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ABSTRACT

This dissertation is dedicated to the problematic of operations control centres in the field of business aviation. Emphasize is given to flights over the oceans and capacity management of the department. In the first part of the thesis, an analysis of the current state is made. Areas with a potential for improvement are defined. In the following part, procedures for capacity planning optimisation are proposed.

KEYWORDS

Flight planning, operational control, OCC, capacity management, oceanic flights

TITUL

Návrh postupů pro plánování korporátních letadel přes oceány

ABSTRAKT

Tato dizertace je zaměřena na problematiku operačních center plánování letů v prostředí letecké společnosti působící v odvětví malých proudových letadel. Důraz je kladen na plánování letů přes oceány a kapacitní řízení. V úvodu práce je zanalyzována současná situace a jsou definovány oblastí s potenciálem pro zlepšení. V další části jsou navrženy postupy pro optimalizaci kapacitního plánování.

KLÍČOVÁ SLOVA

Plánování letů, operační kontrola, OCC, řízení capacity, oceánské lety

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LIST OF ABBREVIATIONS

ACJ	Airbus Corporate Jet
AIP	Aeronautical Information Publication
AOC	Air Operator Certificate
ATC	Air Traffic Control
BA	Business Aviation
BBJ	Boeing Business Jet
CAA	Civil Aviation Authority
CZALDA	Czech Airline Dispatchers Association
DWH	Data Warehouse
EASA	European Aviation Safety Agency
EBAA	European Business Aviation Association
EUFALDA	European Federation of Airline Dispatchers Association
FAA	Federal Aviation Administration
FL	Flight Level
FOS	Flight Operations System
GPS	Global Positioning System
HF	High Frequency
HLA	High-Level Airspace
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
INS	Inertial Navigation System
IRS	Inertial Reference System
IOSA	IATA Operational Safety Audit
MLR	Multiple Linear Regression
NAT	North Atlantic
NOTAM	Notice to Airmen
OCC	Operations Control Centre
OPR	Operator
OTS	Organised Track System
RVSM	Reduced Vertical Separation Minima
SOP	Standard Operating Procedures
TNA	Time and Attendance System

VFR	Visual Flight Rules
VHF	Very High Frequency
VIP	Very Important Person
VLJ	Very Light Jet
VMC	Visual Meteorological Conditions

INTRODUCTION

Flying over the oceans used to be a phenomenon of large airliners. It is nowadays quite usual for air carriers operating small aircraft too. Business jets are today frequent visitors to diverse worldwide airspaces. By gradual upgrades of the equipment (both aircraft and infrastructure), the character of business aviation changes its nature significantly. From the perspective of flight preparation and flight planning these flights range between the most complicated ones. In the business aviation community, not enough attention is often paid to the importance of procedures setup leading to a safe operation. With a higher number of flight areas, which each has many specifics, a high degree of pre-flight research is necessary to get aware of the procedures and required prerequisites.

The goal of this dissertation thesis is to show areas to concentrate on when planning business jets oceanic operations with a particular emphasis given to the position of Operations Control Centres (OCC) and their capacity setup.

The author would like to continue the research performed on the level of master thesis focused on the topic of oceanic operations in business aviation, published in 2010. In the doctorate thesis, the current situation reflecting the latest development shall be reflected, and unlike the master thesis, the OCC dimensioning shall be considered as the primary focus. The author is actively working in the field of business aviation operations, and he would like to provide expertise based on his personal experience as well as a long-term interest in the topic. He would also like to describe available concepts, define gaps that are not covered by the current solutions and identify the research work on similar topics. In the final parts of the thesis, the author would like to propose a robust methodology for the dynamic capacity planning of business aviation OCCs.

1 ANALYSIS OF THE CURRENT PRACTISES

Before any aeroplane can take off, many essential preparation steps must be taken. The magnitude of these steps depends on the complexity and scope of the operation. Whereas single pilot piston-engine operations may require only the pilot, who performs the majority of tasks, the more complicated operations require the stable structure of supporting departments (1). The preparation and oversight steps are all together called operational control. For the purpose of this thesis, the author will focus on operations of aircraft with jet engines with an extra emphasis given to the preparation of business aviation flights.

The author believes there is a real gap in current approaches to business aviation personnel. The assumption is based on several recent analysis performed on the topic of a shortage of skills of aviation professionals. In 2009 the ICAO identified this issue during a symposium dedicated to Shortage of Skilled Aviation Professionals (2). As a result, the Next Generation of Aviation Professionals Taskforce was established. It puts together representatives from industry, education and training providers, regulatory bodies and international organisations. The goal of the activity is to identify problems and find ways to harmonise training regulations, so they become efficient in the upcoming period when a high increase in volumes of flights is expected. The initiative is focused mainly on commercial fleets, but it is evident that the same measures should apply to business aviation sector in the same manner. In 2015 the European Business Aviation Association (EBAA) performed an analysis focused on the shortage of skills in the European Business Aviation sector. It was based on the presumption that *"there are clear signs of a current and forthcoming shortage in the number of professionals working in the sector, and that this shortage will have dramatic consequences for the sustainability of the sector*"(3). The author takes the view that operational control is one of the critical activities and efficient assignment of dispatchers to shifts with better use of their capacity can be a response to the situation.

The goal of this chapter will be a description of the current situation of flight preparation concepts with their legal structures explained. Differences between various kinds of air transportation will be provided.

1.1 Operational Control

In the Commission Regulation (EU) No 965/2012 the operational control is described as the responsibility of the operator for the initiation, continuation, termination or diversion of flight in the interest of safety (4). The author says that the definition is quite broad and not specific enough. The advantage of the broader definition is the possibility for operators to set up a system according to their needs. The disadvantage, on the other hand, is a possible lack of clarity. Because of this relative flexibility nowadays, several diverse approaches to operational control may be seen. The unit in charge of the process can be a specialised centre, outsourced partner or sometimes an operating crew.

The operational control includes many sub-activities before, during and after each flight. The most critical activity is flight planning with the preparation of the navigation documentation. This documentation is used by the operating crews to perform flights. To provide a deeper insight into the problematic, this part of the operational control will be described in a more detailed way.

The early process of flight planning was very problematical with limited information channels available. Routes of flights were prepared using paper charts. Performance of the aircraft was calculated manually, based on supporting documentation provided by manufacturers of aircraft. The longer the flight was, the higher amount of time was needed for the preparation. Meteorological data were less accurate than nowadays. Satellite imagery was not available, and the forecasts were inaccurate.

New navigation concepts such as area navigation, free-flight concept, satellite-based navigation or RVSM were not yet in place and nor were the communication methods frequently used today. Compared with the current situation, the only available communication methods were HF, VHF and LORAN C. Datalink or satellite-based communication was not yet introduced at that time. Legal requirements imposed by civil aviation authorities were developed along, based on the knowledge gained from experience and often also from incidents or accidents of a different degree of seriousness.

Flight planning principles were fundamentally changed with the introduction of computing technologies, efficient information interchange systems (such as the Internet) and by improvement in aircraft designs. Today the flight planning job is automated to a high degree by using computers for many tasks. Majority of the sources such as charts, weather information and aircraft performance characteristics are kept and distributed electronically. A higher variety of specialised software is available on the market. The long-lasting trend is to allow planning of shorter routings (horizontally and vertically optimised trajectories) with the minimum fuel burns and time spent in the air.

The typical flight planning activities are the following ones:

- optimal flight route preparation optimising time, fuel consumption and comfort of passengers while considering the forecasted weather and wind conditions, route systems and operational limitations of areas and airports,
- complying with the operational limitations of aircraft, such as range, maximum payload, performance, communication and navigation capabilities,
- respecting legal requirements of countries involved in the operations (state of registry of the aircraft, state of departure /over-flight/ arrival),
- keeping safety the highest priority at any moment of the flight (for example by not flying over a war area),
- putting all ground arrangements in place for the operation.

1.1.1 Operational Control Differences

The form and magnitude of the operational control vary by size and scope of operators. The operational control copes with different tasks for scheduled, unscheduled, cargo or business aviation operators. This chapter would like to describe fundamental differences among various types of operations. Because of these differences, operational control can have different requirements on the principles of functioning and the definition of what is essential. From discussions with people performing operational control the below-mentioned factors have been identified as the main contributors to its complexity:

- the regularity of schedules,
- the geographical scope of operations,
- aircraft characteristics,
- size of the operator,
- size of the fleet,
- experience and number of personnel performing operational control,
- training of personnel performing operational control,
- information flow setup level,
- economic pressure.

While the operational control of regular operators with a limited geographical scope and operating one type of aeroplanes can be trouble-free at all times, the opposite may be the case in the unpredictable field of business aviation.

1.1.2 Legal Requirements

International Civil Aviation Organization (ICAO) established by the Chicago Convention on International Civil Aviation (Chicago, 1944) creates and issues regulations for its member states. The Convention is supported by nineteen annexes containing standards and recommended practices. These regulations are obligatory for operators from ICAO member countries. The Annexes are subsequently accepted into the member states national legal systems. In Europe, in addition, the European Union regulation comes into force for the member states (in this case European Commission Regulation (EU) No 965/2012). European Aviation Safety Agency (EASA) is the body responsible for regulations creation and publication. The Agency status is based on European Commission Regulation (EC) No 216/2008 and amended by European Commission Regulation (EC) No 1108/2009. The operational control is mentioned in the following regulations (5):

A. ICAO Doc 9376 Preparation of an Operations Manual (Second edition, 1997)

This ICAO document serves as guidelines for creating company operations manuals leading to obtaining Air Operator Certificate (AOC) for commercial operation. The vital information is that an operator shall establish and maintain a method of control and supervision of flight operations and record the procedures (5). The same information is described in Annex 6 of the Convention of International Civil Aviation, parts I and II

B. Commission Regulation (EU) No 965/2012 of 05/10/2012

According to this regulation, the European operators must satisfy the authority issuing the AOC that their organisation and management are suitable and adequately matched to the scale and scope of the operation and procedures for the supervision of operations have been defined with regard to safety (part ORO.GEN.110) (4)

C. IOSA Standards Manual, 11th Edition, 2017

These standards and recommended practises are not mandatory for all operators but only for those performing commercial operations (AOC) and pertaining to IATA (5). It includes several sections out of which one is dedicated to Operational Control and Flight

Dispatch. It is stricter if compared to the Commission Regulation No 965/2012. It also provides more specific recommendations (6).

D. Federal Aviation Regulations (FAR), part 65: Certification of airmen other than flight crew members, subpart C

In the United States, the operational control is described and required by this document. Unlike other listed documents, the FAR strictly requires a dispatcher to be licensed for any form of operational control given to any commercial flight. Commercial air operator certificate (AOC) holders must list the name of a person responsible for exercising operational control within the company (7).

Private operation (not offered to the public for remuneration) is regulated in a less strict way (8). It is astonishing that unlike in other geographical areas (The United States, for example), no robust legal system is in place in Europe concerning the dispatch work and control of activities and processes of individual operators (9). Local civil aviation authorities approve individual companies operating commercial flights. This regulation gap allows the operators to set their standards according to their needs. From the author´s experience, to see operators with a low level of operations control is a common practice, unfortunately. This approach brings situations where many newcomers to the field of operational control have almost unlimited access to the sector (no licensing necessary). Some of them will reach a higher level in time; whereas a great deal of them will never realise the necessity to cope with some more complex aspects of operational control. The author calls this phenomenon "knowing how without knowing why".

1.2 Operation Control Centres (OCC)

At the very beginning of aviation´s first steps, few regulations were in place. Flights were operated exclusively under visual meteorological conditions (VMC) without the aid of radio navigation. Solely the operating crew was responsible for correct calculations of fuel consumption or consultation of weather to make sure the intended crossing would be safe. The OCC concept did not exist. Operational control was not regulated by law whose development was a step behind the technological advances.

With the development of aircraft of better capabilities marked by the beginning of jet-era, the limitations were moved much further. New concepts were introduced. To list several among many, radio navigation aided flights allowed the operations to be less dependent on the weather conditions. The systems reliability allowed flights over uninhabited areas such as oceanic parts of the world; engines became much less fuel-thirsty and reliable, resulting in the introduction of long-haul flights.

To keep pace with the development of aircraft and their systems, a new professional position was needed that could take care of flight preparation. The first OCCs (sometimes also called dispatch centres) were introduced. This reactive approach may be seen today as well. The concepts are typically created as a response to the industrial development, and often there is a transition period during which this dynamic industry remains without effective regulations and solutions in place. Keeping up-to-date with the latest development has always been demanding in aviation.

The OCCs are normally proportionally structured to the size of a company. Large operators frequently apply a high degree of the subdivision to smaller units specialising in a particular area only. In the structures of smaller operators, such as business aviation airlines, the degree of specialisation is lower. On the other hand, their tasks are more variable and challenging. According to the article "Flight Dispatchers in Private or Business Aviation" published by Helmut Lehr, this is due to the non-presence of specialised supporting departments such as customer or fuel departments (10). For companies small in size and volumes of operations, external OCC provided by an external company also becomes one of the options.

Operators wishing to run their own OCC must get well aware of procedures in separate countries, airports and also get to know the operated aircraft into detail. This knowledge set requires much time to learn. The correctly-setup processes and adequate distribution of authorities across the department are vital. Unfortunately, it is not rare that operators run highly risky OCC departments with inexperienced personnel whose decisions may put their operating crew, aircraft or even whole companies involved in flight operations in danger. The results of research performed by Andreas Cordes in his study "Job profile and training requirements for European Flight Dispatchers" are shocking. They show that 85% of operators with less than ten aircraft units in their fleet do not require licensed personnel to perform OCC duties and only 48% of operators operating between 11 and 25 aircraft do (11). This fact is a clear sign of lacking understanding of the OCC importance across the industry.

