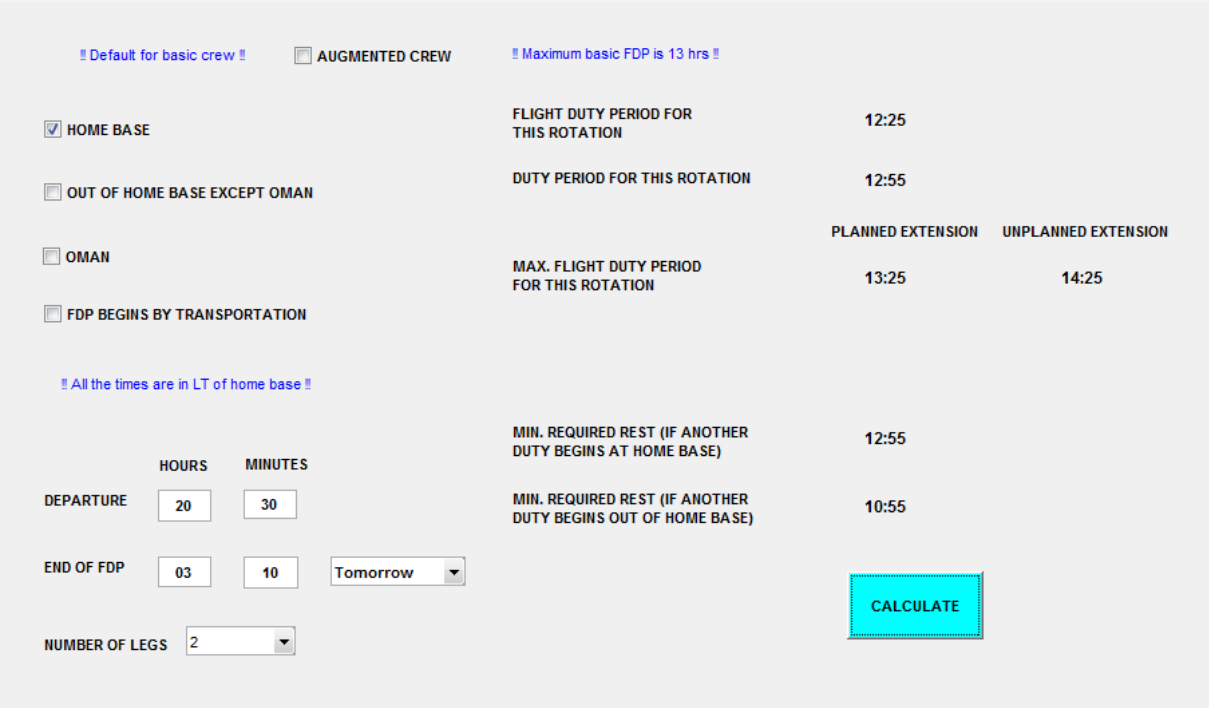
Figure 10 demonstrates the calculation during the WOCL period for following initial conditions:

- Duty begins at home base (means + 75 min as briefing),
- Departure: 20:30 LT,
- End of FDP: 03:10 LT,
- 2 legs (means no reduction) (6.3.2).

The calculated results are:

- FDP for this rotation is 12 hours 25 min. It is calculated as maximal FDP when the end of FDP is included in WOCL interval (based on Appendix 3),
- DP for this rotation is 12 hours 55 min (6.3.2),
- Maximal FDP for planned extension is 13 hours 25 min (based on Appendix 3).
- Maximal FDP for unplanned extension is 14 hours 25 min. Calculated from FDP for this rotation adding 2 hours as a limit for unplanned extension (6.3.4),
- Minimal required rest if another duty begins at home base is 12 hours 55 min (6.3.5),
- Minimal required rest if another duty begins out of home base is 10 hours 55 min (6.3.5).

Figure 10 – After calculation (Demonstration of the programme during the WOCL period)



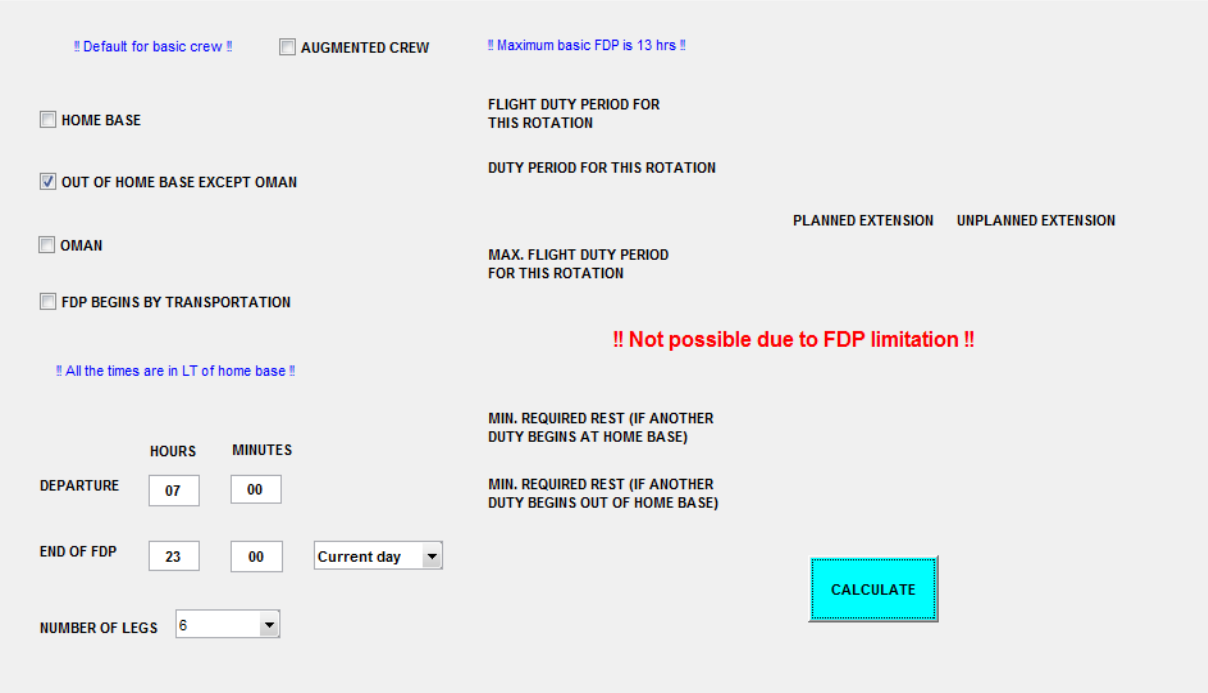
6.4.5 Error message with the reason of illegality

The **Figure11** presents the results if illegal values for calculating FDP are inserted. The input data were following:

- Duty begins out of home base except Oman (means + 45 min as briefing),
- Departure: 07:00 LT,
- End of FDP: 23:00 LT,
- 6 legs (means 120 min reduction) (6.3.2).

In that case the Flight duty period would be 14 hours and 45 min which is illegal due to the FDP limitation. The maximum FDP for basic crew is 13 hours and for this 6-legs flight only 11 hours. As a result the programme did not calculate the results and generated the error message with the reason of illegality.

Figure 11 – After calculation (Error message with the reason of illegality)



Of course there are many programmes which could serve for the flight duty legality validation. However different companies have different flights/duties, rest limitations and pre-flight briefing regulations. Also each airline company operates with different fleet which causes diverse crew composition. So it is not possible to create a programme that would serve universally. The Flight duty period counter serves only for Travel Service usage. It is programmed exactly for the Travel Service regulations (exact times of briefing and debriefing, planned or unplanned extension etc.). Except the calculations, the programme is able to estimate whether the flight duty is legal or not. If not, it is able to generate error message with the reason of illegality. The reasons of illegality are following:

- Not possible due to FDP limitation,
- Not possible for planned extension (in some cases when the FDP begins or ends in WOCL or in case of augmented crew),
- Not possible for number of legs limitation,
- Not possible for augmented crew,
- Incorrect input time.

The programme is set up for the basic crew composition but it can be changed and used also for augmented crew, if needed.

7 Economic analysis of Polish bases´ location

This part of the thesis is focused on the economic analysis of the Polish bases´ location. At first (in chapter 7.1) the current situation in Poland is described, based on the data from the summer season 2014 (obtained from AIMS software). Also the main cost factors are identified there – the compensation fees to passengers of the flights delayed for more than 2 hours and the reasons which caused that. Further the proposals leading to the elimination of the expenditures and their economic evaluation are presented. As a conclusion a proposal solution is presented, based on the calculation that leads to minimizing of extra costs, optimizing the crew transport logistics and bases location.

7.1 Analysis of current situation in Poland

As it was mentioned in previous chapters the company Travel Service has, besides others, its bases also in Poland from where it operates some flights. It depends on the demands of the travel agencies. Most of them are charter flights. One of the aims of this diploma thesis is the economic analysis of the position and quantity of the Polish basis.

In the summer season of 2014 there were two bases in Poland – Warsaw and Poznan. In Warsaw there were five planes type B 738 and in Poznan there was just one plane A 320. The crews were transferred also within other Polish cities, from which other flights were operated (Katowice, Wroclaw, Rzeszow, Lodz, Lublin, Szczecin and Bydgoszcz). Only those crew transfers that were based in Warsaw were included, because in Poznan there was A-320 wet leased from Hermes Airlines. This plane operates its own schedule directly from and to Poznan and the crews were trained for different operation and they also had different qualification type.

During the season there were a lot of delays caused either by weather conditions, technological problems or inconvenience with the crew transfers. Only the road transfer was used for the crew transfers and caused a lot of complications. The main reason for road transfers was savings (it is cheaper than flights) or the departure of the flights was inconvenient. The most common complications caused by these were:

- time needed for transfers was extended thanks to the conditions on the Polish roads,

- lack of information about the delays or the crews not being informed while they were on their way – consequences were that transfer + delays + rotation that followed frequently exceeded the maximum of FDP. And the crews claimed rest before the flight due to the illegal flight duty.

Regulation (EC) No 261/2004 of the European Parliament and of the Council orders the compensation claims in air service for the EU countries. This is based on the decision of the Court of Justice of the European Union. Passengers of both regular and charter flights are entitled to compensation if the delay is not caused by exceptional circumstances that cannot be influenced by the carrier (weather conditions, technological malfunction). Passengers can claim the compensation of 250 euros if the flight is delayed for more than 2 hours into its destination and it is shorter than 1500 km (this is related to all the rotations in the summer season from Warsaw). [25]

The following table shows not only the final number of flights in different Polish cities but also how many flights were delayed because of the crew transfers. It presents that there were 14 delays during the summer season in which the passengers could claim the compensation. (There is no need to take the winter season into account because there are less flights and also long rotations from Warsaw.) In the average occupancy of the flights, which reached 84.1% [26], the compensation claims cost 556 322 euros (the expenses for accommodation of the passengers are neglected because it cannot be looked up if they were claimed or not). The expenses caused by the inappropriate crew logistics are not a negligible sum of money for the company. The optimization of this problem is solved in chapter 7.3.

Table 1 – Total number vs. number of delayed flights in Poland (May – September 2014) [26]

MAY 2014				JUNE 2014			JULY2014		
	Total flights	1:01- 1:59	2:00-999:00	Total flights	1:01- 1:59	2:00-999:00	Total flights	1:01- 1:59	2:00-999:00
WAW	139	0	0	210	0	0	232	0	0
POZ	16	0	0	70	0	0	81	0	0
KTW	5	0	0	31	3	0	12	3	0
GDN	4	0	0	23	4	0	30	3	0
WRO	0	0	0	20	1	0	31	2	0
KRK	3	1	0	22	2	0	21	0	0
RZE	0	0	0	5	0	0	9	1	0
LUZ	0	0	0	4	1	0	10	0	2
LCJ	0	0	0	2	1	0	5	0	1
SZZ	0	0	0	2	1	0	5	1	0
BZG	0	0	0	2	0	0	5	1	0
Totals	167	1	0	391	13	0	441	11	3

AUGUST 2014				SEPTEMBER 2014			TOTAL NUMBERS		
	Total flights	1:01- 1:59	2:00-999:00	Total flights	1:01- 1:59	2:00-999:00	Total flights	1:01- 1:59	2:00-999:00
WAW	234	0	0	221	0	0	1036	0	0
POZ	89	0	0	77	0	0	333	0	0
KTW	39	5	1	36	2	2	123	13	3
GDN	26	5	2	31	3	1	132	15	3
WRO	32	2	1	20	4	0	114	9	1
KRK	24	2	1	23	1	0	103	6	1
RZE	9	0	1	10	1	1	33	2	2
LUZ	8	2	0	8	0	0	30	3	2
LCJ	4	1	0	5	0	1	16	2	2
SZZ	4	0	0	5	0	0	16	2	0
BZG	4	0	0	4	0	0	15	1	0
Totals	473	17	6	440	11	5	1968	53	14

7.2 Proposals leading to the cost elimination

As it was mentioned above, the expenses for the compensation claim for the passengers of delayed flights caused by the inappropriate crew logistics were 556 322 euros.