1.2.1 OCC Operational Control Activities

As mentioned previously, the OCC concept must respect the individual specifics of the performed operation. All OCCs have the same standard goal; efficient information distribution before the flight, during the flight and after the flight. The three phases are also called pre-flight, in-flight and post-flight phase. The three phases always coexist, and each of them is very important. They are presented in Figure 1. Unfortunately, the practice shows that especially smaller operators, do not pay enough attention to the post-flight phase. Sometimes it is not performed at all. The reason for this is, by the author´s expertise, an insufficient understanding of the post-flight analysis importance for operations safety. The flow of information used by OCCs is both, internal-within the operator, and external with other companies (providers) and authorities. An OCC does not only perform flight planning tasks, as is often thought. It also carries out a list of administrative and supporting tasks. The support and quick action of OCCs can save a lot of money and time to the operating crew and is indispensable for complicated operations. The centres are equipped with hardware and software solutions to be in touch with the latest information such as the weather or operational limitations. Even though the OCC work is continuously being simplified with technologies development, it remains a complex activity requiring a high degree of knowledge and organisation. An overview of typical tasks is provided in Table 1.

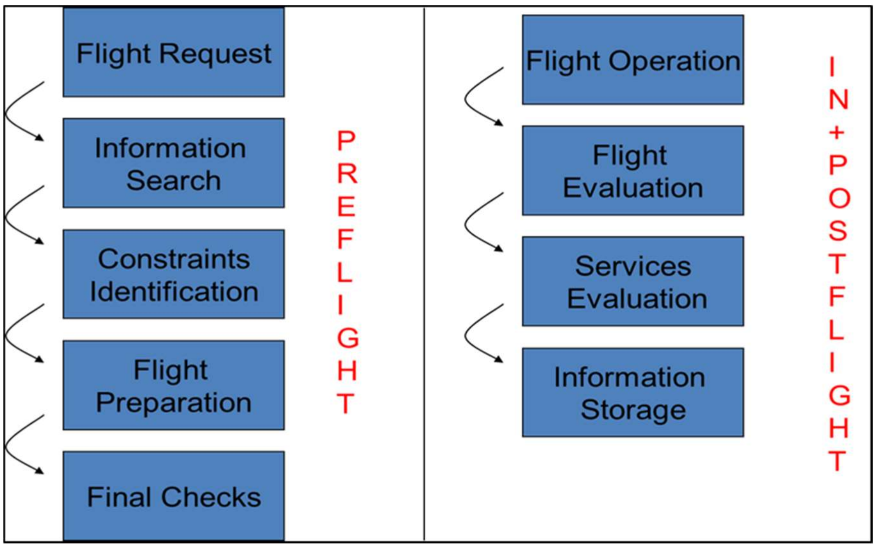


Figure 1 Typical flight preparation flow

Source: Author

Table 1 Overview of typical OCC tasks

Phase	Task
Pre-flight	Airport usability check
	Available routing construction
	Aircraft operational suitability check
	Legal requirements verification
	Arrangements of over-flight and landing permissions
	Verification of airports technical suitability for the operation
	Verification of technical condition of the aircraft
	Crew competency check
	Crew assignment
	Crew visas arrangements
	Accommodation arrangements
	Weather Analysis
	Operational limitations analysis (AIP, NOTAMS etc.)
	Flight scheduling
	Flight Planning
	Flight documentation preparation and distribution
	FPL filing
	Ground services arrangements
	Information flow keeping
	Communication with crews
	Optimisations
In-flight	Flight-monitoring
	Solving non-standard situations
	Distribution of updates / operational changes
	Emergency response action
Post-flight	Data collection and storage
	Data evaluation
	Applications of improving solutions

Source: Author

OCC skills in small departments are based on experience and learning from errors rather than on adequate training. Time pressure is often present and low flexibility to make any changes exists. The author observes that the current level of flight planning skills principally in small flight departments is not sufficient to perform flight support efficiently in complex areas such as the oceanic zones.

1.2.2 OCC Software Solutions

As previously mentioned, highly specialised software is used by OCCs. Today many competing developing companies offer a variety of products to choose from. Flight planning software is used for the construction of routings and performance calculations. Such software includes data about aircraft equipment and performance, available route system with navigation fixes/beacons and weather forecasts (wind strength and direction, temperatures, dangerous phenomena etc.). An example of such software can be seen in Figure 2.

Figure 2 Example of flight planning software screen

Source: (12)

To keep track of the schedules, the Flight Operations System (FOS) is essential. The software typically includes databases of flights, airports, providers or countries. Using FOS helps operators and their OCCs track aircraft, see flights progress or look back for information.

Historical data are used for predicting the future. One of the commercial FOS product's screens is shown in Figure 3.

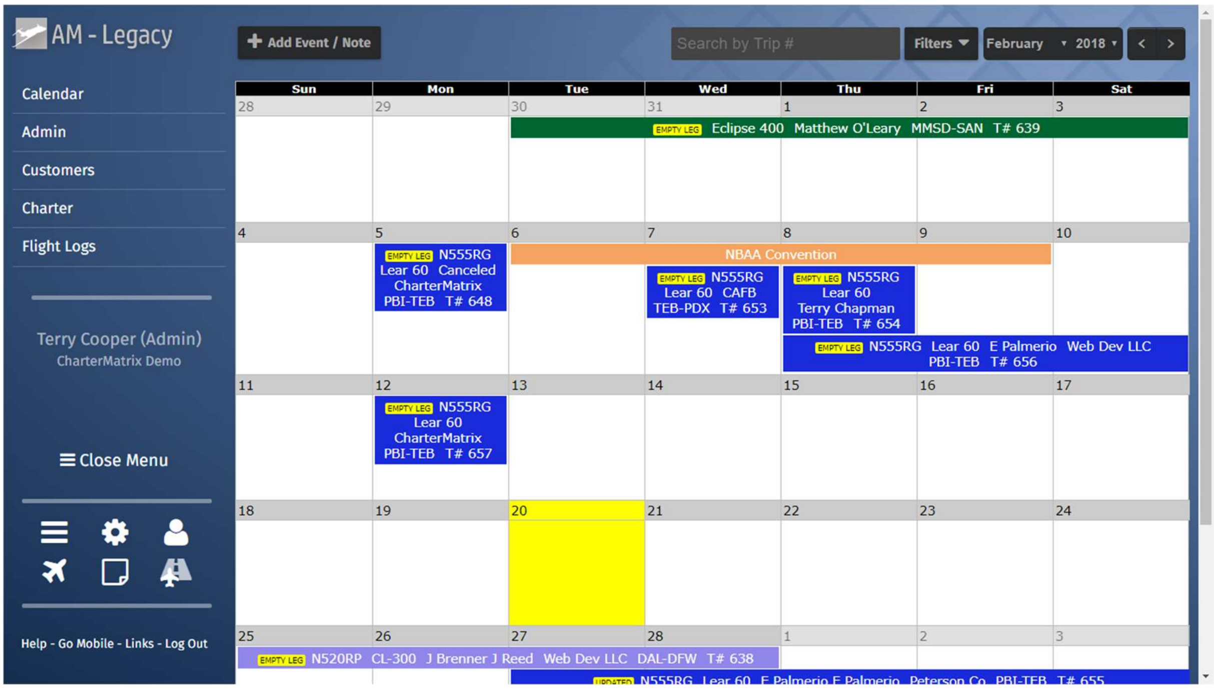


Figure 3 Example of FOS interface

Source: (13)

Map software is helpful when doing strategic planning (avoiding flying over a given country etc.). Airport, area or approach charts are typically part of this kind of software. Other specialised software is used for additional calculations such as runway feasibility tools or weight and balance applications. Time and Attendance System (TNA) is needed to assign dispatchers to shifts and to monitor their time. A typical TNA interface (Timeline) is shown in Figure 4. FOS and TNA are important in terms of providing data to Data Warehouse (DWS) from which reports are obtained for strategic decision-making and planning.

MONTHLY SHIFT ROTATION

YEAR 2018 MONTH JANUARY

KEY: W WORK, R PARTIAL, A ABSENCE, H HOLIDAY, 0 OFF, P PTO, S SICK, V VACATION

ID NO.	EMPLOYEE NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
11111	EMPLOYEE NAME 1	W	0	0	H	V	W	W	W	0	0	R	W	W	W	W	0	0	P	W	W	W	W	0	0	W	W	W	W	W	0	-
22222	EMPLOYEE NAME 2	R	0	0	H	W	W	W	W	0	0	W	W	P	W	W	0	0	W	W	W	W	W	0	0	W	W	W	W	W	0	-
33333	EMPLOYEE NAME 3	R	0	0	H	W	W	W	W	0	0	W	S	W	W	W	0	0	W	W	W	W	W	0	0	V	V	V	R	A	0	-
44444	EMPLOYEE NAME 4	W	0	0	H	W	W	W	W	0	0	W	W	W	W	W	0	0	W	W	W	W	W	0	0	S	W	W	W	W	0	-

Figure 4 Example of TNA interface

Source: (14)

1.3 OCC Personnel

The position of OCC personnel can have several forms. The most commonly used name is a flight dispatcher. Some operators divide the flight dispatchers among navigation dispatchers whose responsibility is merely routings preparation or optimisation, and rather administrative dispatchers who are responsible for ground services arrangements, over-flight and landing permissions or other similar tasks. Another common division is between flight planners, flight schedulers and flight followers (9).

A reasonable level of the OCC personnel is a key to successful operational control. It is common that the understanding of the position is very different in various countries. In one place the requirements and public perception of the job can be very high, whereas in other places the OCC personnel can be seen as a supporting team of low importance with no educations prerequisites. The level of knowledge of the personnel can then be very different. To understand the regional differences is crucial for personnel selection process. Citing Helmut Lehr, *Educated and trained dispatchers are theoretical pilots without flight experience.* He positions dispatchers even higher than pilots because they have an in-depth knowledge of several areas and aeroplanes at the same time and can be a source of valuable information from areas that pilots typically do not know into detail. The main problem he sees is the lack of skilled and trained dispatchers on the market (9). To promote the dispatchers' importance, the author would like to use the following statements made during a Safety Symposium of the Airline Dispatcher Federation (ADF) hosted the United States (15):

- Mr Herb Kelleher, President and CEO of Southwest Airlines: *"Dispatchers are the heart of the Airline".*
- Ms Katherine Hakala, FAA Special Assistant: „*The role of the Aircraft Dispatcher has been proven a critical link in air safety".*
- Mr.Harold Johnson, FAA Regional Dispatch Resource: "*Dispatchers have the ability to shortstop the accident trend and rewrite the Aviation Accident story. History will write your contributions as the unsung heroes of the aviation community".*

1.3.1 Legal Requirements

Because the OCC personnel has a vital position in operation control, it would be expected that a robust legal requirement will be in place for licensing the dispatchers. Unfortunately, in most European countries this not officially required neither for commercial, nor private operations (9). An entirely different situation exists in the United States where commercial, regular operators are obliged to undergo rigorous training and licensing of their dispatchers (9). The OCC Personnel is mentioned in the following legal documents (5):

A. ICAO Doc 9376 Preparation of an Operations Manual (Second edition, 1997)

In this document, several primary responsibilities of the operating personnel are defined providing guidelines for creating operations manual. Two of the positions defined in the section 4.16 of the manual are flight operations officer and flight dispatcher. They are mentioned as an option for operational supervision. The manual provides much flexibility for operators but only gives them recommendations without setting stringent rules. A strict difference is made between licensed and non-licensed personnel. ICAO members may choose whether licensed personnel shall be required for the registered operators and if so, the state authority is then obliged to define legal and training requirements. A guideline for the initial appointment and the maintenance of competencies are listed in Annex 6, Parts I and III (5). In the Czech Republic, the Civil Aviation Authority (ÚCL) does not require licensed dispatchers to perform OCC duties. The operational control of Czech operators is most frequently based on the system of shared responsibility between the dispatcher and operating crew.

B. ICAO Doc 8335 Manual of Procedures for Operations Inspection, Certification and Continued Surveillance (5. edition, 2010)

This document does not require the dispatcher to become licensed. It outlines several primary responsibilities for flight operations officers or flight dispatchers such as assistance to the flight commander, operational flight plan creation or information flow maintenance. Conditions of work are also mentioned, but the central part of the responsibility for operational control is left with state authorities again. They have the flexibility to approve different modes of compliance.

C. Commission Regulation (EU) No 965/2012 of 05/10/2012

According to this regulation, operational control is to be defined by operators and approved by state authorities. Emphasis is given to the description of the competence of operations personnel, their qualification and records management.

The operational control is then based directly on authorities' approvals. It does not necessarily have to apply the same requirements on all the operators registered in the given country.

D. Federal Aviation Regulations (FAR), part 65: Certification of airmen other than flight crew members, subpart C

This document mentions conditions to hold a dispatcher´s licence (age, English fluency, knowledge and practical test, practise under supervision) (7). Interestingly, unlike any other document the FAR lists the "Wind-shear and microburst awareness, identification, and avoidance" and „Aeronautical decision making and judgment" as necessary parts of the syllabus of the knowledge test.

As can be seen, the magnitude of different legal approaches is quite broad. Unfortunately, none of the documents provides a universal and straightforward solution. Furthermore, it is sporadic that the same position in two different companies means the same tasks and expertise.

1.3.2 Limitations

There is a long list of situations where OCC personnel reach its limits. This issue may be caused by mental capacity and education level of the personnel, inadequately defined processes or character of the situation. The area has been explored by IOSA with the goal to identify possible operation problems with regard to OCC. An overview of the problems has been provided by A. Cordes (11). Lukáš Řasa analysed additional problems description in his master thesis (5). He analysed the OCC personnel activities and by a questionnaire distributed among the most significant Czech operators. Subsequently, he defined the dangers and limitations with regard to a risk of error commitment. Very often the identified error cause was a human being. Human error is defined as an incorrect execution of a particular task, which then triggers a series of subsequent reactions in the execution of other tasks resulting in improper task execution (16) (in extreme cases incident/accident). Many operational errors occur on a daily basis. The FAA suggests a continual collection of data on operation errors. They are believed to follow three possible paths where the majority of them are minor errors not reported and sometimes not even noticed. The other two groups are errors which are reported and corrected to limit their future occurrence to maximum extent and errors which are so severe that their immediate adverse effect can be seen (16). This area is well described in literature sources especially with regard to pilots.

1.3.3 Training

Good dispatchers may be very expensive. One of the ways to make the OCC safe and well-performing is to invest in inadequate training of the personnel. Unfortunately, by the author´s experience, very few operators (especially in the business aviation sector) invest in a proper OCC training. The training according to FAA (7) is probably at the best level because its structure requires initial training followed by a knowledge test after which a practical experience under the supervision of a certified dispatcher is required. When all these three parts are complete, a practical test takes place. These steps are very logical, and the licence released by FAA is today believed the highest proof of a dispatcher´s quality worldwide. On the other hand, business aviation specifics and oceanic operations are not mentioned in any of the parts.

The topics of the training for airlines are also covered by the ICAO´s Flight Operations Officers/Flight Dispatchers Training Manual, Part D-3 of document 7192, where Annex 1 and Annex 6 requirements are listed (9). It is common that this document is not even known to smaller or private operators but it is at the moment the most specific document available for OCC Personnel training according to ICAO (17). The organisation has been trying to regulate the operational control since 1955, firstly in the form of a simple circular, followed by this manual´s first edition released in 1975 and updated to the current version 1998. The training of OCC personnel is proposed to be done according to this manual if operators decide to have fully licensed dispatchers. The current syllabus for the OCC personnel training according to the ICAO´s Flight Operations Officers/Flight Dispatchers Training Manual is as follows:

- civil air law and regulations,
- aviation indoctrination,
- aircraft mass and performance,
- navigation,
- air traffic management,
- meteorology,
- mass and balance control,
- transportation of dangerous good by air,
- flight planning,

- flight monitoring,
- communications-radio,
- human factors,
- security (emergencies and abnormal situations).

Two phases are proposed for the OCC training with the first one being a theoretical preparation and the second one in the form of practical training. International Federation of Airline Dispatchers Federation (IFALDA)´s contribution is mentioned in the document. The IFALDA´s dependent organisations are the European Federation of Airline Dispatchers Association (EUFALDA) and separate associations on the individual states level, for example, Czech Association of Airline Dispatchers (CZALDA). Regrettably, the syllabus of this manual was last revised in 1998. It is out-dated, and it does not reflect the latest technological and procedural development, for instance in the area of flight tracking (1). The author finds the scheme proposed in ICAO Doc 7192 Flight Operations Officers/Flight Dispatchers Training Manual, Part D-3 (2. edition, 1998) insufficient. A more detailed guidance material should be available for operators. A high degree of similarity exists between pilots' and dispatcher´s training. Pilots undergo a detailed initial theoretical training, then on-hands experience and the third milestone is a system of recurrent training sessions. Some of these sessions are performed on simulators. The author suggests a similar structure should be applied to dispatchers. No regulation mentions recurrent training sessions and their evaluations for dispatchers. The author comments that it is incredibly challenging to keep the knowledge of dispatchers up without repeating and testing their understanding on a regular basis.

On the Czech national level, the ICAO flight dispatcher license was issued until 2018 by the Czech Civil Aviation Authority (ÚCL) with the below-listed course and exams syllabus:

- meteorology,
- navigation,
- civil air law and regulations,
- communications - radio,
- telecommunication law,
- English.

The Operations Control activities, for instance, aircraft characteristics and performance or non-standard situations dealing, cannot be solved by the current syllabus. More practical training is believed to be more efficient. The Czech syllabus is even less efficient than the syllabus proposed by the ICAO Doc 7192.

Another source of inspiration for OCC training is the IOSA. It is suggesting that all operating personnel be trained according to the kind of operation performed by the operator (6). The following activities are listed as available options:

- flight planning,
- read and analyse NOTAM information,
- read and analyse weather information, wind and significant charts,
- acquire the knowledge of operators´ operations manuals and aeroplane flight manuals,
- winter operations,
- regular meetings and discussions about operational issues with the companies pilots,
- safety and security training.

Compared to the CAA syllabus, the IOSA solution is more up-to-date. It incorporates several vital areas such as flight manuals study or get-together with pilots to share and learn from their problems.

Operators having flights into oceanic operations should certainly not exclude oceanic aviation training. This training is not part of none of the mentioned guidance materials. A simplified example of suggested effective training is shown in the diagram in Figure 5.

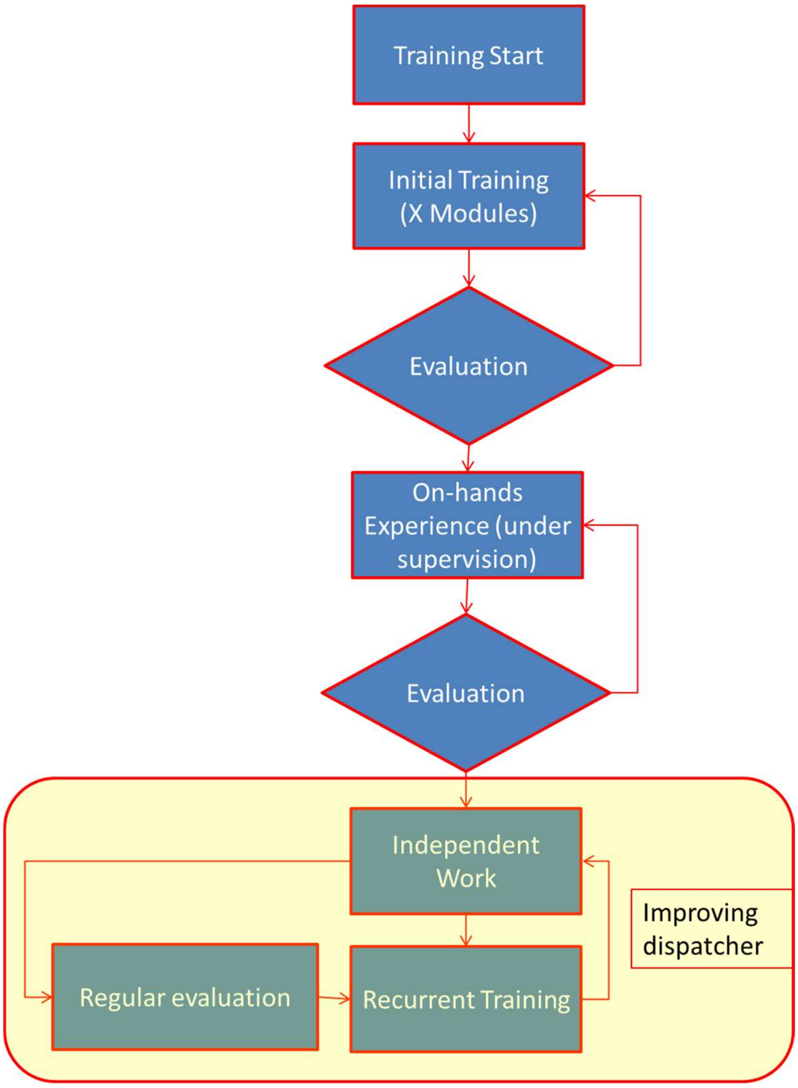


Figure 5 Simplified scheme of efficient OCC training

Source: Author

The author firmly believes the legal requirements for OCC Personnel training are insufficient on both levels, national and international. Relevant topics such as aeroplanes characteristics and performance or area specifics are omitted in the syllabus. This again allows small flight departments to perform OCC task with inexperienced dispatchers who can quickly make mistakes. This condition represents a high risk to the industry. It is common that internal company policy regarding the work of OCC applied by responsible operators is stricter than official regulations. Operators with a higher level of safety understanding should keep the flight dispatcher licence (ICAO) in their internal requirements. According to (18) two kinds of checklists exist in aviation, read-do (normal situations) and do verify (critical situations). This is applicable mainly to pilots´ SOP. A parallel situation exists within OCCs and is recommended to support the training process with the same kind of checklists.

1.3.4 Capacity Management and Dimensioning

It is important that the OCC has a capacity to reply to the entire set of requests. As mentioned earlier, the time periods of high and low workload may be frequent and to adequately dimension the department is complicated. If the OCC is under-dimensioned, the dispatchers will face overload and will most probably commit errors or not finish their jobs satisfactorily and on time. In the opposite case, the dispatchers will have much time without any activity and will lose the ability to perform duties and consequently commit errors as well. For operators with a known schedule (at least some part of it), it is easier to calculate the adequate OCC size to satisfy the operation demand. For irregular operators, the question of dimensioning the OCC accordingly can be done by a first guess method or by analysing historical data, preferably for comparable attributes such as a period of year or presence of events with higher demand for air transportation. The task is much more complicated for irregular traffic because the flights are created randomly and often without a predictable pattern. For a lot of operators the resources to adjust the size of their OCCs are limited. Their dispatchers are left behind with the growing number of tasks. To manage the size of the team can bring cost benefits. A flexible approach may be necessary to cover these challenges.

1.4 Business Aviation

Business aviation comes along with the development of civil aviation from its very beginning. It started to grow steadily and now reaches a stable role in the economies of companies and states worldwide. The literature on Business Aviation mentions this concept as early as 1972 when Warren Alverson described the pros and cons in his article "Businessmen in the blue [or is it red?]"(19). The understanding of Business Aviation is crucial but still different across countries. Business Aviation division may be considered according to aircraft size, capacity or range, regularity of service, passengers' status or legal status. For the purposes of this work "on the demand operations of aircraft in VIP configuration with increased comfort and extra onboard services" definition (20) will be used. With the latest trends of converting large airliners into VIP aircraft such as B737 BBJ and A320 ACJ, the capacity and size of aircraft will no longer be considered.

Business aviation forms a specific part of Air Transportation comprising every category of aircraft ranging from small turboprops to heavy jets. The aircraft range criterion is also becoming less relevant to the definition of what is Business Aviation. Nowadays long-haul and ultra-long-haul biz-jets are in regular use with endurance reaching 13 hours and more. In addition, every time more streamlined aircraft are developed. The community of operators ranges from the tiny ones with one or two aircraft to the multi-types fleets (20).

Several reasons lead passengers to use Business Aviation. Some of the passengers use it for business, others for leisure. The entities using Business Aviation also differ from one case to another. Although having "Business" in its name, sometimes this kind of aviation is used exclusively for leisure purposes (21). Some of the main advantages of this progressive part of aviation are described in Table 2 and Table 3.

Table 2 Advantages of Business Aviation

Factor	Description	Example
Time Flexibility	Several airports can be served within a short period with minimum connecting times.	Aircraft waiting for passengers, not passengers waiting for aircraft
Comfort increase	Additional services can be required on board allowing the passengers to manage their time better. Providing personal space for work while flying	Catering, Internet, furnishing
Places serviceability	Secondary airports and remote places can be served to minimise the ground transportation use and thus benefit to time and cost saving	Self-explanatory

Source: Author

Table 3 Division of business aviation users

Entity		Example
Company	Repetitive flights for employees	On-demand flights bringing employees to remote factories or workplaces.
	Ad-hoc flights for company management	On-demand flights bringing management people to places of business meetings.
Private user	Leisure purposes	Private users travelling on holidays.
	Work purposes	Famous people (singers, actors) travelling to events connected to their work.

Source: Author

Business Aviation has specific infrastructure requirements. Airports and their services themselves are considered important (22). The same applies to the services connected to the status of passengers. It may be more beneficial for the operators and passengers to use smaller airports with less traffic and excellent infrastructure than to operate to a high-density airport. In such airports, the priority of a small business jet typically comes always after regular passengers and cargo traffic. Airports exclusively oriented towards this kind of air transportation are growing and are successful in attracting traffic from previously used high-density airports. Good examples of this phenomenon are Paris-Le Bourget and London Biggin Hill airports, exclusively used by business aircraft and forbidden to any airlines´ traffic.

To demonstrate another significant characteristic of business aviation, the irregularity, the author performed a simple analysis. It was based on the data from several business aviation operators from the same year. Each of the operators had a single aeroplane in the fleet. The author selected the following characteristics for description and comparison:

- number of flights,
- number of destinations,
- monthly flight hours,
- average flight length,
- average daily use of aeroplanes.

The results presented in Table 4, 5, 6, 7 and 8. They show that Business Aviation flights are operated in lower numbers. This is because they are solely based on demand.

Table 4 Yearly number of flights

Number of flights	1	2	3	4	5	6	7	8	9	10	11	12	TTL	AVG
Operator 1	12	14	36	24	33	46	35	34	23	39	22	17	335	28
Operator 2	10	18	8	15	13	9	11	22	18	19	16	18	177	15
Operator 3	11	15	13	13	19	12	7	23	14	20	7	14	168	14

Source: Author

There may be more frequent destinations; however, the character of BA is predominantly random. Unlike airlines operations characterised by a timetable, the operation of Business Aviation does not have a regular character. The typical traffic peaks of regular operations are not so extreme here. Evenly distributed times of operations can be seen.

Table 5 Yearly number of destinations

Number of destinations	1	2	3	4	5	6	7	8	9	10	11	12	AVG
Operator 1	6	5	11	9	10	12	12	10	9	10	11	5	9
Operator 2	5	6	4	3	6	5	6	7	4	6	4	3	5
Operator 3	7	7	5	7	7	7	5	9	7	9	5	8	7

Source: Author

Flight hours and daily use of aeroplanes are much inferior to the values that can typically be seen for scheduled traffic. A few characteristics are described in Table 6, Table 7 and Table 8.