This financial loss could be eliminated in many ways:

- **development of other bases in Poland** – the expenses for opening a new base are almost negligible in total range. They consist of the expense for the technological background (parking for planes and service). The crews based in the city are not entitled to travel and accommodation provided by the carrier. The problem would come in the situation when someone gets sick and it would not be possible to cover the rotation. In this case there would be other expenses for the transfer of steward/pilot replacement.

There are only these possibilities for the new bases in Poland from which Travel Service operates:

- KTW (Katowice), GDN (Gdansk), WRO (Wroclaw), KRK (Krakow).

- Other cities: RZE (Rzeszow), LUZ (Lublin), LCJ (Lodz), SZZ (Szczecin) and BZG (Bydgoszcz) have for about 90% less flights than current bases so the crew based in here would not be worth it.

For better orientation there is a table with the total crew transfer duration from Warsaw to KTW, GDN, WRC and KRK:

Table 2 – Crew transfer duration [26]

	Crew transfer duration
Gdansk	6:00
Krakow	3:30
Katowice	2:30
Wroclaw	2:40

- **Adjustment of crew transfer logistics** – other solution is to adjust the transfers before the flight so that the crews are transported to the destination in advance of 10 hours and they have time for rest (outside the base) before they start the shift.

In this case there would be other expenses for travel allowance and accommodation the crew is entitled to.

There could be some problems in both of the solutions mentioned above. It could lead to higher number of crews needed or higher use of the backup crews. Information about the expenses for the crew salary cannot be published; I would consider them the same amount in both cases so that they could be omitted.

7.3 Economic evaluation of the proposals

Following subchapters presents the economic evaluation of the proposed possibilities:

- Development of new bases in Poland (7.3.1),
- Adjustment of crew transfers (7.3.2).

And as well the suggested solutions that meet the criteria (7.4).

7.3.1 Development of new bases in Poland

From the data received for the summer season of 2014 was evaluated the possibility that the crew member gets sick and a replacement for them has to be sent to the new base (in compliance with the length of transfer and the flying standards). The probability of reporting SICK is the total amount of SICK reported in the period May – September, when the total number for the Polish crews was in average 6.7 reports a day. Taking into consideration the total number of days in the period given then the SICK possibility for one steward/pilot is 2.7 %. [26]

The following tables summarize the total expenses spent on the technological support for developing the bases and the total expenses for the transfer, accommodation and allowance for replacement for the crew member, in case of sickness of the based member.
The technical equipment includes the expenses for:

- **Renting the room for briefings** (facilities for the crew, PC with internet and printer) – 1790 € per season. [27]
- **Parking of the plane and technical service** – 43700 € per season. (Both numbers are only indicative, obtained during the consultation, so I consider them the same for all of the possible bases.) [27]

Table 3 – Expenses spent on developing the basis GDN, KRK, KTW a WRO [26] [27]

	Accommodation per member [€]	**Per diems per member [7][€]**	**Transfer per member [€]**	**Prob. of SICK/ Number of flights**	**Total costs for reported SICK [€]**	**Technical equipment [€]**	**Total costs[€]**
GDN	69	7,2	94	0,0254	431,97	45 490	**45 922**
KRK	50	7,2	145	0,0392	791,61	45 490	**46 282**
KTW	34	7,2	140	0,0378	684,94	45 490	**46 175**
WRO	35	7,2	95	0,0257	351,92	45 490	**45 842**

[7] **Per diems** –unfortunately the exact amount for travel allowance in particular cities couldn´t be found. The range is around 30 pln per day – converted 7.2 € per day. The amount is so low because there has to be considered that these per diems are for Polish crew in Polish cities. [27]

Next table (**Table 4**) shows the overview of money that could be saved while developing the suggested bases. This number was obtained by subtracting the total expenses for proposed bases stated in **Table 3** from the expenses for compensation.

Table 4 – Total savings in proposed bases [26] [27]

	Number of delayed flights	**Compensations [€]**	**Total costs [€]**	**Savings [€]**
GDN	3	119 212	45 922	73 290
KRK	1	39 737	46 282	-6 545
KTW	3	119 212	46 175	73 037
WRO	1	39 737	45 842	-6 105

From the facts above it is evident that only establishing the base in Gdansk or Katowice would be advantageous because the savings extended to **73 290 €** and **73 037 €.** On the contrary establishing the bases in Krakow or Wroclaw would be loss making. Price is calculated for the period May – September 2014, so it can vary a bit for the following season.

7.3.2 Adjustment of crew transfers

The other option to minimalize the expenses caused by inappropriate crew logistics is to transfer the crew to its destination in such advance so they could fulfil the basic rest there and then they would operate the given rotation. This option expects keeping the current bases. This involves increased expenses for accommodation (if the crew is not based there they can make a request for hotel) and also allowance. Expenses for transfer can be neglected because they would be expended anyway. In the following table there is the overview of expenses calculated on operational data. Destinations SZZ and BZG are not included because there were not any delays that would have consequences as paying the compensation.

Table 5 – Additional crew expenses, total costs and savings [26] [27]

Additional crew expenses (EUR)								
	Accommodation/ member [€]	**Accomodation/ crew [€]**	**Per diems/ member [€]**	**Per diems/ crew [€]**	**Total number of the flights**	**Total costs [€]**	**Compensations [€]**	**Savings [€]**
GDN	69	414	7,2	43,2	132	70 409	119 212	48 803
KRK	50	300	7,2	43,2	103	41 241	119 212	77 971
KTW	34	204	7,2	43,2	123	35 473	39 737	4 264
WRO	35	210	7,2	43,2	114	33 675	39 737	6 062
RZE	42	252	7,2	43,2	33	11 365	79 475	68 110
LUZ	45	270	7,2	43,2	30	10 962	79 475	68 513
LCJ	39	234	7,2	43,2	16	5 174	79 475	74 301
					Total	**208 299**	**556 323**	**348 024**

The total expenses are calculated as the sum of accommodation cost and allowance in consideration of the total number of flights operated in the given city. Compensations are related to the real data of flights delayed for more than 2 hours in the destination and the average occupancy of the planes. We get the total savings subtracting these two items. With this being stated it is obvious that if the logistics of crew transfers changed, the company would spent 208 300 € more per season which is not a negligible sum of money. On the other side it would prevent from delays and subsequent compensation pay off. Fourteen delayed planes during the last season in Poland cost 556 323 €, so the savings would be **348 024 €.**

7.4 Proposed solution

Of course any of the options above cannot be 100% applied. Delays caused by those reasons cannot be well predicted and their solution needs a very complex evaluation of the whole situation. First of all the communication among OCC, Crew Scheduling and Crew Support Department should be improved. Also the information about the situation and delays should be given on time so that this information could be further distributed in advance. Crew Dispatch informs the pilots and stewards about delays and Crew Support informs the drivers

who are in charge of the transfer. Eliminating these problems is the easiest way to reduce the loss. Naturally during the season when Travel Service operates more than 200 flights a day and ground staff works in shifts that are not convenient for everybody you cannot avoid mistakes caused by human factor.

From the results in previous chapters it is obvious that if the new bases in Gdansk and Katowice opened, the savings would reach to 73 290 € and 73 037 € per season. Also changes in crew transfer logistics would contribute to significant reduction of expenses with the amount of 348 024 € (calculated for all Polish cities in which the compensations were paid). The ideal solution would be the combination of both options mentioned and developing one other base. I am inclined to think that Katowice would be the better one because it would improve transport services to Krakow and Rzeszow, the crews could be transported from here instead from Warsaw. Katowice is also well connected to Ostrava where Travel Service has other base during the summer season. As for the other cities: Gdansk, Lodz, Wroclaw and Lublin, I would suggest the crew transfer adjustment so that it is not closely before the flight but in sufficient advance and with legal rest.

8 Optimizing of crew rostering process

Crew planning department was basically introduced in chapter 5.5. This part is aimed to deepen the understanding of the rostering procedure and brings further knowledge. Primarily the number of crew members which is needed for operations is presented there. Further the crew composition and qualifications are described. Also the chronology of rostering is shown (receiving requests from crew, evaluation and timeline of assigning the RVAC, ROFF, layovers and other duties). Moreover the so called Bidding system is introduced, which has been implemented at the beginning of the winter season 2014/2015 into the flight deck rostering process with Boeing qualification and has been evaluating its success rate. In the end of the chapter there is the analysis of weak parts of crew rostering process and further recommendations for optimizing of the Bidding system and its possibly usage in cabin crew rostering process are presented.

8.1 Number of the crew per aircraft

Before the rostering starts, it has to be established the number of the crew per aircraft. Basically for one aircraft we need:

- **Flight deck:**
  - **B738**: 5.25 captains + 5.25 first officers to cover all the rotations. With the reserves, the number will be following: **7 CP + 7 FO**. [28]
  - **A320**: 7 captains + 7 first officers. With the reserves, the total number is following: **8 CP + 8 FO.** [28]
- **Flight attendants:**
  - **B738**: the general composition for the Boeing 737-800 is: 1 SC + 3 CC, that means: 5.25 SC + 15.75 CC. With reserves it gives: **7 SC + 21 CC**. [29]
  - **A320**: the general composition of the crew is: 1SC + 3 CC, so it means: **8 CC + 23 CC** with reserves. [29]

We can assume the total number of the flight deck and cabin crew attendant for the winter season 2014/2015. Travel Service has 31 aircraft (2x A320, 21x B 738 and 8x B 738 on dry lease – no need of crew), so the total number of the crew can be calculated:

- **A 320: 16 CP+ 16 FO, 16 SC + 46 CC (with reserves)**.
- **B 738: 147 CP + 147 FO, 147 SC + 441 CC (with reserves).** [29]

8.2 Crew qualifications

The aeroplane crew includes staff, who take part in the flight on board of the aeroplane and perform activities to ensure the safe performance of the flight. [30]

The crew consists of:

- **Flight crew members**
  - **Regular composition:** captain and first officer,
  - **Augmented crew:** commander, captain and first officer.
- **Cabin crew members**
  - **Regular composition**: depends on the type of the aircraft and seat capacity. Basically the cabin crew of **B737-700** is composed of:
    - **1 Senior cabin crew (SC)** – a chief of the cabin who is responsible for coordinating regular and emergency procedures in the cabin. SC is also responsible for providing proper services to passengers.
    - **2 Cabin crew (CC)** – at least one of the CC has to be assigned as 2L position. It means that the CC has to have more than 3 months of experience. 2L position will substitute SC in the duties in case of incapacitation, in normal or in emergency situations.

    Further, the cabin crew of **B737-800** is composed of:
    - **1 Senior cabin crew (SC)**,
    - **3 Cabin crew (CC)** – at least one with 2L position. [30]
  - **Augmented composition**:
    - The cabin crew of **B737-700** is composed of:
      - **2 Senior cabin crew** – includes 1 SC and 1 Purser (PR)[8],
      - **2 Cabin crew** – at least 1 with 2L position.
    - The cabin crew of **B737-800** is composed of:
      - **2 Senior cabin crew** – 1 SC + 1 PR,
      - **4 Cabin crew** – at least 1 with 2L position. [30]

[8] **Purser (PR) -** senior cabin crew who is more experienced and has higher seniority. [30]

8.2.1 Flight deck crew members

The flight deck qualifications are more complicated and structured. At first, each captain or first officer has an A or B qualification:

- **Group A** – experienced flight crew members,
- **Group B** – unexperienced flight members.

The responsibility of Crew Planning Department is not to allow two inexperienced flight crew members (means Group B assigned pilots) to be assigned on one flight. [31]

Along with Group A and B qualifications we categorize the following types of aerodromes. Category A aerodrome is a regular airport without any specific restrictions. A combination of an A and B captain and first officer can be assigned for these.