Table 6 Analysis of monthly flight hours

	1	2	3	4	5	6	7	8	9	10	11	12	TTL	AVG
OPR 1	10.6	13.6	43.0	24.5	49.6	56.6	50.7	50.2	30.7	45.9	23.5	14.2	413	34.4
OPR 2	21.6	27.1	18.2	15.1	22.4	18.3	21.4	42.7	23.9	21.4	27.5	17.3	277	23.1
OPR 3	19.3	25.7	19.3	25.1	25.2	18.3	8.9	36.3	20.5	44.9	14.9	47.4	305	25.5

Source: Author

Table 7 Average hourly length of flight

	1	2	3	4	5	6	7	8	9	10	11	12	AVG
OPR 1	0.9	1.0	1.2	1.0	1.5	1.2	1.5	1.5	1.3	1.2	1.1	0.8	1.2
OPR 2	2.2	1.6	2.3	1.0	1.7	2.0	2.0	1.9	1.3	1.1	1.7	1.0	1.7
OPR 3	1.8	1.7	1.5	1.9	1.3	1.5	1.3	1.6	1.5	2.2	2.1	3.4	1.8

Source: Author

Table 8 Average hourly use of aeroplanes per day

Avg.	1	2	3	4	5	6	7	8	9	10	11	12	AVG
OPR 1	0.4	0.5	1.4	0.8	1.7	1.9	1.7	1.7	1.0	1.5	0.8	0.5	1.2
OPR 2	0.7	0.9	0.6	0.5	0.8	0.6	0.7	1.4	0.8	0.7	0.9	0.6	0.8
OPR 3	0.6	0.9	0.6	0.8	0.8	0.6	0.3	1.2	0.7	1.5	0.5	1.6	0.8

Source: Author

The typical character of operation is point-to-point. Many positioning flights are regularly performed. This is the opposite of airlines where very few positioning flights are made throughout the year, and their operation is mostly of a hub-and-spoke character. The coverage depends on the range of the fleet but is rarely limited to particular geographical areas as can be the case for airlines (20).

Business Aviation may be costly but can save a lot of money and time for its users at the same time. If operating with an entirely used seating capacity, the cost gets close to regular flights business class prices (2018 price level). On top of that, this approach brings to its users flexibility with schedule changes and cancellations and allows the option to operate to smaller airports where no scheduled services are operated. Warren Alverson adds to this list of advantages the opportunity to break new ground with new and exciting marketing concept the business aviation aeroplanes bring, enhance the prestige of the users, providing privacy and increasing time spent at home (19). Given the fact that his study was published as early as 1972, it is interesting to compare the fact with current studies performed on the same topic. He, for example, mentions high operational unprofitability or an inferior level of comfort compared to other kinds of aeroplanes, something that has gone a long way since 1972.

1.4.1 Operational Specifics and Differences

Business aviation OCCs are in addition to standard activities exposed to a variety of non-standard tasks. These tasks may be difficult to predict, and when they appear, they can be very time-demanding, something that can directly influence the safety of operations. Business Aviation OCCs are usually smaller in size (according to the research by Ondřej Zima (23), one dispatcher per shift is common for operators with up to five aircraft and two dispatchers for larger BA operators). Low substitution possibilities exist. Very few companies have a robust system to withstand non-standard situations and lack of supporting departments, such as crew planning department or ground services department, exists. The author´s opinion is that the OCC of business aviation operators is a critical unit for their correct functioning. Utmost attention should be given to them by both, companies and regulatory bodies by requiring adequate training. Unfortunately, the training is very often performed on a random basis without a syllabus and a fixed concept or by the "watch and learn" principle.

Compared to other operations, there are business-aviation-specific activities. The results obtained from discussions with people working in the sector are listed in Table 9.

Table 9 Business aviation additional factors

Phase	Task
Pre-flight	Frequent changes to schedules
	Frequent cancellations of flights
	Complicated information flow
	Frequent multi-tasking
	Approaches allowing the combination of demand by several customers
	Periods of extremely low and high number volumes of work
	High level of information search
	Dealing with non-described situations
	Dealing with requests not related to operational control
	Communication with passengers
	Pressure on cost-driven decisions (to the detriment of quality)
	Comfort optimising solutions required
	Different requirements for different customers
	Decisions making leading to lose-lose situations
	High geographical coverage
In-flight	Re-planning in flight due to a changed request
	Operations changes initiated by a discussion with the operating crew
Post-flight	Influence of services selection by passengers experience

Source: Author

It is possible to mitigate some of the effects of the described factors by buying the operational control or a part of it from one of the third-party providers available on the market. These companies specialise in flight scheduling and dispatching and are typically familiar with a variety of tasks which the newcomers will probably come across with difficulties. The cons of such cooperation are applying the legally or internally required specifics of the operators into the providers' framework. In the Czech Republic as well as other countries this activity is subject to an approval issued by the state authority. Being very specific in its operations, Business Aviation needs a separate organisation taking care of the community needs and creating a better environment for the operators. In Europe, this body is the European Business Aviation Association (EBAA).

1.4.2 Aircraft Characteristics and Parameters

Vital configuration differences exist in the business aviation sector. The typical approach of several classes' distribution as known from the airlines does not apply here. The aircraft are fitted with VIP interiors in the whole cabin increasing the level of comfort to its passengers. Business aviation aircraft tend to accumulate fewer flight hours and cycles as they are not rotated in the same extensive manner as regular aircraft fleets (24).

The characteristics can be grouped into two big groups. One is the comfort of the aircraft and suitability for long crossings. The other group are performance factors necessary for the feasibility of the crossing itself. Larger business aircraft made for the purposes of long crossing are capable of long ranges, high service ceiling and speed which brings more autonomy to their operation. The real challenge is imposed when smaller aircraft are planned for an oceanic operation. High penalisation comes into effect. The range is typically the most critical one. The performance characteristics regularly play a vital role in decision making whether to perform an extended oceanic crossing or instead opt for longer options including several technical stops for refuelling. Other factors critically affecting such an operation are service and real ceiling meaning the aircraft may be operating at lower flight levels (FL) with a higher fuel burn. Speed is penalising in the way that slow aircraft may be slowing down a flow of higher speed aircraft and must then be rerouted or are kept at low flight levels. Apart from performance characteristics, a great deal of attention is paid to navigation and communication equipment and independence of the aircraft. An example of a typical business jet design is presented in Figure 6.

Figure 6 Business aviation aeroplane

Source: Author

1.5 Oceanic Flight Planning

Since the first oceanic crossing at the beginning of the previous century, an enormous development has been taking place. The infrastructure need is invariably a question of airports and air routes availability, weather patterns, aircraft navigation and communication equipment. The trend is to simplify all related procedures and allow higher density and flexibility of operation in oceanic airspaces. In terms of airports, the choice is, especially in some oceanic areas, insufficient and the major airports are heavily used for emergency or technical stops purposes. These airports typically have the necessary equipment to support this kind of operations. Three routing concepts are available in oceanic airspaces. First of them is a classical approach of fixed airways non-respecting any weather and wind patterns. This approach is decreasing in popularity and is less widespread because of its flexibility limits. Another popular method of route systems are the routes of temporary validity constructed in a predefined period. They take into account weather and winds conditions, and their goal is to unify the flow of aircraft in areas of heavy traffic. This concept is called Organised Tracks System and is also known under the abbreviation OTS. The most flexible concept, however, is a random flight, also known as free flight concept which offers high flexibility. The operators can file their flight plans by connecting coordinates or available fixes and beacons (if available). This brings optimisation for fuel, helps avoid areas of bad weather and offers a high level of independence (25). Every oceanic area defines its own set of rules for the routing concepts availability and use.

The weather is an important factor in long oceanic crossings, and it is essential to be aware of up-to-date information about wind strength and direction, temperatures and significant occurrences in the specific area. In remote areas communication methods are limited to HF and satellite-based communication. In terms of navigation, no ground stations are available, and long-range navigation methods are to be used, for example, IRS, INS or GPS.The world oceanic areas are variable. Different rules are applied to them and to perform a safe operation, it is necessary to keep the information about the areas updated. Not all aircraft are suitable for oceanic crossings, but it does not restrain their operators from keeping them flying in these areas. They face high penalties such as low comfort, slow speed or complicated routings. Another problem is a high density of some oceanic airspaces (26). Errors in-flight planning can become a serious issue in airspaces where so many aeroplanes operate at the same time. An example of a heavily operated oceanic area (NAT-HLA) is provided in Figure 7.

Figure 7 Example of high-density traffic in NAT-HLA

Source: http://flightservicebureau.org/nat/

Operational control of oceanic operations bears several differences. It is one of the most complicated areas. It requires more profound knowledge and a high degree of self-coordination of the performing dispatcher (27). The author has identified the characteristics linked to oceanic operations and listed in them in Table 10.

Table 10 Oceanic operations characteristics

Phase	Task
Pre-flight	The possible low frequency of oceanic operations
	Difficulty to keep pace with all oceanic areas updates
	Difficult comparison with previous operations
	Crossings with tech-stops
	Low-speed crossings
	Low flight altitude crossings
	Crossings with non-adequately equipped aircraft
	High sensibility to weather
	Dealing with ETOPS rules
	Frequent operations on the edge of aircraft capabilities
	Flights with no backup solution
	Dealing with inexperienced crews

In-flight	Tracking complications Communications complications Low extra fuel reserves for emergency situations
Post-flight	The larger volume of data to analyse

Source: Author

1.6 Identification of Hazards for Business Aviation Oceanic Flight Planning

According to the numbers published by the United Kingdom air navigation service provider NATS, for example, the ratio of all movements to business aviation movements is much higher than the ratio of flight planning and procedural errors of all movements to business aviation movements. The percentage of business aviation traffic is approximately seven per cent of all movements in the NAT airspace. On the contrary, the percentage of errors reaches as many as 93% (27). The errors are mostly caused by the operating crews, but proper dispatchers' insight can help avoid a lot of them. The errors committed by dispatchers are improper route planning or improper altitude planning. Very similar information is provided in the article Safety warning for UK's corporate jets published in the magazine FlightGlobal (28). The author believes these errors can partly be avoided by experience and training but also by providing the dispatchers with adequate time to do these tasks properly. When more complicated oceanic flights are prepared by a single dispatcher under time pressure (for example, fuel critical or with complicated weather conditions), the eventuality of an error increases.

Some of the oceanic areas publish guidance materials for both, controllers and operators (pilots and dispatchers). Good coverage is definitely available for the area of the North Atlantic (NAT-HLA) where the North Atlantic Operations and Airspace Manual (29) and North Atlantic International General Aviation Operations Manual (30) are published. The first of them gets excellent attention and is periodically updated. The second one reflects situation from as early as 2004, and an update should be considered necessary. Both of the manuals will be closer described in chapter 2 of this thesis. Other oceanic operations have very few materials available. This complicates the situation for new or low-frequency oceanic operators (31).

The introduction of a new phenomenon called Very Light Jets (VLJ) into business aviation in 2005 identified a lot of challenges for the sector of oceanic crossings. The two main representatives Cessna C510 Mustang (first flight in 2005) and Embraer Phenom 100 (first flight in 2007) manufactured in North and South Americas were delivered to Europe. The author participated in the preparation of the first oceanic crossing of Embraer Phenom 100 from the United States to Europe. The team had to explore a lot of new information and consult with professional to make the crossings as trouble-free and without surprises as possible. Unfortunately, it is highly probable that a newcomer to the sector of OCC will be exposed to the same situation again and will most probably commit errors. The hazards identified during several years of experience with preparation of crossings during author´s professional life as a dispatcher as well as from email communication with FAA, Gander Oceanic and Shanwick Oceanic ATC Controllers are listed below:

a) insufficient knowledge of equipment of BA and penalisation in oceanic airspace,
b) insufficient knowledge of differences and procedures in oceanic areas,
c) insufficient knowledge of flight levels availability (semi-circular rules within and outside RVSM),
d) low frequency of oceanic operations of the majority of BA operators causes lack of practical experience,
e) higher time demand for BA OCC dispatchers to verify the correctness of flight planning (low frequency = low fluency),
f) the high pressure of BA clients to operate to destinations requiring non-typical operations,
g) difficulties to setup SOPs for oceanic operations with little or no previous experience,
h) difficulties in applying SOPs to different aircraft types within one fleet,
i) low knowledge of emergency procedures such emergency descent or diversion,
j) low knowledge of aircraft capabilities,
k) inadequate reporting points planning,
l) low knowledge of Mach number technique,
m) low knowledge of airport characteristics in oceanic airspaces,
n) limited improvising ability of dispatchers,
o) not enough attention is paid to the operation of non-fully compliant aircraft in oceanic areas,
p) oceanic areas are evolving, and procedures and requirements are not always updated on a regular basis at OCC,
q) guidance material on some oceanic areas is very limited or not available.

The author suggests two approaches to mitigate or avoid these aspects. The first of them is very robust training dedicated to the given oceanic area. The latter approach is capacity dimensioning that will give dispatchers enough time to think and apply their knowledge.

1.7 Summary of Today´s Approaches

The three of the described areas (OCC, Business Aviation and Oceanic Flying) form a very complex set of activities. The characteristic feature of all of them is the dynamics of their development. Operation control is a crucial activity for safe operations. Unfortunately, with the different forms of aviation, understanding of its principles is variable. Substantial legal and unified regulation should be in place, but instead of a specific set of rules, somewhat abstract legal documents with recommendations are published. This leads to operators setting up their standards in many different ways. The consequences then influence more areas than just safety. The OCCs that provide operational control to third-party clients look for a guarantee of quality by licensing the personnel. Their competitors are not obliged to go in the same direction. This may bring financial losses and the safety of the operations may be put at risk. The regulators do not consider licensing necessary, though. In business aviation, most of the OCCs do not employ licensed dispatchers (9). The dispatchers of such operators face a lot of new challenges because of the character of business aviation. When oceanic flights appear on schedules, such dispatchers face a significant gap in their knowledge. The area to focus on to mitigate the possible effects of low or no knowledge is training and dimensioning. There are legal documents dedicated to the training of OCC personnel. Most of them are old-fashioned and do not reflect the current state of aviation. Specifics of business aviation are rarely mentioned in them or are considered marginal.

2 CURRENT STATE OF SCIENTIFIC KNOWLEDGE

In this section, an analysis of the current state of the scientific knowledge of the area is performed. The analysis aims to complement research done by the author. In general, very little attention is currently paid to the combination of OCC, Business Aviation and Oceanic Flights topics across the literature sources. The author has been supervising or opposing several bachelor and master theses with related separate topics. Their results will also be used in the thesis. The analysis will be applied to the whole community in the Czech Republic and abroad at the same time due to the limited sources on the topic. To the best of the author´s knowledge, there have been no studies undertaken in this exact area. Research supports this opinion in information sources (books and articles). The author has had access to renowned article databases such as the Journal of Air Transport Management or Journal of Transport Geography, and very little is dedicated not only to this exact area but also business aviation and the OCC concept in general. There has been some coverage of the topics by economic studies by aeroplane manufacturers and organisations such as the Eurocontrol. The author explains the reason for this low coverage by masses in the relative anonymity of business aviation to the professionals' and students´ community. The topic, which is very sporadically communicated at schools and universities, would undeniably deserve more academic attention and space in courses syllabuses.

2.1 Analysis of the Scientific Knowledge in the Czech Republic

In the Czech Republic very little is published on the any of the three subjects. One of the few academic books dedicated to the subjects in the Czech Republic is "Flight Planning Management" by Rudolf Volner and a team of authors published in 2007 (32). The chapter eight of this book is systematically dedicated to flight planning. It gives an excellent overview of the position of a flight dispatcher and its tasks followed by detailed description of the most important ones (weight and balance, fuel policy, performance calculation, OFP and FPL generation etc.) The description is based on tasks performed by scheduled operators. Unfortunately, no mentioning of business aviation specifics is provided.

Jakub Chmelík provides the most current academic benefits for the area of flight planning, and dispatchers work through his contribution in (32) and (33). Flight planning is required for pilots to pass their ATPL exams where general knowledge is required on the concept (34). All of the mentioned documents need an update to reflect current conditions.

Lukáš Řasa´s master thesis "Enhancing Safety at Operations Control Centre"(5) is dedicated to the identification of critical processes in the work of OCCs is very well describing the limitations of OCC personnel during everyday activities. Ondřej Zima in his master thesis "Flight Planning-Pilot versus professional provider" (23) performed an analysis of tasks of business aviation OCC compared to scenarios where pilots are used for the job. Neither of the two theses is dedicated to OCC training and capacity planning.

2.2 Analysis of the Scientific Knowledge at Global Scale

To find materials with relevance to the topic of the thesis, it is essential to go beyond the borders of the Czech Republic. It is not surprising that most of the materials come from the United States, where business aviation made its first steps and is an integral part of the aviation industry with the highest number of aircraft and their movements in the world.

2.2.1 Analysis of the Scientific Knowledge on Business Aviation

Several publications and studies have been dedicated to the description and statistical development of the business aviation sector. The sector belongs to air transportation studies. The problematic is, again, much better described in American literature where it is believed to be one of the most important yet least understood industries (35). The topic of business aviation is taught at specialised aviation universities across the United States (e.g. Embry Riddle Aeronautical University) and a high level of attention is given to this sector to promote it and share obtained experience.

An excellent example of American literature on business aviation is "Business and Corporate Aviation Management" by John J. Sheehan (36). The goal of the book is to guide entities starting with the business as well as improving processes for the already running companies. Business aviation is described as a rapidly changing field where operational control is shared by dispatchers and pilots much more than in scheduled airlines industry. This opinion is entirely shared by the author of this thesis. Furthermore, the difficulty in complying with ICAO's operational control definition, not only across different companies but also across multicultural countries (ICAO member states), is evident. This proves the author´s point about the ambiguity and unclarity of the definition what the operation control is. Enormous differences among operators exist. One of the chapters of the book is dedicated to operations, even though the OCC concept and specifics are not explored deeply. More attention is unfortunately given to schedulers (typical American division) than dispatchers. Schedulers are described as administrative assistants with high importance for a prosperous company existence. The key to success is believed to be in setting up standards (SOPs) and rules exceeding states rules. This is precisely where many operators stand now. At the same time, the schedulers should be part of a larger team sharing similar policies and level of compliance. In-house OCCs are supposed to perform better for simplicity of communication and efficient information transmission. A fascinating idea mentioned in the book is the concept of constant learning comprising more than only initial and recurrent training (in the same way as the author suggest in this thesis). A personal desire of the personnel for self-improvement (pilots and dispatchers) is expected. The limitations of OCCs are regrettably not mentioned in the book. Surprisingly, and as is typical for American operators with a majority of domestic operations, the source of fear and respect are international operations. This is utterly unthinkable for European operators whose operations are, because of inferior country size, mainly international.

Another interesting book is “Practical Applications in Business Aviation Management” by James R. Cannon and Franklin D. Richey (35). It is more descriptive in a way to link the concepts to the current (mostly US) legislation. Business aviation operators are positioned as airlines with a typically low number of personnel obliging to cope with the same tasks as their colleagues from scheduled airlines. The phenomenon is supposedly present with as many as 70 % business aviation operators worldwide. The situation may be potentially dangerous because the image is fundamental to business aviation and every form of negative publicity may have a considerable financial impact.

Compared to the previous book there is a full chapter dedicated to personnel training. It is described as an important factor necessary to maintain safe and efficient operations, but at the same time, something challenging to obtain due to the mentioned low number of personnel and a self-regulated nature of business aviation. The book provides more guidance for pilots and mechanics training but presents several attention-grabbing approaches to dispatchers training as well. One of them is a constant look for new technologies use leading to tasks simplification. The author suggests this approach be combined with human thinking at all times. Too much automation could merely lead to the loss of control and consequently the ability to perform the tasks satisfactorily. Training principles offered in the book ask for the addition of new training topics. These include decision-making, communication, leadership, conflict resolution or organisational behaviour. This is one of a few publications giving importance to soft-skills management in the work of OCCs. One chapter of the book is also dedicated to oceanic operations. Remarkably, strict regulation exists for licensing crews and operators to fly within oceanic airspace but to license is not mandatory for the OCC preparing the flights. Dispatchers must have at least the same (if not higher) knowledge of oceanic areas as the pilots flying in them. Compared to the previous book the same concerns are mentioned about international operations. Only a low number of US operators perform international flights, and in the community of operators, they are understood as high-complexity tasks.

On the European level, the topic of business aviation is accurately described by a couple of studies. The first of them is the Eurocontrol study "Getting to Point: Business Aviation in Europe" (37) and PwC Economics study "The economic impact of business aviation in Europe" (38). Like the US sources, the business aviation sector in Europe is on the rise with a high ratio of quick changes but faces poor documentation. Both studies provide an overview of operations and operators specifics valid on the European market. The described specifics are small operators' market domination with around 90 % of all movements being a short or medium haul. The safety aspect is approached swiftly by mentioning that business aviation deserves extra attention because of the accidents rate almost twice worse than scheduled operations in the last decade.

2.2.2 Analysis of the Scientific Knowledge on Operation Control Centres

Andreas Cordes very well analyses the topic of OCC Training and tasks in his master thesis "Job profile and training requirements for European Flight Dispatchers" published in 2007 (11). Unlike Andreas Cordes, the author would like to concentrate on the area of business aviation only. Several areas specific guidance materials are available such as the North Atlantic Operations and Airspace Manual (29). Chapter 17 of the manual is precious for the OCCs as it brings "Guidance for Dispatchers". Indeed, the dispatchers are positioned very high in the preparation steps. As the authors say: A successful flight will always start with an intelligent, informed and conservative plan"; dispatchers are those who make the plan. The responsibility is shared between them and the pilot in command. The topics covered by the manual are technical and legislative as well. The dispatchers can learn about flight planning rules, organised track system and other routing concepts, separation, communication or Mach number technique use. The publication is a real help for inexperienced dispatchers or for those who do not perform NAT-HLA flight planning on a regular basis. This is precisely the case of business aviation operators. The manual itself does not include training methods. Operators should, therefore, incorporate information from this manual to their training and adequate capacity planning.

Unfortunately, the same coverage that NAT-HLA gets in the form of the aforementioned manual is rarely seen in any other oceanic area. This means much research is needed when an operation is being prepared to these areas.

To complement the scientific knowledge, the author would like to highlight two projects dedicated to education and knowledge in aviation. The EDUCAIR project (39) was aimed at assessing the educational gaps in aeronautics and air transport and finding a link between needs in human resources and educational opportunities in Europe. A set of seven fundamental skills was analysed (analytical background, technical background, theoretical background, oral and written communication, problem-solving, leadership and ability to work in a team). Among all the skills, "problem-solving" was identified as the most relevant topic. This corresponds perfectly with the author´s presumption described in chapter 1.3.

The other project is initiated by the ICAO (2) and is aimed at research a possible shortage of skilled aviation professionals on the horizon of the next 20 years. The presumption is that a significant rise in fleet numbers is expected and the world will not be able to furnish an adequate number of professionals. The study is focused mainly on technicians and air traffic controllers, but an analogy with the dispatchers' community can be applied. One of the identified issues is training methodologies and costs followed by lack of harmonisation of aviation disciplines competencies.

2.3 Analysis of the Scientific Knowledge on Oceanic Operations

Oceanic operations in some areas are quite well described. One of the areas is the North-Atlantic (NAT-HLA) administered jointly by Portugal, United Kingdom, United States and Iceland. ICAO formed the North Atlantic Systems Planning Group (NAT SPG) responsible for creating and maintaining operating procedures developed in the NAT-HLA area. One of the group's initiatives is NAT-HLA Manual publication (29). This manual is a recommended guidance bearing essential information for pilots and dispatchers. If any vital change takes place within the NAT-HLA area, a NAT Region Updates Bulletin is published. Chapter 17 of the manual is precious for the OCCs as it brings "Guidance for Dispatchers". Indeed, the dispatchers are positioned very high in the preparation steps. As the authors say: A successful flight will always start with an intelligent, informed and conservative plan"; dispatchers are those who make the plan. The responsibility is shared between them and the pilot in command. The topics covered by the manual are technical and legislative as well. The dispatchers can learn about flight planning rules, organised track system and other routing concepts, separation, communication or Mach number technique use. The publication is a real help for inexperienced dispatchers or for those who do not perform NAT-HLA flight planning on a regular basis. This is precisely the case of business aviation operators. The manual itself does not include training methods. Operators should, therefore, incorporate information from this manual in their training. To provide even more specific information for the community of general aviation (including business aviation) the North Atlantic International General Aviation Operations Manual (30) is published as well. The latest version of the manual dates back to 2004, but it still brings a lot of relevant information. The presumption is that the increase of general aviation oceanic crossing numbers brought a similar increase in numbers of accidents, a number of search-and-rescue (SAR) operations and expenses in this harsh climate with long distances travelled and low infrastructure available. The goal of the manual is to supply information to the general aviation community such as regional specifics or meteorological phenomenon description. Compared to NAT-HLA Manual the volume of information is relatively low.

Unfortunately, the same coverage that NAT-HLA gets in the form of the aforementioned two manuals is rarely seen for any other oceanic area. This means a lot of ad-hoc research is needed when an operation is being prepared to these areas.

2.4 Summary of the Scientific Knowledge

Based on the analysis of the sources, it is revealed that each of the available studies and books approaches only one part of the thesis ‘topics. In none of the sources, no obligatory steps are defined so these sources will be used as supporting pieces of information to the author. In the available literature, some ideas are described, and it is suggested that the methods of training and definition of the OCC tasks should be defined more specifically. Unfortunately, no specifics steps have been taken yet, for example on the ICAO level. In addition to the described sources the author also got inspiration from his master thesis “Operation of Business Aviation Aircraft over the Oceans” dealing with description of oceanic areas, articles “Business Aviation in Europe”, “The Challenges of Operations Control Centres (OCC) in European Business Aviation” and conference material “Business Jets Long-Haul Operations”. To summarise the scientific knowledge state, the following statements are made:

a) business Aviation is a dynamic field and has a lot of unique specifics,
b) very little publicity is given the topic of OCCs,

c) OCC is a vital element in the successive chain of activities leading to flight operations,
d) dedicated personnel is needed to perform operational shifts,
e) lack of guidance and training material is evident,
f) a new set of skills is expected to take place in future training,
g) dynamic capacity planning is very scarce today,
h) regional differences exist, mainly between the United States and Europe,
i) a higher ratio of incidents/accidents has been noticed recently in the business aviation community,
j) oceanic guidance is available only for NAT-HLA,
k) oceanic areas are not satisfactorily described.

3 GOAL OF THE DISSERTATION THESIS

The author analysed the current situation in the field of operational control on a general basis, pointed out characteristics of business aviation and described specifics of oceanic flights. This analysis was performed in the first two chapters of the thesis. It is evident that the topic is not adequately covered by legal requirements and general understanding from the operators´ point of view is low. This is especially the case of newly set up or small business aviation operators. It is common that legal authorities do not see the danger of not requiring a higher degree of coverage. The other two significant problems are training and capacity management of OCCs. To have these areas managed could help deal with complicated flights. Oceanic flights have a high potential to meet the criteria "complicated". For this reason, the author has decided to focus primarily on the capacity planning questions in this thesis. In the succeeding chapters, a study will be performed to identify areas where OCCs reach limits or tend to make errors caused by inadequate capacity planning.

A methodology for OCCs capacity management will be proposed in the thesis. A detailed overview of the methods will be described in chapter 4. This methodology will consider areas which are typical for this kind of operations.

The expected benefit of the thesis is to provide a tool for business aviation operators to help them the structure of their OCCs´ size dimensioning resulting in better responding to the complex flights request such as oceanic crossings. A lower number of errors will be made, and better problematic understanding will be obtained even for more complicated tasks. There may be limiting conditions for the expected thesis solution out of which the following ones have already been identified at this stage:

a) dimensioning complexity will have to meet all levels of OCC dispatchers (structured positions expected),
b) the conditions (legal and operational) may be changing in time (the methodology will have to include a definition for regular updating),
c) new concepts introduction (the methodology will have to be adaptable to new technological concepts),
d) low-legal update reaction time.

4 RESEARCH METHODS

In order to eliminate the adverse effects stated in the hypothesis mentioned in the previous chapters, the author will apply several methods. At the first stage, he will benefit from research made in real life conditions of an OCC and his personal experience in the field. A proposal of adequate functions and variables linked to flights and OCC specifics will be followed by the regression analysis. The results obtained will consequently lead to the creation of an algorithm. The algorithm will be tested on a set of real data to find a typical behaviour and confirm the validity of the author´s hypothesis. Once the algorithm is found satisfactory, the author expects to use it for flights scoring and identification of possible room for higher and lower workload giving space to play with the OCC shift composition. Evaluation of financial effects of such a solution will be the last part of the research.