B and C categories are special airports which have some restrictions (such as shorter length of the runway, high terrain, high traffic, non-standard approaching systems etc.). **Karlovy Vary** with the runway width 30 meters would be an example of category B aerodrome. From category C could be mentioned **Skiathos** because of the short runway (only 1620 meters) or **Innsbruck** where there is high terrain and special approaching and landing procedures have to be applied. When the crew rosters are made, both of the pilots have to be from category A. [31]

The captain or the first officer is authorized to conduct line flying on the routes and to the aerodromes which meet the requirements. Also the planned alternate aerodromes have to meet the competences of the flight crew. The route competences in Travel Service are divided into:

- **Less complex route competence –** is divided into following regions:
    - Europe,
    - Near East,
    - Middle East,
    - North Africa,
    - Cape Verde and West Africa,
    - Central and South Africa,
    - North Atlantic Europe – Iceland,
    - Russia and China. [32]

- **More complex route competence** is divided into following regions:
    - Far East,
    - North Atlantic: Canary – Iceland,
    - North Atlantic,
    - South Atlantic,
    - ETOPS. [32]

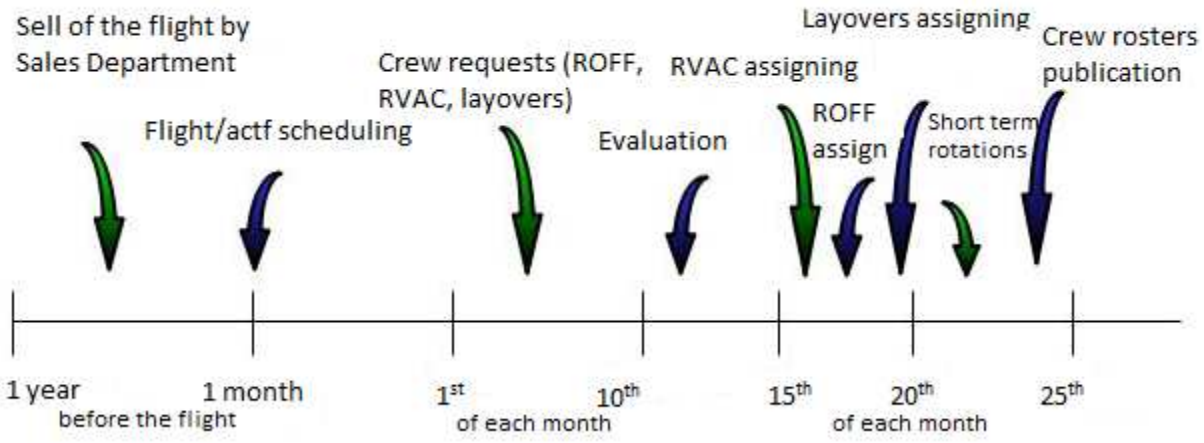
To obtain less complex route competence the pilot shall familiarize himself with the route by studying the route documentation according to Route Briefing Checklist. To obtain more complex route competence it is necessary to study the route documentation, further to pass out briefing with examiner/instructor or authorized pilot. In addition to that in Travel Service pilots who want to obtain the less or more complex route competence has to land on any airport in the required region. [32]

8.3 The crew rostering timeline

If the total number of the crew is known, the Crew Planning department can start to schedule the rosters. Till 10th day of the month each crew member sends their own requests for ROFF, medical checks etc. to the long term planning office. Also they have a possibility to let the long term crew planning know about their layover requirements. And the crew with part-time agreements is obligated to let know about their availability for the next month. After the requests are evaluated and assigned into the rosters. At first the RVAC requests are assigned if it is possible, after the ROFF and layovers.

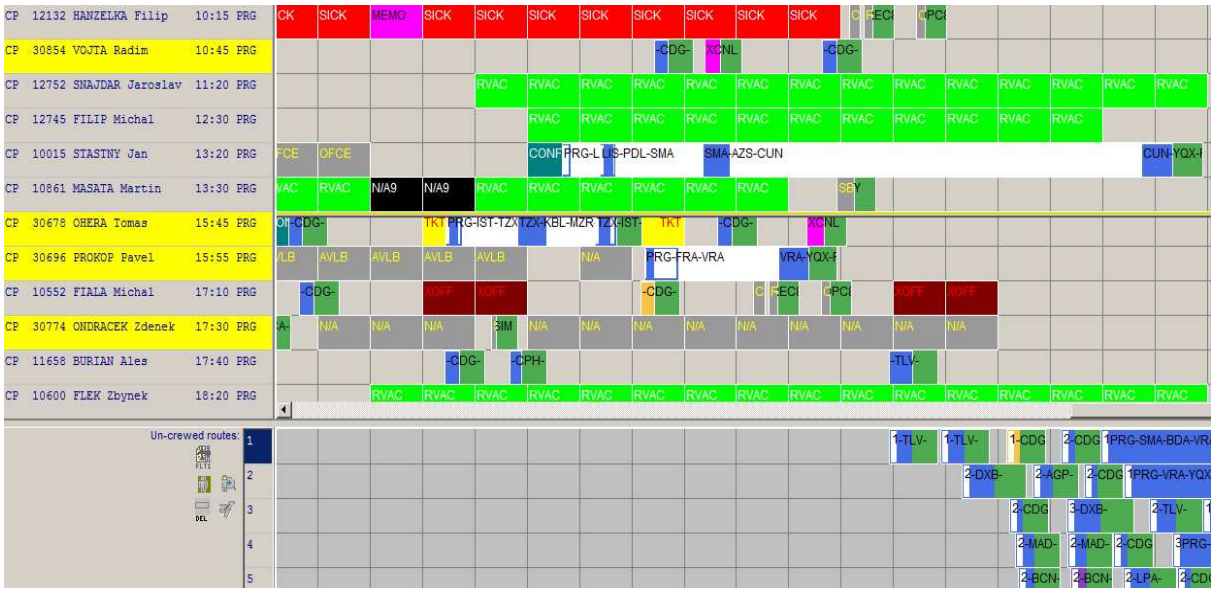
In one calendar month it is possible to have maximum of 4 ROFFs (except for the mothers with children up to the age of 2 years – they can obtain maximum 10 ROFFs). The short term rotations and SBY duties are assigned into the rosters as the last. Also the stand-by duties are limited by 4 SBY in one calendar month. [21] The process of the crew rostering timeline is presented on the **Figure 12**.

Figure 12 – Crew rostering timeline



The duty tours are made with regards to the minimum costs of the duty (means cost for hotels, per diems and other transportation), but it also has to meet the duty legality requirements. At first the long-term planning schedule the longer layovers with regards to all mentioned factors (qualifications, type-rate qualifications, ROFF and vacancy requests etc.) and after that the shorter layovers and flights from base to base (Prague-Paris-Prague, Warsaw-Tenerife-Warsaw, etc.) are scheduled. Further the **Figure 13** represents the process of the roster scheduling.

Figure 13 – The process of crew rosters making [22]



On the left side the names of the captains with Boeing qualification are listed. The yellow colour indicates the part-time contract, the grey one full-time contract. In the middle part we can see their rosters in progress. The red boxes with sign SICK mean that the pilot is currently on the sick leave. The green boxes indicate the vacancy or ROFF. The grey ones assigned by AVLB means that the pilot can fly on the particular day, but nothing has been planned yet. And the rest are flights or longer rotations/layovers that have been scheduled. Bellow this part we can see the flights/layovers that aren´t scheduled yet and they are supposed to.

When the rosters are made, the changes are made only in case of operation´s difficulties (change of the type of the aircraft due to technical reasons etc.), illness or other serious reasons. The important fact is that crew members have to be informed about the changes by e-crew[9] and only in case of change in time to 48 hours before departure, the crews are notified by phone. [21]

8.4 Bidding system as a tool for crew rostering process

At the beginning of the winter season 2014/2015, in November, the Bidding system was implemented into the crew scheduling procedure. This implementation was made only for the flight deck (captains and co-pilots) with **Boeing qualification** in **Prague base**. The Bidding for the pilots with Airbus qualification and flight attendants is not available yet.

The Bidding system was launched in order to reduce the current amount of communication between the crew and the crew planners. It should also serve as a tool to take part in creating the schedule and to understand human interference better. The initial run of the Biding system was established for the whole season, being evaluate every month and analysed after the end of the winter season. The more pilots do their bidding, the better it is. Because of the fact that crew planners know their preferences, the process of crew scheduling is simplified. Some shorter layovers that are not that important regarding the qualifications as France and Canary Islands are not included in the Bidding system. [29]

The bidding timeline is following: from 25th to 5th crews do their bidding for layovers. From 5th to 15th crew schedulers work and schedule the rosters to be published between 15th and 20th. The number of layover that pilots can bid for is not limited. And after the roster publication is done, pilots can fill the reclaim protocol and further changes based on it may

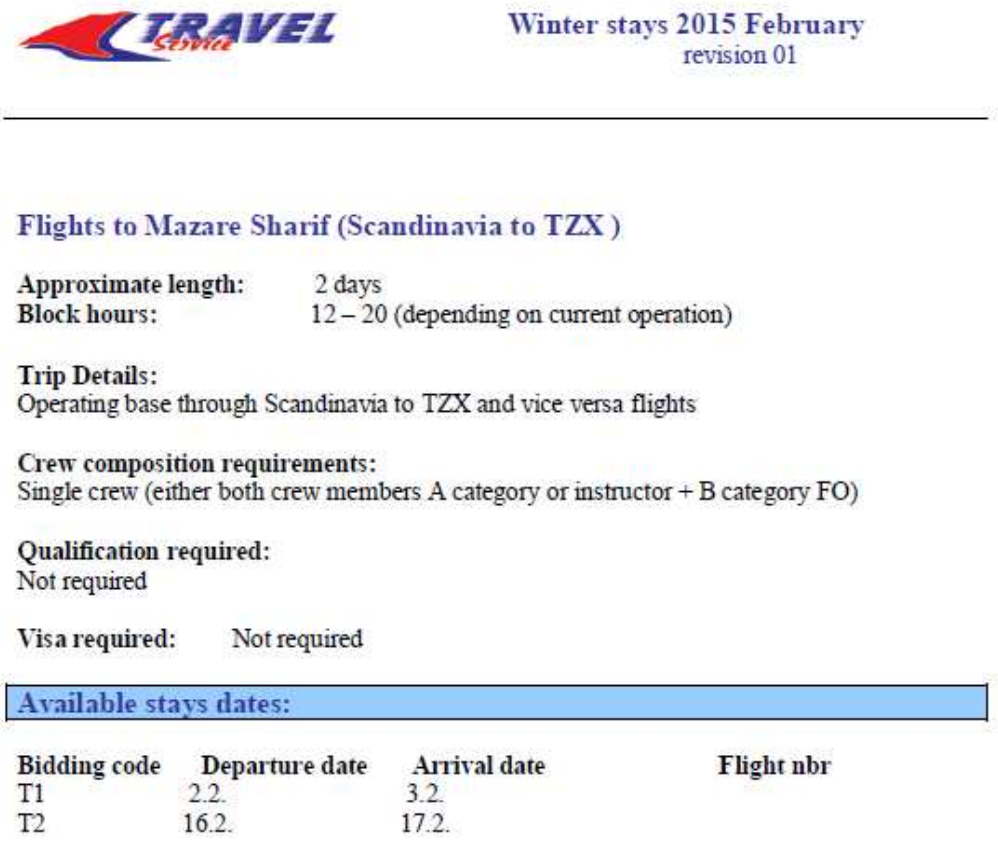
[9] **E-crew –** online application for the Travel Service´s crews where each member can see his/her roster and the changes that have been done.

appear.[29]

The related information about the winter stays for the 2014/2015 season is presented in Extranet Flight Application (EFA) where can all Travel Service staff log in. And each pilot can find the list of the layovers in EFA application in the section **"Winter stays 2014/2015".** On the **Figure 14** there is presented related information about the winter stay in **Mazare Sharif** for February as an example. We can see what is presented there:

- Length of the layover,
- Block hours,
- Trip details (included the destinations of the operation),
- Crew composition requirements,
- Qualification,
- Available stays days,
- Visa requirements. [33]

Figure 14 – Winter stay in Mazare Sharif [33]



TRAVEL Service

Winter stays 2015 February
revision 01

Flights to Mazare Sharif (Scandinavia to TZX)

Approximate length: 2 days
Block hours: 12 – 20 (depending on current operation)

Trip Details:
Operating base through Scandinavia to TZX and vice versa flights

Crew composition requirements:
Single crew (either both crew members A category or instructor + B category FO)

Qualification required:
Not required

Visa required: Not required

Available stays dates:

Bidding code	Departure date	Arrival date	Flight nbr
T1	2.2.	3.2.	
T2	16.2.	17.2.	

Each pilot can bid for his preferred stay (the amount of requests is not limited) via e-crew. There is interactive form at online platform, where codes are presented. Pilots can choose them and after that the request is send to pivot table and further it is processed by crew planners.

8.4.1 Criteria for evaluation

When the Crew Planning Department wants to evaluate the bidding results, at first they have to realize the purpose of this process: to cover all the rotations. The system is following: the most complicated rotations are assigned at first and then the rest. The short flights from base to base are done at the last. In the winter season 2014/2015, the layovers assigned at first are following:

- **Maldives:** pilots have to meet ETOPS and Far East qualification as well as ditching[10] qualification.
- **Canada wet lease program (Caribbean stay):** pilots have to meet following requirements: NAT/ETOPS, especially LTI [11] qualified crews are preferred. [29]

Basically there have to considered several criteria while the bidding is evaluated:

- Whether the pilot did his bidding or not (it is not obligated),
- Parallel processes (according to expiry dates, ground training etc.),
- Operation sustainability (if Travel Service has sufficient number of Far East + ETOPS trained pilots),
- Trainings,
- Selective seniority (means seniority among the crews who are qualified to operate destination),
- Selective seniority II (takes in account Base Chief pilot etc.),
- Straight seniority (means the length of the working contract in Travel Service among the pilots). [29]

[10] **Ditching** - refers to an aviation accident as a planned event in which a flight crew makes a controlled emergency landing in water. Ditching qualification is mandatory for every crew member participating on ETOPS flights or flights planned with longer than 50 NM distance from the continent. [31]

[11] **LTI** – Line Training Instructor. LTI has privileges to conduct flight deck members during line flying under supervision. [31]

8.4.2 Evaluation of bidding system

This sub-chapter is focused on evaluation of the bidding system for the period November – February in winter season 2014/2015.

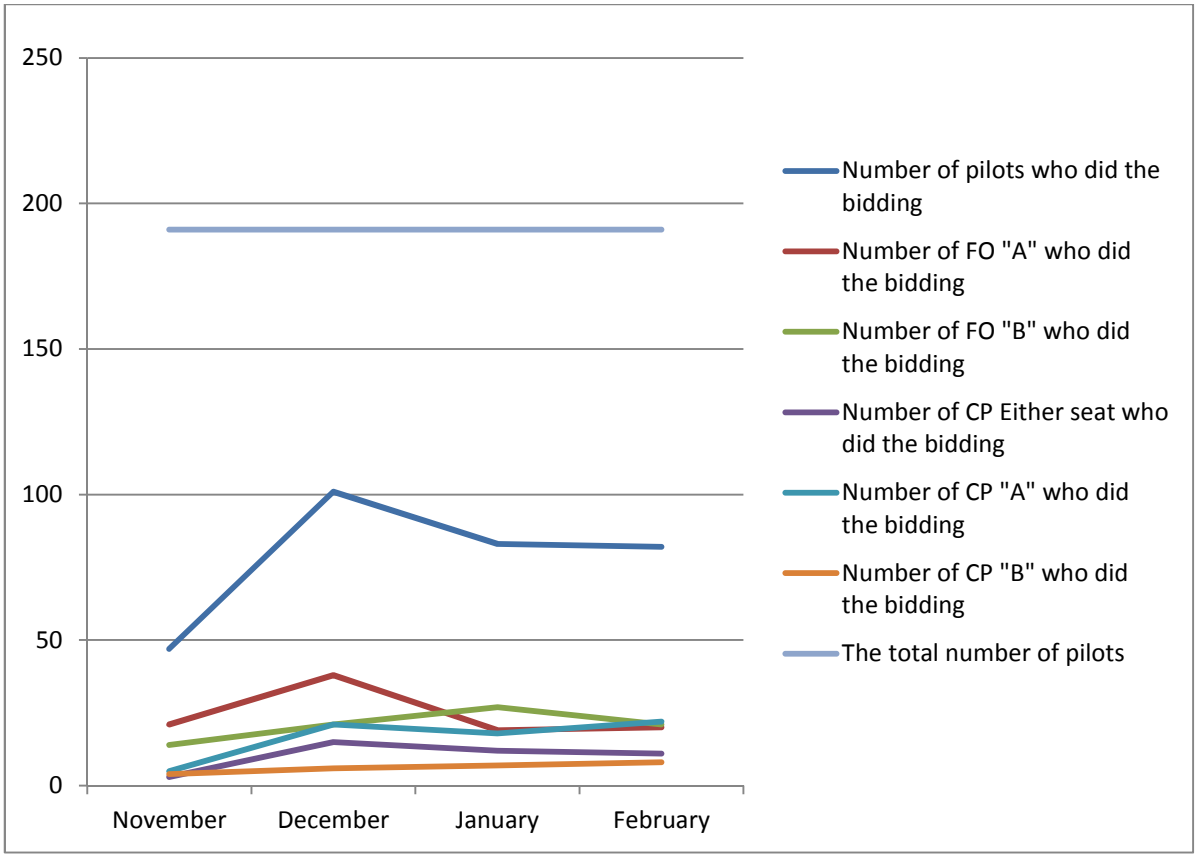
From the **Table 6** and **Figure 15** can be assumed that in November only 24.6% of the pilots did the bidding. The reason was probably due to the fact that the system was just implemented. In December number of pilots who did their bidding increased on 52.9%, obviously due to the arrangement of duties during the Christmas holidays. In January and February the number of pilots who did the bidding was settled down 43.5% and 42.9% respectively. The reason was increasing awareness about the bidding system as an efficient tool for layover scheduling. Also because of the number of pilots that bid prevail. However, even if the percentage of flight deck who used the bidding system has grown up, the total amount is still less than 50% which is not sufficient.

Table 6 – Statistics of pilots who did/did not the bidding during the winter season 2014/2015 [33]

	CP Either seat	**CP A**	**CP B**	**FO A**	**FO B**	**Total number of pilots who did the bidding**	**Total number of pilots**
NOV	3	5	4	21	14	47	191
DEC	15	21	6	38	21	101	191
JAN	12	18	7	19	27	83	191
FEB	11	22	8	20	21	82	191

Figure 15 shows the graphical form of the results presented in **Table 6.** It can be claimed that the most frequent group that participates on bidding system are first officers - category A (in November and December) and first officers category B (in January and February). Further the CP with either seat qualification is the less frequent group that participated in bidding system.

Figure 15 – Statistics of pilots who did/did not the bidding during the winter season 2014/2015 [33]



Apart from the statistics above the **Tables 7** and **8** establish the number of first officers´ and captains´ requests that was successful in the 1st 2nd or 3rd bidding line, **Table 9** shows the number of requests that weren't successful.

Table 7 – Number of FO´s requests succeeded in the 1st 2nd or 3rd bidding line [33]

	Total number of requests		***Number of requests succeed in***					
			1st BID line		**2nd BID line**		**3rd BID line**	
	FO A	**FO B**	**FO A**	**FO B**	**FO A**	**FO B**	**FO A**	**FO B**
NOV	30	18	15	10	10	5	4	2
DEC	102	80	38	23	26	20	15	19
JAN	63	103	20	28	16	25	12	19
FEB	71	104	20	25	20	24	12	20

Table 8 – Number of CP´s requests succeeded in the 1st 2nd or 3rd bidding line [33]

				Number of requests succeed in								
	Total number of requests			1st BID line			2nd BID line			3rd BID line		
	CP Either seat	CP A	CP B	CP Either seat	CP A	CP B	CP Either seat	CP A	CP B	CP Either seat	CP A	CP B
NOV	**5**	**6**	**8**	**4**	**3**	**5**	**1**	**2**	**2**	**0**	**1**	**1**
DEC	**32**	**51**	**17**	**15**	**21**	**6**	**7**	**14**	**5**	**5**	**9**	**3**
JAN	**22**	**56**	**16**	**12**	**20**	**6**	**6**	**14**	**5**	**3**	**10**	**2**
FEB	**21**	**63**	**24**	**12**	**25**	**9**	**8**	**12**	**7**	**1**	**9**	**4**

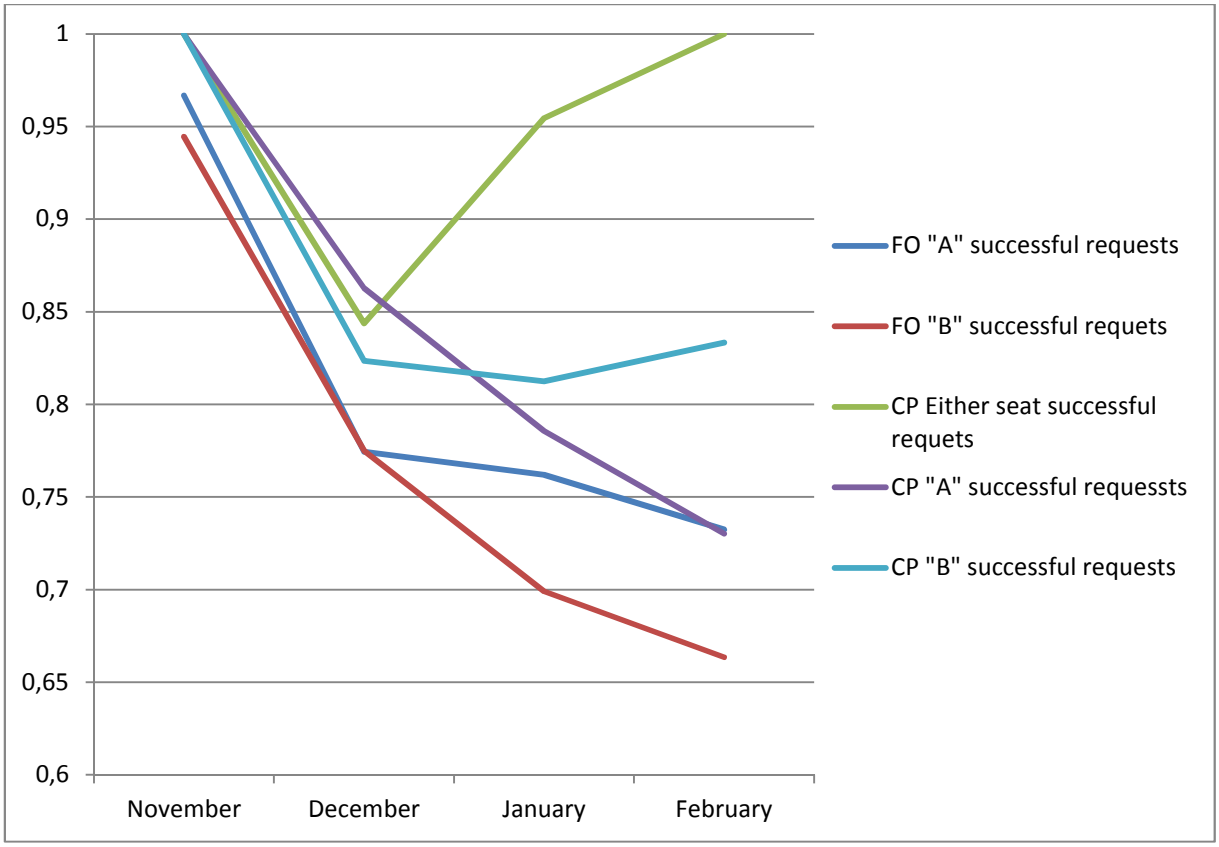
Table 9 – Number of FD´s requests succeeded in the 1st 2nd or 3rd bidding line [33]

Number of requests that did not succeed in the first three BID lines				
FO A	**FO B**	**CP Either seat**	**CP A**	**CP B**
1	1	0	0	0
23	18	5	7	3
15	31	1	12	3
19	35	0	17	4

From the results we can assume following:

- In November 95.6% requests of FO and 100% requests of CP succeeded.
- In December, when the bidding was used the most, there was a reduction. The percentage of FO´s successful requests was 77.4% and CP´s was 84.3%. It was caused due to the higher interest about bidding and as well as due to many of the requests overlapped.
- In January and February 73% and 69.8% of FO request succeeded and 85.1% and 85.4% of CP requests respectively. The reduction of success was because of the higher amount of request in comparison with November and due to more demanding qualification requests. The following figure presents the percentage of successful requests in all categories.