4.1 Analysis and Synthesis of Available Sources

The author has based the analysis on his hands-on experience from OCC leadership and training. To complement the personal experience, articles and books from the field have been read and reviewed. This set of assets has helped to get a more specific idea on how to build the research methodology. The following research techniques and methods are used in this phase.

a) recording personal knowledge,
b) literature review,
c) brainstorming and discussion with experienced leaders in the field,
d) consultations with performing professionals,
e) observation and recording of real-life situations.

One of the sources is the author´s analyses performed in the article "Assessment of Business Aviation OCCs' Capacity Issues" [1]. This article described and demonstrated several characteristic capacity issues. Observation has been performed with a real business aviation operator during several randomly selected twelve-hour day and night shifts on different days of a week. The dispatchers were asked to monitor and record they personal feeling of levels of performance, stress and fatigue. These factors and their description are listed in Table 11. To better characterize the results, their graphical representation is provided in Appendix 1, Appendix 2 and Appendix 3 with the aim to show how different parameters change over time.

Table 11 Shift workload description

Parameter	Description
Level of Performance	The subjective feeling to perform and solve unexpected tasks
Level of Stress	The subjective feeling of pressure experienced when performing tasks
Level of Fatigue	The subjective feeling of being tired

Source: Author

As apparent from the first group of graphs, characterizing the development of dispatchers' performance during their shifts, there are significant irregularities caused by constantly changing demands. In general, it is possible to follow a similar trend in the early phases of both day and night shifts, when, based on the transmission of the current state of work and all necessary information from the previous shifts, dispatchers continue the preparing and pre-flight planning. It is obvious that there are phases of shifts when the dispatchers' performance decreases and grows again rapidly, mostly due to sudden changes and new customers' requirements. At the end of shifts, there is a significant decrease in performance caused by the handover of shifts.

The second group of graphs representing the average development of the level of stress is very similar to the first one. It is probably caused by close links between both observed factors. However, more pronounced transitions between the phases are noticeable during shifts. The reason for the phenomenon is a sudden increase of psychic load when an unexpected change or crisis situation happens and, on the other hand, a significant decrease in stress after resolving such a situation.

In the third group of graphs, there is a noticeable increase in fatigue during the on-going shift. The rate of this undoubtedly depends on the current demand for the shift, and it is essential to react in time to avoid adverse effects on dispatchers' performance and attention. There are significant fluctuations in both diagrams, namely a slight drop in overall fatigue thanks to regular rest periods during the day shifts and a similar phenomenon in the early morning before the end of shifts. It is also apparent that the level of fatigue increases considerably faster during the night shifts compared to the day shifts. This is caused by higher demands on the dispatcher due to natural biorhythms and human habits.

In the second round, the same dispatchers were asked to identify the reasons for high and low peaks of the described factors. They have identified the below-listed causes:

- aircraft knowledge and inadequate planning with respect to performance,
- health or physical conditions preventing entirely from performing,
- slowly working or faulty hardware and software,
- increased number of never experienced situations,
- comparing different scenarios (positioning flights and technical landings),
- schedule and aircraft position incertitude,
- area and airports knowledge/experience,
- inadequate transfer and recording of information,
- limited time for full analysis of new destinations,
- need for immediate action with short notice given,
- the relation between OCC and operating crew,
- correction of errors in flight documentation,
- little awareness of the weather,
- multitasking and irregular work distribution,
- other departments pressure (sometimes money-driven),
- work conditions, ergonomics,
- pressure to satisfy passengers, avoid penalties,
- a high portion of changes in schedules,
- special operations (oceanic, winter, military etc.),
- the inadequate atmosphere among the OCC members,
- a low number of dispatchers on shift.

Several of the factors mentioned in chapter one of the thesis are identical while there is a beautiful set of additional factors describing the limitations. The number and variability of the identified factors show that in-depth understanding of OCC activities is essential for a successfully functioning operator. Even though business aviation operators and their OCCs are very often overlooked and their job considered less critical compared to their airlines counterparts, the opposite is true. OCC personnel of such operators must often face a higher load to cope with. Oceanic flights are part of this complicated load. Business Aviation OCC and their dispatchers are exposed to the same kind of work as fire-fighters. They may spend a lot of time waiting without knowing when the high workload will come in the form of new flights creation or changes to previously known schedules. To act correctly when the action comes is indispensable. The probability to commit an error is higher than for other regular workload sectors. It is of extreme value to describe the system and understand its limits. There is a constant need for observation and adjustments in case of any, even minor changes. A correct description can help to get rid of processes duplicities and therefore supports their simplification. Out of the whole group of obtained factors, the following ones were identified as directly related to capacity management:

- comparing different scenarios (positioning flights and technical landings),
- inadequate transfer and recording of information,
- limited time for full analysis of new destinations,
- need for immediate action with short notice given,
- multitasking and irregular work distribution,
- pressure to satisfy passengers, avoid penalties,
- a high portion of changes,
- a low number of dispatchers on shift.

The goal of the proposed solution will be eliminating them to a maximum practicable extent or at least minimising their effects significantly.

4.2 Real Data Testing

To validate the proposed algorithm, a set of real operations data will be analysed. The set of flight data used in this thesis represent an extract coming from a small operator having a simple one-aeroplane fleet. Operation of this aeroplane during the whole year 2017 will be evaluated. The aim of this sampling is to understand typical behaviour, to cover seasonal changes in volumes of operation fully and to help identify separate functions. The following information will be analysed:

A. Departure and Arrival Airports

Four-letter ICAO codes represent the airport of departure and arrival. It is assumed that the airports of departure and arrival have a significant influence on the complexity of a flight. Factors contributing to difficulties to operate to or from an airport are its geographical characteristics such as elevation or presence of obstacles around it, followed by operational limitations, position or primary purpose of the airport (military airports may be more restrictive for civil traffic, for instance). The departure and arrival points of the extract will be grouped together, and a pattern will be looked for to predict a trend in the data.

B. The Geographical Area of Departure and Arrival airports

Numerical index of the area complexity is based on the first letter of the ICAO code of the departure airport. Geographic area complexity is very similar to the airport complexity. Unlike for the airports, the complexity of geographical areas is, in addition, based on the entry requirements, language barriers or cultural and religious differences. There are many challenging and complicated geographical areas with relatively easy airports in them and vice-versa.

C. Services Complexity

The suggested format of complexity is the number of services required on each planned flight. The request for services is individual on every occasion. In general, handling services will be present on most flights. The same logic will be applied to refuelling. On the other hand, there are services that depend strictly on the upcoming schedule such as the necessity to accommodate the crew. The last group of services will be over-flight and landing permissions and all other on-demand VIP and non-VIP services. The author´s aim will be to identify an average amount of typical service per flight and classify flights with higher values as more complicated.

D. Date and Time of Departure

This information will be expressed by the date and time rounded to the multiples of five minutes. The author will use this parameter to calculate several other time-related parameters. Any notions of seasonality and the presence of peaks in the schedule will be identified to validate the assumptions made in the first two chapters of the thesis.

E. Time of Flight Notification

Recorded date and time of the moment the flight was notified to the Operations Control Centre (OCC). The aim of examining these values will measure what is a typical amount of advance notice before the flight. Any late notice will create extra pressure with a potential the OCC will make mistakes. For this reason, the same simple flight from A to B cannot be treated identically if it was created shortly before its planned date/time of departure.

F. Knowledge of Flight

The knowledge is supposed to be represented by the difference between the time of notification and time of departure. This indicator shows how well in advance the flight was announced to the Operations Control Centre (OCC).

G. Dispatch Time

Recorded date and time of the moment when the flight completion was finished by the Operations Control Centre (OCC) and made fully available to the operating crew.

H. Flight Readiness

The time of departure and Dispatch time will be additionally used to define the flight readiness. In other words, it will be the amount of time before take-off when the operating crew has complete arrangements including flight documentation available, and no further changes or updates are executed. If the dispatch time is very close to the time of departure, it indicates the OCC had some difficulties with the completion such as a missing confirmation of the service, lack of time or complicated weather patterns.

I. Number of Flight Changes

This number represents the total amount of significant changes to the flight happening between the time of flight notification and dispatch time. Changes can occur well in advance or at late notice. This is the case of delays, for example. If a substantial change occurs requiring a new preparation of flight documents or request of new services, it may have a significant impact on the flights feasibility. For the purpose of this thesis, a significant change will be considered any change where time and/or date, the composition of passengers or departure/arrival airports are concerned.

J. Flight Preparation Duration

Representation of the difference between the Dispatch time and the Time of notification give information about the duration of preparation. For the purpose of this thesis, it is expected the preparation starts immediately after the flight is notified even though the practice shows it is not always the case, especially for trivial flights which are notified well in advance. This indicator shows how much time was needed to complete all tasks of the pre-flight operational control including the creation of the flight documentation.

4.3 Regression Analysis

In situations where a relationship between independent and dependent variables is to be estimated, the use of the regression analysis is extremely suitable. It helps to understand how the dependent variable values change when one of the independent variables varies. In this thesis, the regression analysis is used to recognise the magnitude of relationships between the variables and to provide a base for forecasting (future effects will be forecasted using previously known data). In practice, the regression approximates the model using the best fit line expressing the relationship between the variables. The goal is to find an equation, then define adequate parameters and finally calculate the statistical significance. The regression model can either be linear or non-linear and the analysis simple or multiple (41).

4.3.1 Simple Linear regression

The linear models have linear parameters and are generally defined as in (4-1). The residual ε is a representation of deviation between the regression function and the reality. The regression function result itself does not include ε. If the value of the independent variable is equal to zero, the resulting value of the dependent variable will still have a value. Linked to the problematic of this dissertation thesis, where the dependent variable describes a complexity of a flight, it means that there will still be some complexity even though the flight independent variable does not contribute to it.

$$Y = \beta_1 + \beta_2 \cdot X + \varepsilon \; [-] \tag{4-1}$$

Where:

Y …Dependent variable

β_1…Regression parameter intercept

β_2…Regression parameter slope

X …Independent variable

ε …Residual

A graphical representation of the linear regression example is shown in Figure 8.

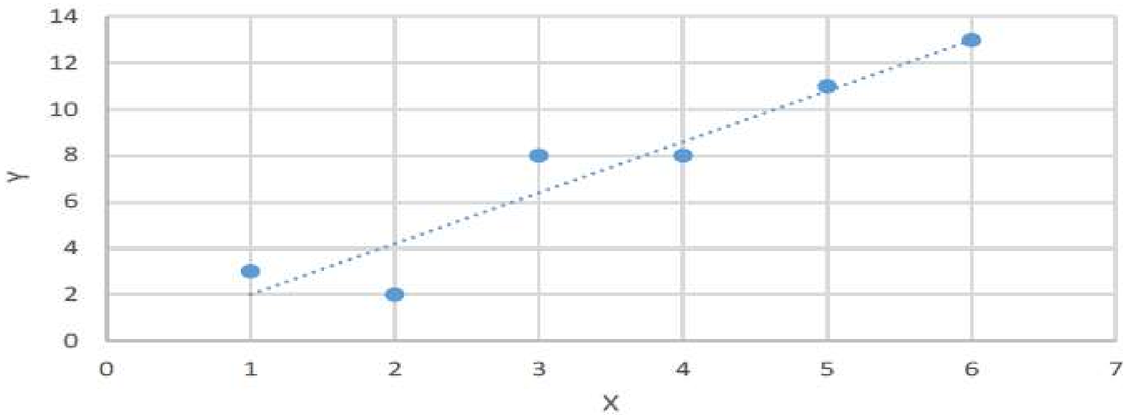


Figure 8 Example of approximately linear relationship

Source: (42)

The points represented by variables X and Y lie exactly on a straight line only in cases where they are fully represented by a function. This does not happen very often. That´s why a technique based on a common measure is needed. The most common solution is the method of least squares. It considers various combinations of the measured X and Y values. The goal of the method is minimising the squares of residuals. A more detailed overview can be seen in Figure 9.

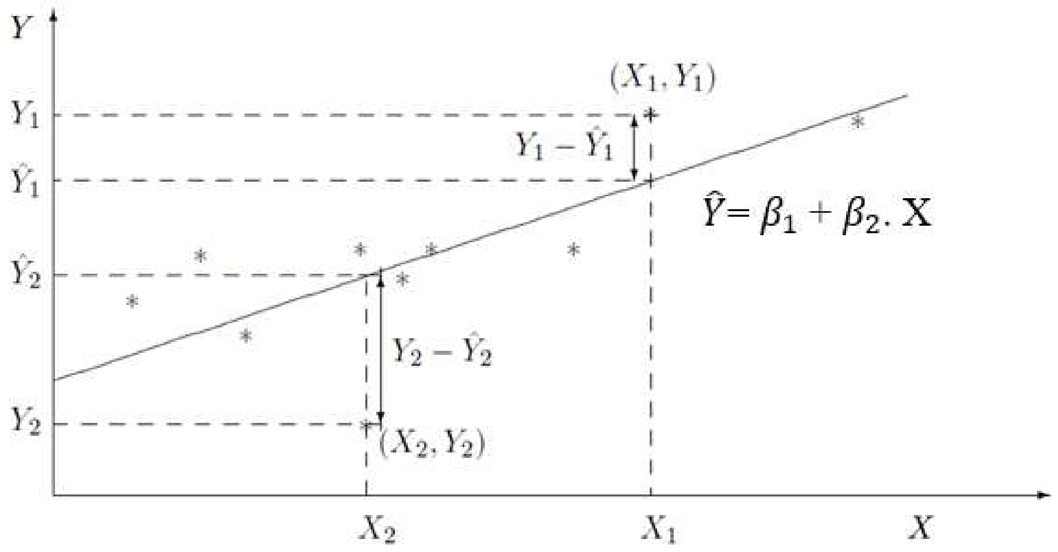


Figure 9 Regression line and representation of residual

Source: (41)

The equation of the regression line is expressed by (4-2) and the residual ε is equal to the difference between $\hat{Y}_i$ and Y_i (4-3).

$$\hat{Y} = \beta_1 + \beta_2 \cdot X \; [-] \tag{4-2}$$

$$\varepsilon_i = Y_i - \hat{Y}_i \; [-] \tag{4-3}$$

Where:

Y_i…Dependent variable

$\hat{Y}_i$…Estimates of dependent variables

X_i…Independent variables

ε_i …Residuals

To obtain a line that fits the points best it is necessary to minimise the sum of the squares of the residuals $\sum \varepsilon_i^2$. A couple of partial derivations is calculated (4-4) and the values for the parameters β_1 and β_2 obtained (4-5), (4-6).

$$\frac{\partial \sum \varepsilon_i^2}{\partial \beta_1} = 0 \, , \frac{\partial \sum \varepsilon_i^2}{\partial \beta_2} = 0 \tag{4-4}$$

$$\beta_1 = \hat{Y} - b \cdot \hat{X} \ [-] \quad (4\text{-}5)$$

$$\beta_2 = \frac{\sum (X_i - \hat{X}) \cdot (Y_i - \hat{Y})}{\sum (X_i - \hat{X})^2} \ [-] \quad (4\text{-}6)$$

4.3.2 Multiple Linear Regression (MLR)

It is common that the dependent variable is affected by more than one independent variable. It is also the case of the analysed data in this dissertation. The linear regression solving this kind of tasks is called Multiple Linear Regression (MLR). The method of least squares is equally used in MLR (42). The basic formula is shown in (4-7).

$$Y_i = \beta_1 + \beta_2 \cdot X_{i2} + \cdots + \beta_k \cdot X_{ik} + \varepsilon_i \ [-] \quad (4\text{-}7)$$

Where:

Y_i…Dependent variables

β_1…Regression parameter intercept

β_2…β_k…Regression parameters slope

x_{11}…x_{13} …Independent variables

ε_i…Residual

The equations can be expressed in a matrix as shown in (4-8). They are solved by linear algebra notations. MS Excel is used in the dissertation to obtain parameters.