Figure 16 – Statistics of successful request in each flight deck category [33]

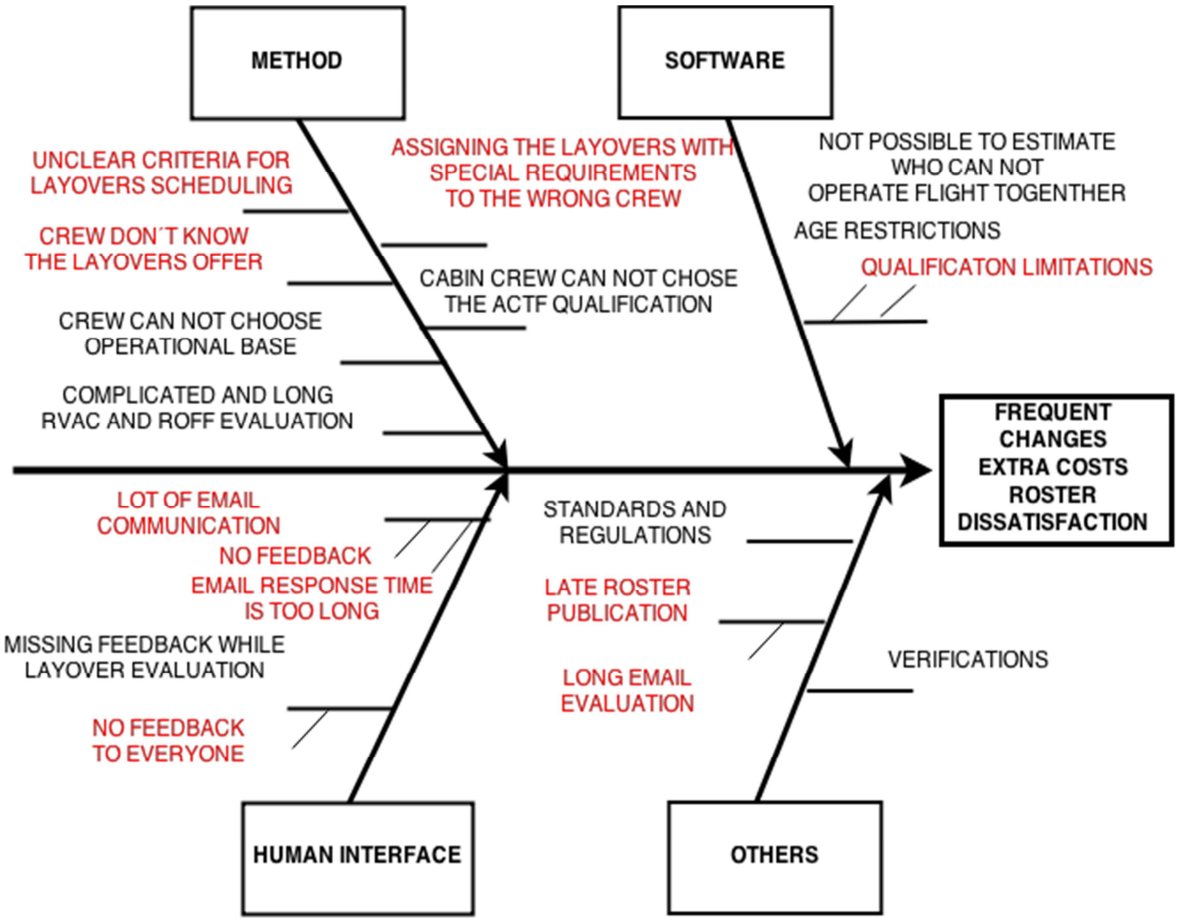


From the results it is obvious that the most successful requests were from CP with Either seat qualification. In November and February it was 100%, in December and January 84% and 95% respectively. It is due to the fact that these pilots could be scheduled with both FO categories – A and B. Also the either seat qualification allows to operate wide scale of rotations. On the other hand the least successful group were FO in category B. The percentages were following: 77.5% in December, 69.9% in January and 66.3% in February. These results are understandable, because FO “B” are usually ones that have not much experience and qualifications (so they can be scheduled only with CP A on the flights). Also they are often new in Travel Service that is reflected on their lower seniority.

8.5 Assessment of crew rostering process

It can be assumed that Bidding system has been helping in the crew rostering process. It eliminated the email communication with flight deck crew, so that it saved the time on both sides (pilots and crew planners). Also it presented the layover´s offer that hadn't been known before and defined the exact criteria for layover evaluation. However, there are still several criteria and processes, which could be further optimized. **Figure 17** represents the Ishikawa diagram of causes and problems of crew rostering process. It is created generally for both – flight deck and flight attendants. Causes marked red have been solved using the Bidding system, thus they are expected to be optimized only in case of cabin crew rostering. The diagram was created based on consultation with Crew Planning Department Supervisor.

Figure 17 – Ishikawa diagram of causes and problems in crew rostering



8.5.1 Identification of weaknesses in flight deck rostering process

As it was mentioned in the introduction of this sub-chapter, Bidding system is a helpful tool that eliminated many of the causes that lead to the problems defined in Ishikawa diagram:

- **Frequent changes** – were caused mainly due to assigning the layovers with special qualification requirements to the wrong crew, unclear criteria for layovers scheduling and because of the late rosters publication. As is shown on the crew rostering timeline, previously the evaluation of email communication lasted several days and the rosters for the next month were published around 25th.
- **Extra costs** – were caused mainly due to assigning of the layovers with special qualification requirements to the wrong crew which didn't possess required visa or qualifications. As well the extra costs were caused due to late rosters publication because pilots didn't know their schedule in advance.
- **Roster dissatisfaction** – understandably it was a problem only for the flight deck´s side because they didn't know where they could be send to, for how long and where to. However, it further reflected in the willingness of accepting ad hoc changes or flights.

However, those problems were mitigated because of the Bidding system. Nevertheless, there are still several problems that should be optimized:

- Missing feedback during the layover evaluation,
- RVAC and ROFF assigning,
- Possibility to request the layover with specific person.

8.5.2 Identification of weaknesses in cabin crew rostering process

Following causes and thus weaknesses in the cabin crew rostering process could be identified from the Ishikawa diagram:

- **Methodical:**
    - **Crew don't know the layovers offer,**
    - **Unclear criteria for layover scheduling** – there are no specific criteria for scheduling the rosters (seniority, mothers with small children, examinators)

- **Assigning the layovers with special requirements to the wrong crew** – when the layovers with special requirements (language, visa, male crew on deportee flights) are not abided.
- **Cabin crew can´t choose the aircraft type qualification and operation base** – to obtain the aircraft type rate is not for cabin crew as complicated as for pilots. For the flight attendants it is sufficient to pass out the training (it usually lasts one week) and pass the final exam. In Travel Service it is possible to obtain Boeing or Airbus type rate. As it was mentioned in the chapter 5.4.1, during the summer season Airbuses mainly operate the rotations from Brno or Ostrava. It would be more suitable for cabin crew who live nearby. Also each summer season there are wet leased aircraft from different companies (Smartlynx, Spicejet etc.) that need the crew with required training. Usually the choice of the flight attendants is made randomly without the crew´s participation that leads to dissatisfaction.
- **Complicated and long RVAC and ROFF evaluation** – this problem is connected to the long-wined email communication which occurs during the RVAC and ROFF assigning. Before the ROFF and RVAC are assigned it takes several days of email communication and evaluation.

- **Human interface:**
  - Missing feedback, long email response time or no feedback for everyone – caused by the amount of email communication, so that the crew planners are not able to give feedback to everyone or reply to the emails in time.
- **Others:**
  - Late roster publication,
  - Long email evaluation.

Both problems are a combination of human interface and methodical causes.

The rest of the causes that weren't mentioned as age restrictions, qualification limitations are only the matter of flight deck. Also the standards, regulations and verifications were solved in the chapter 6.

8.6 Proposed solutions

Taking in account importance of all the causes and sequentially the problems they lead to, there are some proposals of solution. They are split up into two parts: improvements in flight deck rostering process which is in progress and improvements in cabin crew rostering process and possible implementation of Bidding system.

8.6.1 Further improvements in flight deck rostering process

It can be assumed that implementation of Bidding system was successful. However, the total assessment of it would be objectively necessary after the whole winter season and summer season as well. Anyway there may be further optimizations:

8.6.1.1 Missing feedback during the layover evaluation

Although the requesting via Bidding system eliminates the email communication and saves time, the feedback is still missing. After every month when pilots bid for their stays, it would be appreciated to get reasons why the stay they bid for wasn't allocated to them. If the criteria are given (parallel processes, operation sustainability, trainings, selective and straight seniority) the feedback should be easy.

8.6.1.2 Possibility to request the layover with specific person

Flight deck should have the possibility to request with who they would like to stay in crew during the layover. It could be done easily via the interactive platform in e-crew, where beside from the code of the layover, it would be also possible to insert an ID number of the requested person.

8.6.1.3 RVAC and ROFF assigning

Obviously, the Bidding system would help in the RVAC and ROFF assigning process. It would eliminate the whole email communication and shorten the time needed for evaluation. The criteria should be the same as while layovers evaluating. The interface would be sufficient as well. Each pilot sets the ROFF into the system and the crew planners would confirm or reject his requests based on operational situation and evaluating criteria.

8.6.2 Improvements in cabin crew rostering process, implementation of Bidding system

8.6.2.1 Setting the criteria for layovers, ROFF and RVAC evaluation

Before the implementation of Bidding system into crew stewards rostering process, it is necessary to define the criteria for evaluation. It is obvious that cabin crew don´t have group A and B qualification, less or more route competence thus the evaluation would not be so complicated. This should be considered this way:

- If the cabin crew did the bidding or not,
- Parallel processes (expiry dates, trainings),
- If the crew member is mother with children up to 2 years,
- In case of layovers with special requirements: whether the crew member has the visa or required language knowledge,
- Selective seniority (examiner or instructor qualification),
- Straight seniority (means the length of the working contract in Travel Service among the cabin crew – it is divided according the ID number).

8.6.2.2 Implementation of Bidding system

Bidding system could be used not only for the pilots, but for the cabin crew as well. The online interface could be the same. Its usage could be beneficial for layovers requesting and also for the RVAC and ROFF. It would eliminate the email communication, save time and make planning process more transparent and efficient. In case of usage of Bidding system for different type rates (Boeing, Airbus) and wet leased aircraft which needs crew with special training, the evaluation should be done independently.

Apart from this usage, Bidding system could be helpful at the beginning of each summer season. The number of pilots is the same during the whole year, but Travel Service employs higher number of cabin crew during the summer season to cover the operation. These flight attendants are mostly employed from April or May till the end of September or November. Most of them have expired licences and type rate qualifications (in case of cabin crew the type rate on license automatically expire when they don’t operate flight for five months and more). Using Bidding system at the beginning of each season to request for the

operational base and qualification type rate would be useful. Cabin crew who live nearby Brno or Ostrava could bid for these bases, if they are interested in it, and stay home instead of paying rent in Prague. Mothers with small children are not keen on to operate longer layovers and prefer to stay at home, so they can bid for wet leased qualification, thus these aircraft mostly operate from base to base. These improvements would make the planning process more efficient, they would save time and money and make the final layovers fit better crew´s needs.

9 Conclusion

Optimization of logistic processes in crew rostering and scheduling is an important part of airline operations and an interesting topic for the research. The aim of this work was to improve the logistics processes in Travel Service, a.s. in relationship with minimum costs, connection times for crews, delays and flight duty time legality. The following table presents the analysed areas, identified problems and proposed solutions.

Table 10 – Final review of analysed areas, identified problems and proposed solutions

ANALYSED AREAS	IDENTIFIED PROBLEMS	PROPOSED SOLUTIONS
Flight duty period legality	AIMS software used for crew rostering is not able to calculate FDP limitations and rest requirements in ad hoc changes	Creating FDP counter in MATLAB, which could serve as a suporting tool for crew planners and as check back for crew
Economic analysis of Polish bases location	Compensation fees to the PAX of more than 2 hours delayed flights	Development of one extra base - Katowice
	Inappropriate crew logistics	Changes in crew transfers
Crew rostering process -flight deck	Frequent changes	Feedback
	Extra costs	Possibility to request the layover with specific person
	Roster dissatisfaction	Improvements in ROFF and RVAC assigning
Crew rostering process -cabin crew	Crew don´t know the layover offer	Setting the criteria for layovers, ROFF and RVAC evaluation
	Unclear criteria for scheduling	
	Assigning the layovers with special requirements to the wrong crew	Implementation of Bidding systém:
		Possibility to request the layover with specific person
	Cabin crew can´t choose the aircraft type qualification and operation base	Possibility to request the aircraft type and qualification
	Complicated and long RVAC and ROFF evaluation	
	Missing feedback	
	Late roster publicataion	
	Long email evaluation	

9.1 Flight duty period legality

The first analysed area was the flight duty period legality. In Travel Service, the process of the crew rostering is carried by the AIMS (Airline Information Management System) software. The planning is not done automatically, but mostly manually by adding the flight to the crew based on the qualifications and limitations.

However the software AIMS is not able to calculate the maximum duty limitation and the rest requirements in many cases. The flight duty limitation calculations are very complex and it is quite easy to make a mistake. AIMS is able to control it to a certain extent of maximal FDP, appropriate rest of crew and determine the time of duty beginning. This applies only for planned long term flights. In case when the commercial department or OCC sells ACMI flight, or the planned rotation is changed due to operational changes (unexpected

stopover, FDP extension due to a technical failure or advanced over-routing), AIMS is not able to determine the FDP limitations for crew. Planners have to calculate the standards by themselves that can lead to inaccuracy and miscalculation, which can end in an illegally planned duty.

Therefore a simple application – **Flight duty period counter**, created in **MATLAB** language is presented. It is able to determine basic parameters, such as FDP, FDP while un/expected duty extension and following rest. It would ease the work of both planners and crew. Planning department could also use this for the matters of standards verification and crew as a check back.

9.2 Economic analysis of Polish bases´ location

Further the second analysed area aimed on economic evaluation on Polish bases location. As is obvious, an airline receives revenue from air-tickets and pays for aircraft, maintenance, aerodrome usage, fuel and crew. After costs for fuel, crew costs are the largest expenses of an airline. Cost efficient crew planning is of the major importance for airlines. Even a few percent cost reduction could reflect in annual savings of millions euros. Due to the potential for cost saving the economic analysis of Polish bases´ location was made. Based on the data from summer season 2014 the main cost factors are identified there: the compensation fees to passengers of more than 2 hours delayed flights and inappropriate logistics of crew transfers. In a conclusion of this part, the further improvements in crew transfer logistics are presented there. Also a proposal to open a base in Katowice that would lead to cost savings 73 037 € per season is described.

9.3 Optimizing of crew rostering process

Last analysed area was the crew rostering process regarding flight deck and cabin crew. At first the current improvements (Bidding system) in flight deck rostering are described and its statistical evaluation is presented. After the other problems are identified and the further improvements in current procedures are proposed in order to reduce the current amount of communication between the crew and crew planners, improve the human interference, eliminate the weaknesses in rostering process and make the whole system more systematic.

9.4 Further recommendation for research

Apart from analysed problems there could be mentioned another areas for further research. First of all there is still place for progress in the crew rostering process. Even though the Bidding system would be implemented which would lead to higher level of automation and time saving, further optimization could be implemented leading to lower interventions by the crew planners.

Based on knowledge about the duty limitation, qualification requirements, age restrictions, language requirements and other important parameters, might be interesting to use the mathematical model for manpower planning. In this case it would be useful for determining the optimal number of crew, which would lead to more accurate number of crew needed for each aircraft type.

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References:

[1] ICAO, The Economic and social benefits of Air Transport. Air Transport Action Group, Home page. [online]. 2006, 2015 [cit. 2015-02-07]. Available from:https://www. ashgate.com/pdf/SamplePages/Modeling_Applications_in_the_Airline_ Industry_Ch1.pdf

[2] WiseGeek: What is differential analysis. CONJECTURE CORPORATION. [online]. 2003, 2015 [cit. 2015-03-20]. Available from:http://www.wisegeek.com/what-is-differential-analysis.htm

[3] Manegement Mania: Diferenční analýza. [online]. 2013. vyd. [cit. 2015-03-06]. Available from:https://managementmania.com/cs/diferencni-analyza

[4] Peridrome: Workflow techniques to optimize your operations. PERIDROME CORPORATION. [online]. 2009 [cit. 2015-03-20]. Available from:http://www.peridrome.com/workflow-tech-1

[5] KO, Ryan, Stephen LEE a Eng WAH LEE. Business process management standarts (BMP): a survey. *Business Process managements Journal*. 2009, roč. 2009, No.5, s. 744-791. Available from:https://ryanko.files.wordpress.com/2008/03/bpm-journal-koleelee-bpmssurvey. pdf

[6] Business dictionary: What is workflow. WEB FINANCE. [online]. 2015 [cit. 2015-03-20]. Available from:http://www.businessdictionary. com/definition/workflow.html

[7] ASQ-The global voice of quality: Fishbone (Ishikawa) diagram. AMERICAN SOCIETY FOR QUALITY. [online]. 2015 [cit. 2015-03-20]. Available from:http://asq.org/learn-aboutquality/cause-analysis-tools/overview/fishbone.html

[8] Quality Gurus: Fishbone diagram. QUALITYGURUS.COM. [online]. 2014 [cit. 2015-03-20]. Available from:http://www.qualitygurus. com/ images/ fishbone.gif

[9] KRAUS, Pavel. Travel Service: Home page. [online]. 2004, 2014 [cit. 2014-11-19]. Available from:http://www.travelservice.aero/index.php

[10] Czech Republic. Operations Manual part A, revision no.39 of 28.10.2014. In: Prague: Civil Aviation Authority Czech Republic, 2014. Available from:https://app.smartwings.net/efa/mod/file/folder/ detail/?id=6&subfolder_id=6

[11] Charter flights: Difference between charter and scheduled flight. [online]. 2014. vyd. [cit. 2014-11-19]. Available from:http://www.charterflights.co.uk/faq# What_is_the_difference_between_a_charter_and_scheduled_flight?

[12] SŮRA, Jan. IDNES.cz-Ekonomika: ČSA jsou v soukromých rukou, Travel Service koupil třetinu akcií. [online]. 2015 [cit. 2015-04-01]. Available from: http://ekonomika.idnes.cz/travel-service-kupuje-cast-csa-dzg-/eko-doprava.aspx?c=A150331_163148_eko-doprava_suj#utm_source=sph.idnes&utm_medium=richtext&utm_content=top6

[13] Hospodářské noviny. ŠITNER, Roman. Travel Service poráží ČSA. Národní aerolinky čekají na navýšení kapitálu. [online]. 18.11.2014 [cit. 2015-01-21]. Available from: http://archiv.ihned.cz/c1-63134260-travel-service-porazi-csa-narodni-aerolinky-cekaji-na-navyseni-kapitalu

[14] E15.cz. Travel Service loni zvýšil tržby i zisk [online]. 7.7.2014 [cit. 2015-01-21]. Available from:http://zpravy.e15.cz/byznys/doprava-a-logistika/travel-service-loni-zvysil-trzby-i-zisk-1099448

[15] TĚŠITEL, David. Operating Procedure,OP-II-GO-MZR-09/15: Military flights to Mazare Sharif. 2015, 37 s. Available from:https://app.smartwings.net/efa /mod/file/file/require-download/?display_mode=all&offset=1

[16] Czech Republic. Travel Service, a.s.,Operations manual, part A: chapter 8: Operating Procedures. In: Document Number PŘ – I – TVS - 001-35/13. Prague, 2013. Available from:https://app. smartwings. net/efa/mod/file/folder/detail/?id=6&subfolder_id=6

[17] MERCIER, Anne; SOUMIS, Francois. An integrated aircraft routing, crew scheduling and flight retiming model. Compters and operations research: École Polytechnique de Montréal and GERAD, C.P. 6079, Succ. Centre-Ville, Montréal, Canada H3C 3A7. 2005, s. 15. Available from:http://scholar.google.cz/scholar url?url=http:// mestradocc. googlecode. com/svn/Pre/Proposta%2520%28Final%29/artigos/An%2520integrated%2520aircraft%2520routing,%2520crew%2520scheduling%2520and%2520flight%2520retiming%2520model.pdf &hl=cs&sa=X&scisig=AAGBfm2N4Ao7bnBidiMMKtmnYD_xPKxdg&nossl=1&oi=scholarr&ei=WVzWVK7zCdLT7Abek4GICQ&ved=0CCAQgAMoADAA

[18] YAN, TUNG, TU. Optimal construction of airline individual crew pairings. Computers & Operations Research. 2002, s. 23. Available from:http://www.sciencedirect.com/science/article/pii/S0305054800000708

[19] MEINDL, Peter a Sunil CHOPRA. *Supply Chain Management: Strategy, Planning, and Operation*. Prentice Hall, 2014. 6. ISBN 9780133800203.

[20] RUSSEL a TAYLOR. *Operations Management*. Prentice Hall, Upper Saddle River, 2000. 7. ISBN 0-13-013092-3.

[21] Operations Manual – TVS Crew Planning Regulation PN-GŘ-TVS-017/01/12

[22] Print screen of AIMS, AIMS Inc.

[23] AIMS: Crew management. [online]. 2012 [cit. 2015-01-21]. Available from:http://www.aims.aero/page3.html

[24] Czech Republic. Travel Service, a.s.,Operations manual, part A: Chapter 7: Flight time limitations, duty periods, and rest period requirements. In: Document Number PŘ – I – TVS - 001-35/13. Prague, 2013.Available from:https://app.smartwings.net/efa/mod/file/folder/detail/?id=6&subfolder_id=6

[25] KRAUS, Pavel. Práva cestujících v letecké dopravě. *Travel Service: Dokumenty* [online]. 2015. vyd. [cit. 2015-03-06]. Available from:http://www.travelservice.aero/dokumenty/airpassenger-rights-cz.pdf

[26] Data obtained from AIMS software

[27] Data obtained from consultation with Crew Support Department

[28] Czech Republic. Travel Service, a.s., Operations manual, part A: Chapter 2:Operational control and supervision. In: Document Number PŘ – I – TVS - 001-35/13. Prague, 2013.Available from:https://app.smartwings. net/efa/mod/file/folder/ detail/ ?id=6& subfolder_id=6

[29] Data obtained from consultation with Crew Planning Department

[30] Czech Republic. Travel Service, a.s.,Operations manual, part A: Chapter 4: Crew composition. In: Document Number PŘ – I – TVS - 001-35/13. Prague, 2013.Available from:https://app. smartwings. net/efa/mod/file/folder/ detail/?id=6&subfolder_id=6

[31] Aerodrome Categorization,Travel Service, a.s: Document Number PŘ – III – LÚ – 018B-02/14 June 28, 2014. 27.8.2014, rev 2. 2014. Available from:https://app.smartwings.net/efa/mod/file/folder/detail/?id=6&subfolder_id=267

[32] Czech Republic. Travel Service, a.s.,Operations manual, part A: Chapter 5: Qualification requirements. In: Document Number PŘ – I – TVS - 001-35/13. Prague, 2013.Available from:https://app. smartwings. net/efa/mod/file/folder/ detail/?id=6&subfolder_id=6

[33] Data obtained from EFA (Extranet Flight Application), Travel Service

[34] Boeing: Aviation Safety and Aviation Security. [online]. 1995-2015 [cit. 2015-01-21]. Available from:http://boeing.mediaroom.com/2002-07-19-Aviation-Safety-and-Aviation-Security

[35] Travel Service Fleet list 2014/2015. In: Extranet Flight Application (EFA): Travel Service [online]. 13.12.2014. 2014 [cit. 2015-01-21]. Available from:https://app.smartwings.net/ efa/mod/file/folder/detail/?id=7&subfolder_id=163

[36] Civil Aviation Authority: Ownership and leasing. UK Civil Aviation Authority [online]. 2013 [cit. 2015-01-21]. Available from:http://www.caa.co.uk/ default.aspx?catid= 1434&pagetype=90

[37] Planes.cz. [online]. 10/14 [cit. 2015-01-21]. Available from:http://www.planes.cz/cs/photo/1199650/b737-8z9-ok-tvx-travel-service-tvs-qs-praha-ruzyne-prg-lkpr/