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} 1 & x_{12} & x_{13} & \dots & x_{1k} \\ 1 & x_{22} & x_{23} & \dots & x_{2k} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & x_{n2} & x_{n3} & \dots & x_{nk} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_k \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \vdots \\ \epsilon_n \end{bmatrix} \quad (4\text{-}8)$$

Where:

y_1…y_n …Dependent variables

β_1…Regression parameter intercept

β_2…β_k…Regression parameters slope

x_{11}…x_{nk} …Independent variables

ε_1…ε_n…Residuals

There are several forms of MLR. The first one is called Enter and it expects to enter all the variables at the same time. Stepwise and Blocks methods are based on entering variables step by step. The Enter and Stepwise methods calculated in Microsoft Excel will be applied in the dissertation to obtain relationships between the dependent variable I_{flc} and independent variables represented by separate indexes described previously in this chapter.

4.4 MLR Results Interpretation

The analysis performed in Microsoft Excel has three parts of results: Regression Statistics Table, Analysis of variance (ANOVA) table and regression coefficient table (43). Several tests based on residuals are available to assess the obtained function. To understand the indicators describing the quality of the model the formulas (4-9), (4-10) and (4-11) will be used.

$$SSR = \sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2 \ [-] \tag{4-9}$$

$$SSM = \sum_{i=1}^{n}(\hat{Y}_i - \bar{Y})^2 \ [-] \tag{4-10}$$

$$SST = \sum_{i=1}^{n}(Y_i - \bar{Y})^2 \ [-] \tag{4-11}$$

Where:

SSR… Sum of squares of residuals

SSM… Sum of squares of model

SST… Total sum of squares

Y_i…Dependent variable

$\hat{Y}_i$…Estimate of dependent variable

$\bar{Y}$…Average values of dependent variable

The most important indicator is the determination coefficient R^2 which explains how much of the variable is described by the model (44). The more the value of R^2 approaches 1, the more precise the model is. The determination coefficient is obtained as a ratio of SSM and SST (4-12).

$$R^2 = \frac{SSM}{SST} = 1 - \frac{SSR}{SST} \ [-] \tag{4-12}$$

4.5 Economic Analysis

In this part of the thesis, the proposed methodology is supposed to be compared with several simple scenarios of capacity planning frequently today. This includes under-dimensioning, relying on average values of flight volumes as well setting up the coverage according to maximum expected volumes of operations. The associated salary costs are not negligible in this field, and any savings will be highly appreciated by business aviation operators. Financial effects of each of the approaches are compared.

5 PROPOSED METHODOLOGY

The proposed methodology is based on several fundamental assumptions. They are described later in this chapter. Definition of essential parameters in the form of mathematical functions with adequately selected variables complements the assumptions. The output of the methodology is a tool based on two sets of functions: flight-related functions and OCC related functions. The first group includes several sub-functions describing partial areas contributing to their degree of flights complexity. One by one, the author focuses on their characteristics to be able to describe them mathematically. The latter group of functions is straightforward and reflects the number of dispatchers on each shift and their quality assessment.

5.1 Introduction

The method is based on a combination of known current data and historical data. It expects to estimate what effects will future flights, and their combination, have on the OCC. Some of the parameters and variables are quite evident and can easily be identified immediately when a flight is created. Unfortunately, other parameters are hardly predictable and can only be measured precisely during flight preparation or, in the worst case, only after the flight is executed. Because of this conflict of source data, the methodology proposed by the author will have to be partly based on historical data to create conditions for a realistic guess of the current setup. The logic is shown in Figure 10.

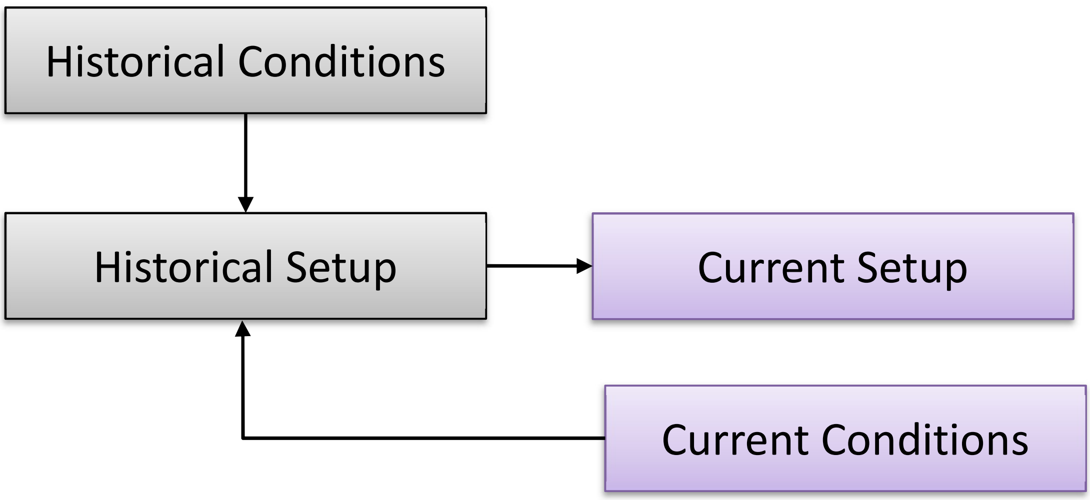


Figure 10 Data and setup sources for the definition of new setup

Source: Author

To be able to see how well a shift is covered by adequate composition and number of dispatchers, the OCC Shift Capacity and Shift Demand Indexes are introduced. The goal is to compare them and find misbalances between them for each day. The simple methods very often used today bring unnecessary over-dimensioning of OCC to be able to respond to maximum possible volumes or under-dimensioning very often respecting average values of parameters. Both of the approaches bring a lot of disadvantages such as low-utilisation resulting in higher risk to commit errors or inadequately high cost of dispatchers when the operation volumes are low. The author considers the application of dynamic planning and assignment dispatchers to shifts as a solution leading to savings and better workforce coverage.

5.2 Assumptions

Successful implementation of the methodology proposal into operational control is based on several assumptions delimiting the problem. High understanding is expected from the management teams of the companies and their OCCs to implement an improving solution to the company´s and department´s structures. In-depth details of each of the assumptions are listed in the following paragraphs.

A. Operators are looking for a reliable and long-term OCC solution

This approach is fundamental for all OCCs that would like to apply the proposed methodology. As stated in the first parts of the thesis, some operators run highly risky OCCs with a reactive and unstable approach to solving problems. Inputs from the operation are an essential part of the algorithm. It is expected that the algorithm provides a higher degree of precision in time. Patience with collecting data is an integral part of the implementation.

B. Operators have functioning tools to collect and analyse data

Some operators do not have financial, human or mental resources to collect critical operational data and use them for further analysis. This fact prevents them from obtaining valuable information for management of their OCC. The more data are available, the more precise and wide-ranging the proposed algorithm may become. The mentioned tools include data stores in a unified format so that all the records may be easily compared with one another. The usual software solutions have been mentioned in chapter 1.2.2. These sources are ideal tools to be used for logging information that is crucial for building the algorithm.

C. Operators are dedicated to continuous improvement

Operations Control Centres can only be viable if they are based on continuous improvement. That means learning lessons from previously committed errors and having the ability not to repeat them again. Aviation is a sector where the application of the latest technology trends typically comes swiftly. It is vital to stay informed about the industry news and be open to this development. It translates to streamlining and simplification of processes. This ability must be supported by the operators' management teams.

D. Operators look for a cost-efficient solution

In the business aviation field costs are typically crucial elements for companies to survive in the competition with other operators. It is expected the operators will not be willing to look for significantly more or equally expensive solutions. The methodology will have to be in a form that can be easily demonstrated to end-users.

E. The proposed methodology is flexible and easily adjustable

Business Aviation is sometimes very unpredictable. Operators are requested to change their structure, number of operated aircraft or the whole scope of operations. To reorganize OCCs compositions is not always as quick as the changes taking place. It is no surprise that the proposed tool must be simple enough to remain flexible and adjustable should such major operational changes of the OCC structure occur.

F. The proposed methodology does not compromise the quality

Reasonably, operators look for solutions that enhance an increase of the capacity of their OCCs without compromising quality. The lowering level of quality is sometimes linked to the implementation of new rules without a proper setup, for example, putting a new software solution into practice. Dispatchers may be left behind in situations that are difficult to solve. As a result, they lose their capacity to perform their primary duties.

5.3 Flight-related Functions and Indexes

To adequately describe the flight-related processes a set of functions is needed. The purpose to set them up is quantifying operational control in its every-day aspects. Some of them are related to flights and some to OCCs and their dispatchers. The author offers the below-described set of flight-related functions and variables. The first functions are related to the analysis of historical statistics. The absolute results can be more precise in cases where the frequency of occurrence is lower but in order to make the proposed functions comparable even though most of them are dimensionless, the author uses a probability scale from zero to one in all cases.

5.3.1 The Familiarity of the Departure Airport F_{da}

In this thesis F_{da} represents a ratio of departures from the airport supported by the OCC in the last twelve months to the number of all departures in the same period. It is undisputed that the more a departure airport is visited, the higher gets F_{da} be. The function was tested on the mentioned real set of data. The results depend very much on the character of operations. In the case of the analysed extract, a total of 169 flights were operated. The author could identify 37 different airports were visited during the observed period and only fifteen of them more than once. This is a typical result for business aviation. The distribution of the operation can be seen in Figure 11 Distribution of visited airportsFigure 11. This operating model apparently has a stable home base of the aeroplane. Other destinations are more or less regular visits, typically not lasting many days. This behaviour is characteristic for private purpose aeroplanes that are not often used for charter market. Another typical characteristic applicable to the whole business aviation community is the fact that the majority of airports are visited only once in the measured period (in the case of the analysed data as many 60% of the visited airports had a frequency of only one visit per year).

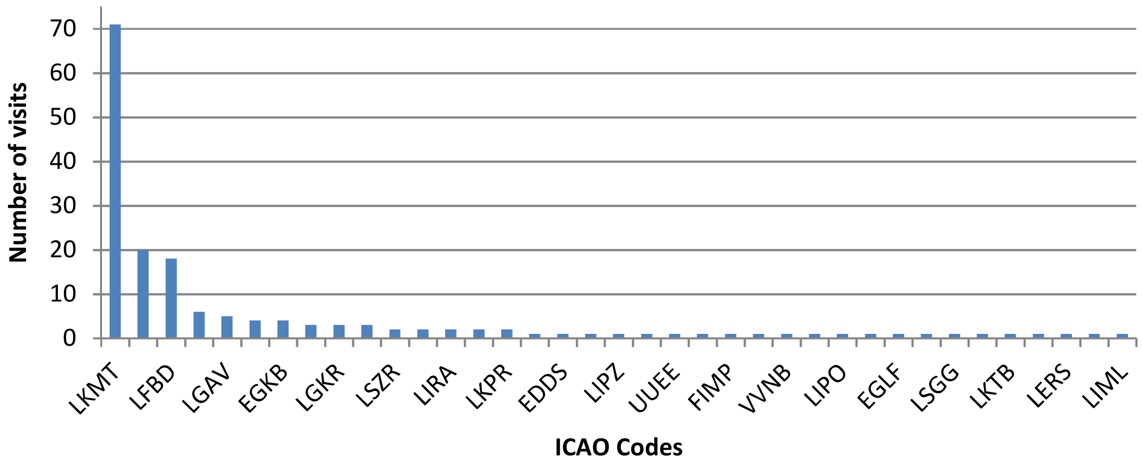


Figure 11 Distribution of visited airports

Source: Author

The F_{da} of the visited airports changes in time and with every subsequent visit made. When the whole year is analysed, values between 0.1 and 0.4 are obtained for top destinations. Low-frequency destinations keep the value of F_{da} close to zero. The proposal of familiarity of the departure airport is expressed by Formula (5-1). The mathematical representation of F_{da} is a positive number ranging from zero to one. The calculation of F_{da} is only applicable if n≠0 (nothing can be measured if no previous flights were supported).

$$F_{da} = \frac{\sum_{i=d-1}^{d-366} n_{di}}{\sum_{i=d-1}^{d-366} ni} \, [-] \qquad (5\text{-}1)$$

where:

n_d …Number of flights supported departing from the same airport [number]

n…Number of all flights supported [number]

d…Day of operation [−]

Min F_{da}= 0

Max F_{da}= 1

The distribution of F_{da} of the analysed extract is shown in Figure 12.