[38] Planes.cz. [online]. 10/14 [cit. 2015-01-21]. Available from: http://www.planes.cz/cs/photo/1200987/a320-211-yl-lce-travel-service-tvs-qs-praha-ruzyne-prg-lkpr/

[39] Planes.cz. [online]. 10/14 [cit. 2015-01-21]. Available from: http://www.planes.cz/cs/photo/1035050/cessna-680-ok-uni-travel-service-tvs-qs-praha-ruzyne-prg-lkpr/

List of abbreviations

	A
A320	Airbus 320
ACMI	Aircraft, Crew, Maintenance, Insurance
AIMS	Airline Information Management System
	B
B737 - 700	Boeing 737 - 700
B737 - 800	Boeing 737 - 800
BZG	Bydgoszcz Airport
	C
CC	Cabin Crew
CSA	Czech Airlines
	D
DP	Duty Period
	E
EFA	Extranet Flight Application
ETOPS	Extended Twin-Engine operations
EU-OPS	European Union Regulations for minimum safety procedures for cargo and passengers in civil aviation
	F
FD	Flight Deck
FDP	Flight Duty Period
	G
GDN	Gdansk Airport
	H
Hrs	Hours
	I
ISAF	International Security Assistance Force
	K
Km	Kilometre
KRK	Krakow Airport
KTW	Katowice Airport

	L
LCJ	Lodz Airport
LUZ	Lublin Airport
	M
Min	Minute
	O
OCC	Operations Control Centre
	N
NAT	North Atlantic
	P
PAX	Passenger
POZ	Poznan Airport
PR	Purser
	R
ROFF	Requested Day Off
RVAC	Requested Vacancy
RZE	Rzeszow Airport
	S
SBY	Stand-by
SC	Senior Cabin Crew
SICK	Sickness
SMS	Safety Management System
SZZ	Szczecin Airport
	T
TVS	Travel Service
	W
WAW	Warsaw Airport
WOCL	Window Of Circadian Low
WRO	Wroclaw Airport

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Appendix 1 – Company structure

In this appendix the general structure of the Travel Service, a.s. is presented, especially the main managers/directors responsible for the ground and flight operations are mentioned as well. Further the structure of the Flight Operations Division is described there, which is necessary to introduce due to approach of the crew planning issue.

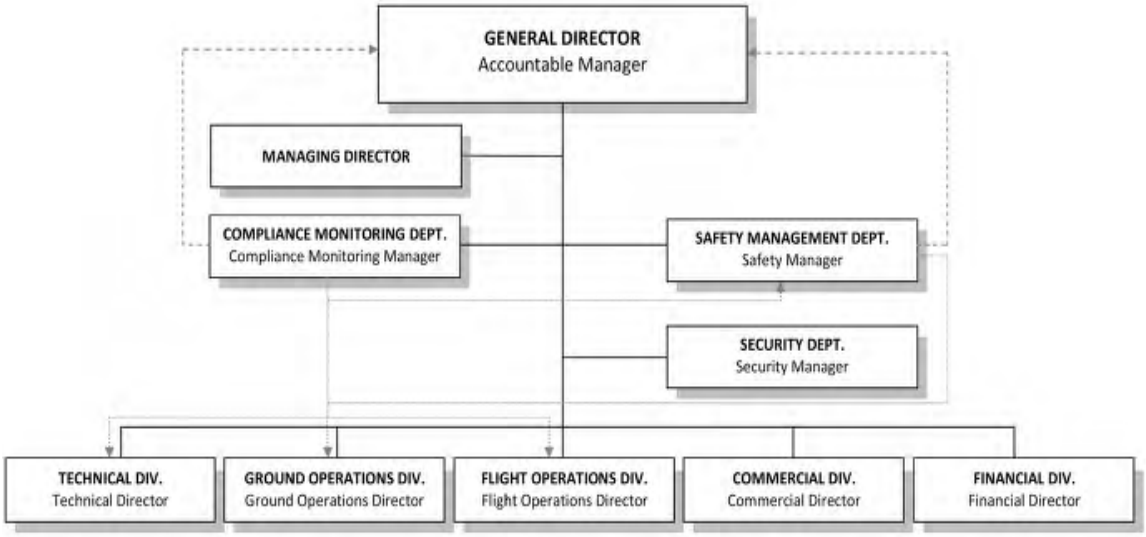
General structure of the company

On the figure bellow (**Figure 18**) the structure of the company is described. The General Director and Accountable Manager of Travel Service, a.s. is Roman Vik, who is responsible for everyday operations of the airlines. The Chef Financial Officer Jiří Juráň and Michal Tomis as a Managing Director act on behalf of the General Director during his absence. Further the Managing Director participates in management and control of the company everyday operations. Than Compliance Monitoring Manager Jiří Kaňák is responsible for monitoring the compliance of the company with the relevant requirements of regulations. Further the Safety Manager – Vladimír Vlk is responsible for all safety related matters and managing SMS[12]. Security Manager is responsible for all aviation security[13] related problems and for implementation of the requirements in the National Security Program. Security Manager of Travel Service, a.s. is David Těšitel. Director of Flights Operations is Pavel Veselý. He is responsible for management, control and supervision of the flight operations and crew training. Jan Bělina as a Ground Operations Director acts as a person responsible for flight planning and ground operations. Technical Director, the person responsible for airworthiness, maintenance of the aircraft and training of the technical company personnel is Luděk Stašek. [10]

[12] **SMS –** safety management system, refers to approach the managing safety risk. It includes systematic approach to managing safety, organizational structures and procedures. [34]

[13] **Aviation security vs. safety** - **Aviation safety** refers to the efforts that are taken to ensure airplanes are free from factors that may lead to injury or loss. **Aviation security** is only one component that may affect passenger safety. It is not so much related to the airplane itself, but rather to intelligence gathering, pre-boarding procedures and airport security personnel. [34]

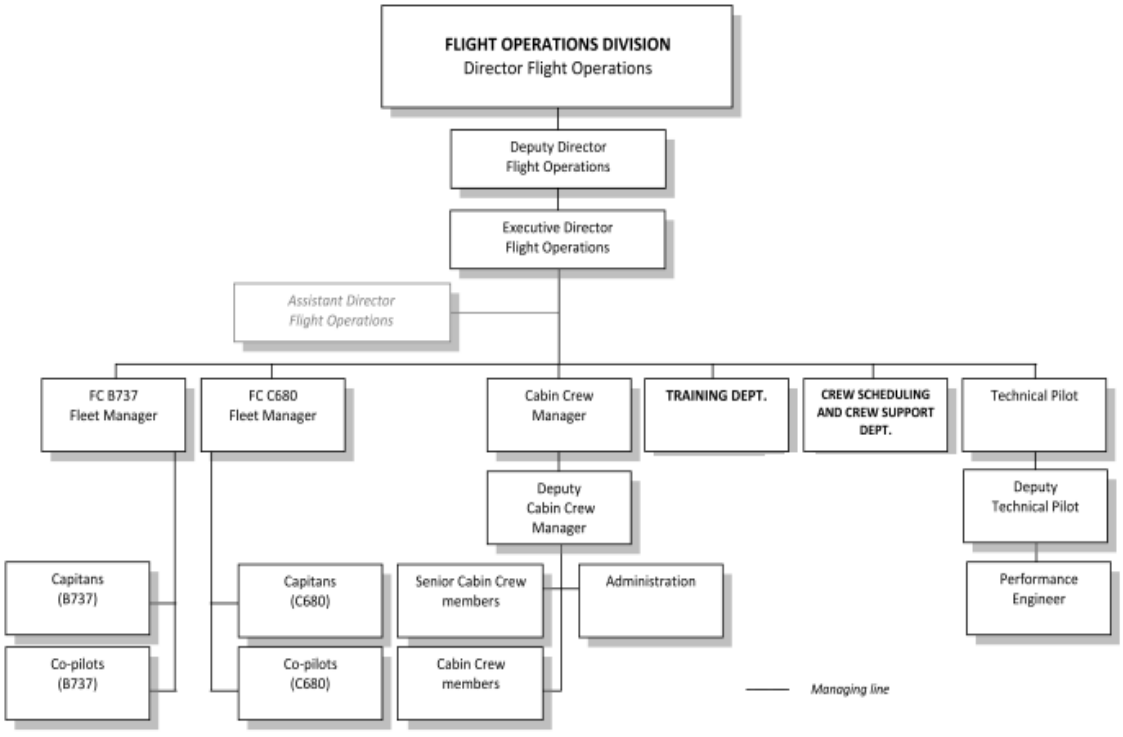
Figure 18 – Organisation structure of the Travel Service, a.s. [10]



Flight Operations Division

On the **Figure 19** the Flight Operations Division is presented, which introduces the structure of the cabin crew and the flight deck management.

Figure 19 – Flight Operations Division structure of the Travel Service, a.s. [10]



Appendix 2 – Airline fleet

This appendix is focused on Travel Service´s fleet. The regular and charter flights are operated by:

- **Boeing 737-700** – capacity: 149 PAX, cruising speed: 828 km/hrs, number of aircraft: 2, registrations: OK-SWW, OK-SWT. [35]
- **Boeing 737-800** – capacity: 189 PAX, cruising speed: 828 km/hrs, number of aircraft depends on summer/winter season.
    - **Travel Service, a.s.** operates 26 Boeing 737-800 with registrations: OK-TSA/C/D/E/F, OK-TVE/F/G/H/J/K/L/M/O/P/R/S/T/U/V/W/Y. OK-TVU and OK-TVV are wet leased[14] to Oman Air. (**Figure 20** presents B737-800, registration OK-TVX)
    - **Travel Service KFT.** operates 1 Boeing 737–800 with registration: HA-LKG.
    - **Travel Service Polska, Sp. z.o.o.** owns 1 Boeing 737 – 800 (registration SP-TVZ).
    - **During the summer season 2014** Travel Service had long term wet leased:
        - 2 models of B737-800 from **Sungwings Airlines** (Canada), registrations: C-FLSW and C-FYLC
        - 1 B737- 800 from **Spice Jets** (India), registration: VT – SPQ. [35]

[14] **Wet lease –** wet lease is a leasing arrangement, where the airline (so called leaser) provides an aircraft, crew, maintenance and insurance (ACMI) to another one. On the other hand **dry lease** is a type of agreement, when one airline provides the aircraft without the crew and maintenance staff. [36]

Figure 20 – B737- 800 at Prague aerodrome [37]

- **Airbus 320** – capacity: 180 PAX, cruising speed: 835 km/hrs.
    - **Travel Service Slovensko, s.r.o** – operates 2 A320 with the registrations: OK-HCB and OM-HCA (previously belonged to Czech Airlines Holidays)
    - **Long term wet leased A320**:
        - **Czech Airlines** – 5x A320 (OK-LEE/LEJ/LEG/MEJ/NES)
        - **Smartlynx Airlines (Latvia)** – 2x A320 (YL-LCD/LCE), **Figure 21** presents A320 with registration YL-LCE
        - **Hermes Airlines (Greece) –** 1x A320 (SX-BHV)
    - **Occasional wet leased A320**:
        - **Czech Airlines** – 2x A320 (OK-MEH/MEI). [35]

Figure 21 – A320 (registration YL-LCE) wet leased from Smartlynx [38]

Business jet flights are operated by **Cessna 680 Citation Sovereign** (presented on the **Figure 22**) which has rating capacity 9 PAX, maximal cruising speed 848 km/hrs and maximal distance 5 336 km. Travel Service airline disposes by 3 models of these aircraft with registrations OK-UNI/EMA/UGJ. [35]

Figure 22 – Cessna 680 Citation Sovereign [39]

In next years is planned to expand the fleet by seven models of Boeing 737 MAX (modernized version of B738). Three of them will be delivered in 2018 and 2019 respectively and the rest four will be leased by the **Gecas Company.**

Appendix 3 – WOCL interval FDP limitations [24]

BASIC CREW LIMITATION								
start LMT	2sectors	plan ext.	3sectors	plan ext.	4sectors	plan ext.	5sectors	6sectors
.0201-0400	1100	**1145**	1030	1030	1000	1000	.0930	.0900
.0405	1105	**1145**	1035	1135	1005	1105	.0935	.0905
.0410	1110	**1145**	1040	1140	1010	1110	.0940	.0910
.0415	1115	**1145**	1045	1145	1015	1115	.0945	.0915
.0420	1120	**1145**	1050	**1145**	1020	1120	.0950	.0920
.0425	1125	**1145**	1055	**1145**	1025	1125	.0955	.0925
.0430	1130	**1145**	1100	**1145**	1030	1130	1000	.0930
.0435	1135	**1145**	1105	**1145**	1035	1135	1005	.0935
.0440	1140	**1145**	1110	**1145**	1040	1140	1010	.0940
.0445	1145	**1145**	1115	**1145**	1045	1145	1015	.0945
.0450	**1145**	**1145**	1120	**1145**	1050	**1145**	1020	.0950
.0455	**1145**	**1145**	1125	**1145**	1055	**1145**	1020	.0955
.0500	1200	1300	1130	1230	1100	1200	1030	1000
.0505	1205	1305	1135	1235	1105	1205	1030	1005
.0510	1210	1310	1140	1240	1110	1210	1040	1010
.0515	1215	1315	1145	1245	1115	1215	1045	1015
.0520	1220	1320	1150	1250	1120	1220	1050	1020
.0525	1225	1325	1155	1255	1125	1225	1055	1025
.0530	1230	1330	1200	1300	1130	1230	1100	1030
.0535	1235	1335	1205	1305	1135	1235	1105	1035
.0540	1240	1340	1210	1310	1140	1240	1110	1040
.0545	1245	1345	1215	1315	1145	1245	1115	1045
.0550	1250	1350	1220	1320	1150	1250	1120	1050
.0555	1255	1355	1225	1325	1155	1255	1125	1055
end or fully	2sectors	plan ext.	3sectors	plan ext.	4sectors	plan ext.	5sectors	6sectors
.0210	1255	1355	1225	1325	1155	1255	1125	1055
.0220	1250	1350	1220	1320	1150	1250	1120	1050
.0230	1245	1345	1215	1315	1145	1245	1115	1045
.0240	1240	1340	1210	1310	1140	1240	1110	1040
.0250	1235	1335	1205	1305	1135	1235	1105	1035
.0300	1230	1330	1200	1300	1130	1230	1100	1030
.0310	1225	1325	1155	1255	1125	1225	1055	1025
.0320	1220	1320	1150	1250	1120	1220	1050	1020
.0330	1215	1315	1145	1245	1115	1215	1045	1015
.0340	1210	1310	1140	1240	1110	1210	1040	1010
.0350	1205	1305	1135	1235	1105	1205	1035	1005
.0400	1200	1300	1130	1230	1100	1200	1030	1000
.0410	1155	1255	1125	1125	1055	1055	1025	.0955
.0420	1150	1250	1120	1120	1050	1050	1020	.0950
.0430	1145	1245	1115	1115	1045	1045	1015	.0945
.0440	1140	1240	1110	1110	1040	1040	1010	.0940
.0450	1135	1235	1105	1105	1035	1035	1005	.0935
.0500	1130	1230	1100	1100	1030	1030	1000	.0930
.0510	1125	1225	1055	1055	1025	1025	.0955	.0925
.0520	1120	1220	1050	1050	1020	1020	.0950	.0920
.0530	1115	1215	1045	1045	1015	1015	.0945	.0915
.0540	1110	1210	1040	1040	1010	1010	.0940	.0910
.0550	1105	1205	1035	1035	1005	1005	.0935	.0905
.0559	1100	1200	1030	1030	1000	1000	.0930	.0900

Appendix 4 – Source code of the Flight duty period counter

```
% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

Minuta=str2num(get(handles.edit16,'String'));
Minut_e=str2num(get(handles.edit18,'String'));
Hodina=str2num(get(handles.edit15,'String'));
Hodin_ee=str2num(get(handles.edit17,'String'));

a=get(handles.checkbox1,'Value');%Home base
if a==1
    t1=75;
end

b=get(handles.checkbox8,'Value');% Out of Home base except Oman
if b==1
    t1=45;
end

c=get(handles.checkbox9,'Value');%Oman
if c==1
    t1=90;
end

d=get(handles.checkbox10,'Value');%FDP begins by transportation
if d==1
    t1=0;
end

LEG=get(handles.popupmenu3,'String');
LEG02=get(handles.popupmenu3,'Value');
switch LEG{LEG02};
    case '1'
        leg=0;
    case '2'
        leg=0;
    case '3'
        leg=-30;
    case'4'
        leg=-60;
    case'5'
        leg=-90;
    case'6'
        leg=-120;
end

DAY=get(handles.popupmenu4,'String');
DAY02=get(handles.popupmenu4,'Value');
switch DAY{DAY02};
    case 'Current day'
        Hodin_e=Hodin_ee;
    case 'Tomorrow'
        Hodin_e=Hodin_ee+24;
end

z=get(handles.checkbox12,'Value');

HH=(0:1:24);
MM=(0:1:60);
hh=intersect(Hodina,HH);
```

```
hh_e=intersect(Hodin_ee,HH);
mm=intersect(Minuta,MM);
mm_e=intersect(Minut_e,MM);

if 1==isempty(hh) || 1==isempty(hh_e) || 1==isempty(mm) || 1==isempty(mm_e) ||
((Hodin_e*60+Minut_e)-(Hodina*60+Minuta))<=0
        set(handles.text60,'String','!! incorrect input time!!');
        set(handles.text4,'String','');
        set(handles.text5,'String','');
        set(handles.text9,'String','');
        set(handles.text8,'String','');
        set(handles.text6,'String','');
        set(handles.text38,'String','');
else
    if z==1
        if ((Hodin_e*60+Minut_e)-(Hodina*60+Minuta)+t1)>1140
            set(handles.text60,'String','!! Not possible due to FDP limitation!!');
            set(handles.text4,'String','');
            set(handles.text5,'String','');
            set(handles.text9,'String','');
            set(handles.text8,'String','');
            set(handles.text6,'String','');
            set(handles.text38,'String','');
        else
           if leg>-90
               T=(Hodin_e*60+Minut_e)-(Hodina*60+Minuta)+t1;
                set(handles.text4,'String',datestr(datenum([0 0 0 0 T
0]),'HH:MM'));
                T_D=T+30;
                set(handles.text5,'String',datestr(datenum([0 0 0 0 T_D
0]),'HH:MM'));
                Rest=max([(T+30) 720]);
                set(handles.text9,'String',datestr(datenum([0 0 0 0 Rest
0]),'HH:MM'));
                if (T+30)<=720
                    Rest=10*60;
                else
                    Rest=T-90;
                end
                set(handles.text8,'String',datestr(datenum([0 0 0 0 Rest
0]),'HH:MM'));
                NP=19*60;
                set(handles.text38,'String',datestr(datenum([0 0 0 0 NP
0]),'HH:MM'));
                set(handles.text6,'String','');
                set(handles.text60,'String','!! Not possible for planned extension
!!');
            elseif leg==-90
                set(handles.text4,'String','');
                set(handles.text5,'String','');
                set(handles.text38,'String',datestr(datenum([0 0 0 19 0
0]),'HH:MM'));
                set(handles.text9,'String',datestr(datenum([0 0 0 19 0
0]),'HH:MM'));
                set(handles.text8,'String',datestr(datenum([0 0 0 17 0
0]),'HH:MM'));
                set(handles.text6,'String','');
                set(handles.text60,'String','!! Possible only for unplanned
extension !!');
            elseif leg==-120
                set(handles.text4,'String','');
                set(handles.text5,'String','');
                set(handles.text9,'String','');
                set(handles.text8,'String','');
                set(handles.text6,'String','');
                set(handles.text38,'String','');
                set(handles.text60,'String','!! Not possible due to number of legs
limitation !!');
```

```
            end
        end

    elseif z==0
        if ((Hodin_e*60+Minut_e)-(Hodina*60+Minuta)+t1+leg)>780
            set(handles.text60,'String','!! Not possible due to FDP limitation
!!');
            set(handles.text4,'String','');
            set(handles.text5,'String','');
            set(handles.text9,'String','');
            set(handles.text8,'String','');
            set(handles.text6,'String','');
            set(handles.text38,'String','');
        else
            if Hodina>=2 && Hodina<=5
               load('FDP_begining.mat');
               radek_h=find(Departure(:,1)==Hodina);
               min=Departure(radek_h,2);
               min_radek=find(min<=Minuta);
               minuta_final=min_radek(end);
               radek=radek_h(minuta_final);
               sloupec_x=[0 -30 -60 -90 -120;3 7 11 15 19];
               sloupec_xx= sloupec_x(1,:)==leg;
               sloupec=sloupec_x(2,sloupec_xx);
               set(handles.text4,'String',datestr(datenum([0 0 0
Departure(radek,sloupec) Departure(radek,sloupec+1) 0]),'HH:MM'));
               TT=(Departure(radek,sloupec)*60+Departure(radek,sloupec+1))+30;
               set(handles.text5,'String',datestr(datenum([0 0 0 0 TT
0]),'HH:MM'));
               MinRest=max([TT 720]);
               set(handles.text9,'String',datestr(datenum([0 0 0 0 MinRest
0]),'HH:MM'));
               set(handles.text8,'String',datestr(datenum([0 0 0 0 MinRest-120
0]),'HH:MM'));
               set(handles.text6,'String',datestr(datenum([0 0 0
(Departure(radek,sloupec+2)) (Departure(radek,sloupec+3)) 0]),'HH:MM'));
               set(handles.text38,'String',datestr(datenum([0 0 0
(Departure(radek,sloupec)+2) (Departure(radek,sloupec+1)) 0]),'HH:MM'));
               set(handles.text60,'String','');
            else
               if Hodin_ee<=5 && Hodin_ee>=2
                   load('FDP_end.mat');
                   radek_h=find(End(:,1)==Hodin_ee);
                   min=End(radek_h,2);
                   min_radek=find(min<=Minut_e);
                   minuta_final=min_radek(end);
                   radek=radek_h(minuta_final);
                   sloupec_x=[0 -30 -60 -90 -120;3 7 11 15 19];
                   sloupec_xx= sloupec_x(1,:)==leg;
                   sloupec=sloupec_x(2,sloupec_xx);
                   set(handles.text4,'String',datestr(datenum([0 0 0
End(radek,sloupec) End(radek,sloupec+1) 0]),'HH:MM'));
                   TT=End(radek,sloupec)*60+End(radek,sloupec+1)+30;
                   set(handles.text5,'String',datestr(datenum([0 0 0 0 TT
0]),'HH:MM'));
                   MinRest=max([TT 720]);
                   set(handles.text9,'String',datestr(datenum([0 0 0 0 MinRest
0]),'HH:MM'));
                   set(handles.text8,'String',datestr(datenum([0 0 0 0 MinRest-120
0]),'HH:MM'));
                   set(handles.text6,'String',datestr(datenum([0 0 0
(End(radek,sloupec+2)) (End(radek,sloupec+3)) 0]),'HH:MM'));
                   set(handles.text38,'String',datestr(datenum([0 0 0
(End(radek,sloupec)+2) (End(radek,sloupec+1)) 0]),'HH:MM'));
                   set(handles.text60,'String','');
               else
                   T=(Hodin_e*60+Minut_e)-(Hodina*60+Minuta)+t1+leg;
```

```
                    set(handles.text4,'String',datestr(datenum([0 0 0 0 T
0]),'HH:MM'));
                    T_D=T+30;
                    set(handles.text5,'String',datestr(datenum([0 0 0 0 T_D
0]),'HH:MM'));
                    Rest=max([(T+30) 720]);
                    set(handles.text9,'String',datestr(datenum([0 0 0 0 Rest
0]),'HH:MM'));
                    if (T+30)<=720
                        Rest=10*60;
                    else
                        Rest=T-90;
                    end
                    set(handles.text8,'String',datestr(datenum([0 0 0 0 Rest
0]),'HH:MM'));
                    P=14*60+leg;
                    set(handles.text6,'String',datestr(datenum([0 0 0 0 P
0]),'HH:MM'));
                    NP=15*60+leg;
                    set(handles.text38,'String',datestr(datenum([0 0 0 0 NP
0]),'HH:MM'));
                    set(handles.text60,'String','');
                end
            end
        end
    end
end
guidata(hObject,handles);



function edit40_Callback(hObject, eventdata, handles)
% hObject    handle to edit40 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit40 as text
%        str2double(get(hObject,'String')) returns contents of edit40 as a double



% --- Executes during object creation, after setting all properties.
function edit40_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit40 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
```