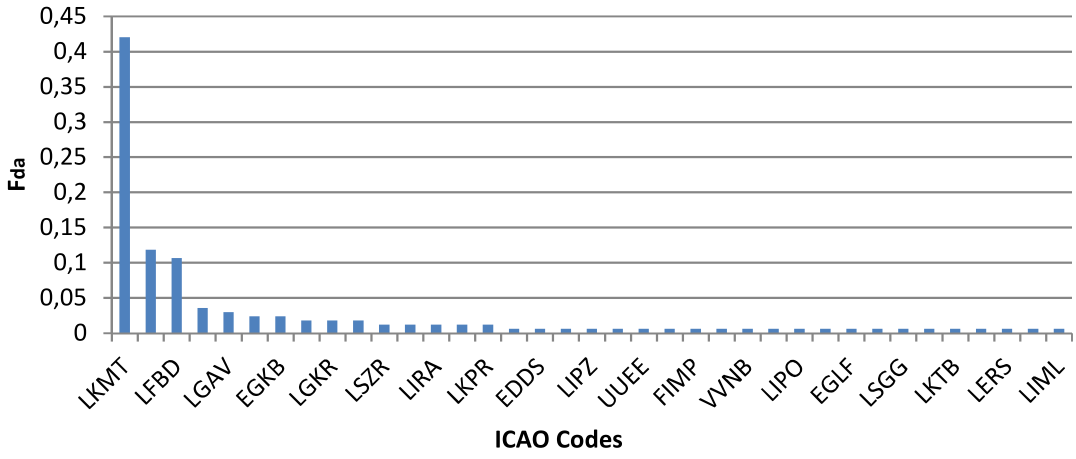


Figure 12 Familiarity of the departure airport

Source: Author

To describe how F_{da} changes in time a set of four most frequented airports was selected and analysed. The results are shown in the graph where the cumulative number of flights was compared with the cumulative number of visits of each destination in each calendar month. It was found the behaviour depends very much on the fact if the airport is a frequent destination or not. All the functions start at [0, 0] and approach asymptotically n. A graphical representation of the result is shown in Figure 13.

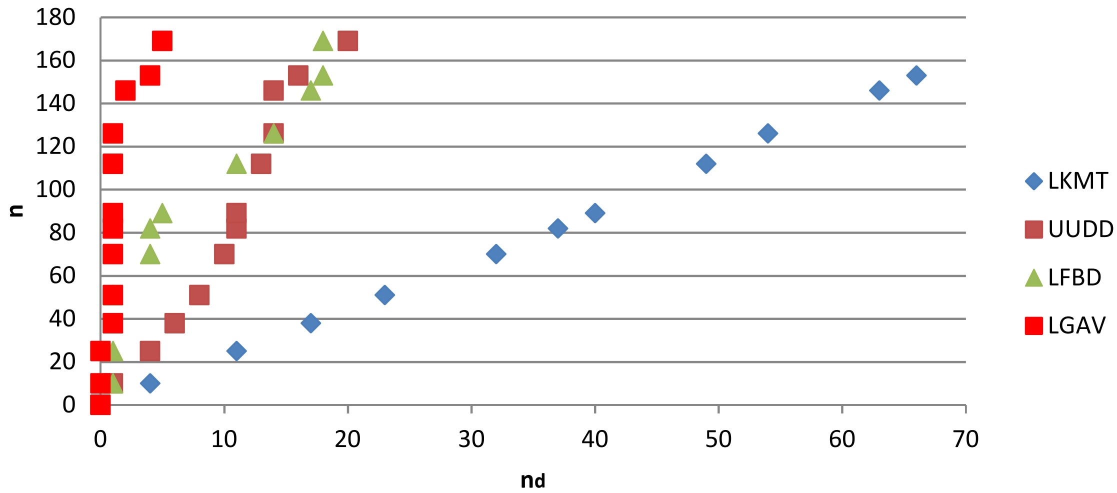


Figure 13 Dependency of airports visits on a total number of flights

Source: Author

5.3.2 The Familiarity of the Arrival airport F_{aa}

The F_{aa} represents a ratio of arrivals in this airport supported by the OCC in the last twelve months compared with the full set of arrivals. It is evident that the more an arrival airport is visited, the higher gets F_{aa}. Every arrival airport is the departure airport for the next flight. The numerical representation of F_{aa} is identical as is the case of F_{da}. The proposal of familiarity of the arrival airport is expressed by Formula (5-2) and the mathematical representation of F_{aa} is a positive number ranging from zero to one. The calculation of F_{aa} is only applicable if n≠0 (nothing can be measured if no previous flights were supported).

$$F_{aa} = \frac{\sum_{i=d-1}^{d-366} n_{ai}}{\sum_{i=d-1}^{d-366} ni} [-] \quad (5\text{-}2)$$

Where:

n_a…Number of flights supported arriving in the same airport [number]

n…Number of all flights supported [number]

d…Day of operation [−]

Min F_{aa}= 0

Max F_{aa}= 1

5.3.3 The Familiarity of City Pair F_{cp}

The F_{cp} represents the number of the same or vice-versa city pairs operated during in the last twelve months. The more frequent a city pair is, the fewer surprises will a dispatcher theoretically encounter in its preparation. Compared to entirely unknown airports, preparation of flights between frequent city pairs also eliminates basic information research to a significant extent. Apart from departure and arrival airports, the knowledge of the airspace between them, mainly airways system specifics, must be considered here. The data were analysed, and the frequency of city pair operations observed. The result available in Figure 14 clearly shows the city pairs are operated in lower volumes. Most of the city pairs have the frequency of occurrence very low.

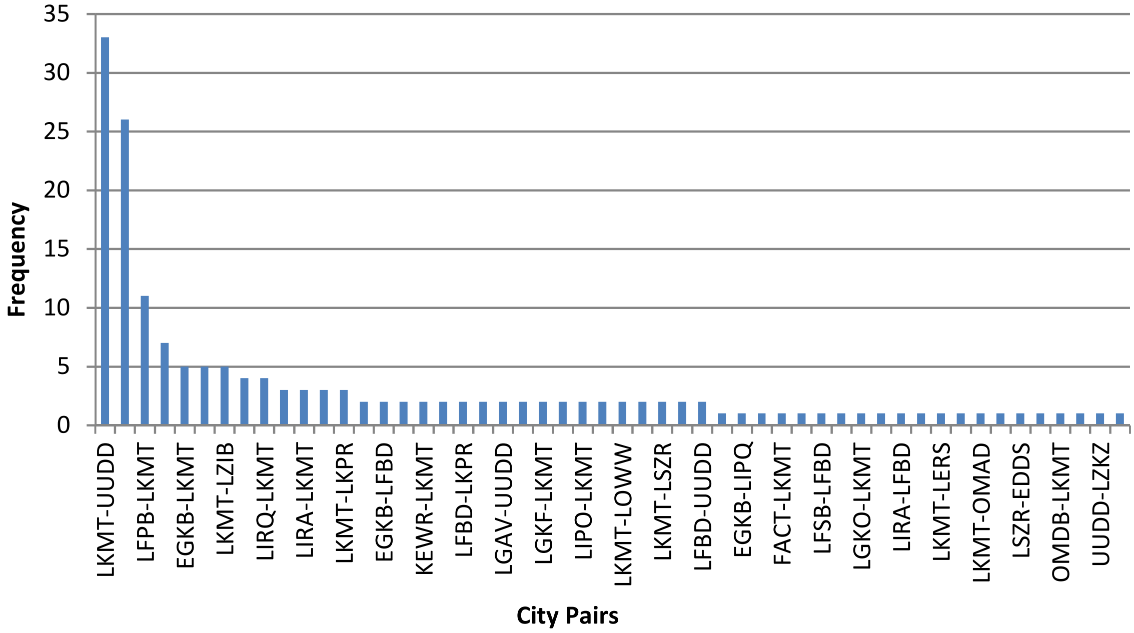


Figure 14 Frequency of city pair occurrence

Source: Author

The familiarity of city pair is calculated according to the introduced Formula (5-3), and its mathematical representation is a positive number ranging from zero to one. The calculation of F_{cp} is only applicable if n≠0 (nothing can be measured if no previous flights were supported).

$$F_{cp} = \frac{\sum_{i=d-1}^{d-366} n_{adi}}{\sum_{i=d-1}^{d-366} ni} \; [-] \qquad (5\text{-}3)$$

Where:

n_{ad} …Number of identical city pairs supported [number]

n…Number of flights supported [number]

d…Day of operation [−]

Min F_{cp}= 0

Max F_{cp}= 1

5.3.4 Geographical Area Index I_{ga}

The I_{ga} represents the numerical evaluation of the complexity of a geographical area. Division of the world areas respects basic ICAO codex where the first letter of the airport in ICAO code represent the area according to the scheme provided in Figure 15.

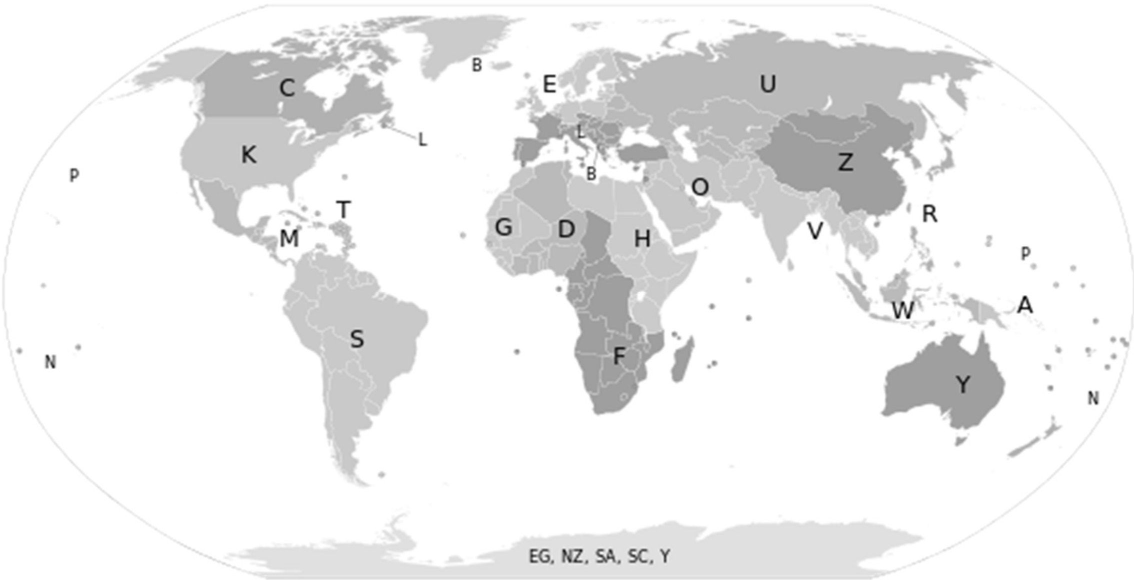


Figure 15 ICAO codes division

Source: Wikipedia

The corresponding value of I_{gad} and I_{gaa} is based on the author´s personal experience and is shown in Table 12. For a different operation, the division may be easily done in a different manner, but the goal is always to sort out separate letters of ICAO codes in order of complexity to express their effect on preparation demand and assign an adequate coefficient of I_{gad} and I_{gaa}.

Table 12 Geographical indexes proposal

Group	I_{gad} and I_{gaa}	Geographical Area
1	0.1	E, L
2	0.2	B, C, K
3	0.3	M, O, S, T, U,
4	0.4	A, N, P, R,V, W, Y, Z
5	0.5	D, F, G, H

Source: Author

When an analysis of the data extract is done, a very strong presence of departures and arrivals from the group one which represents ICAO codes starting with E, L can be seen. They correspond to European airports. This is very logical, and every extract has many operations from home base as well as from nearby airports. For the real operations, it is essential to set up corresponding indexes with the home base location and geographical scope of operations in mind. The results of the analysis of the geographical area index are provided in Figure 16.Figure 16 Representation of geographical area index division

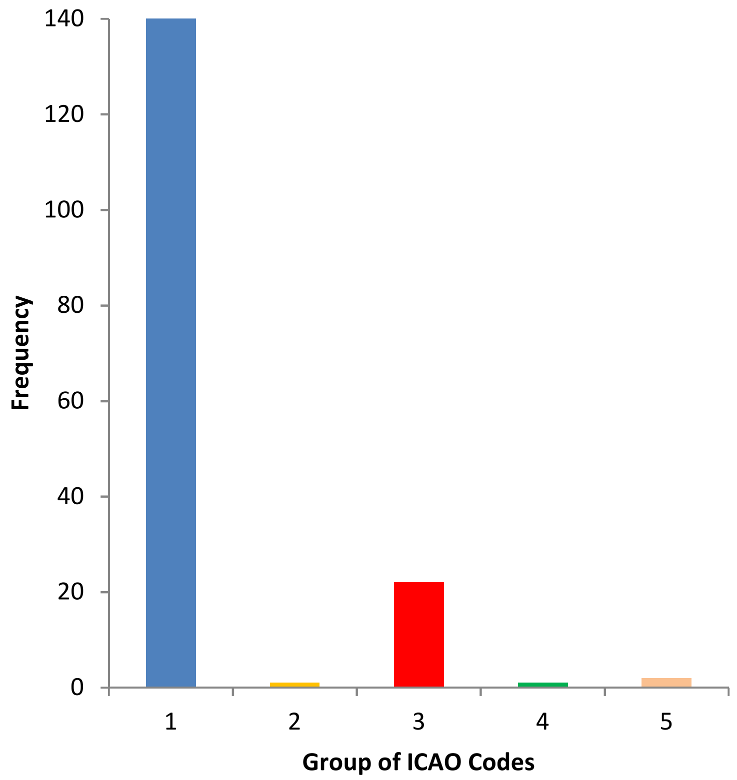


Figure 16 Representation of geographical area index division

Source: Author

The Geographical area index function is a simple combination of indexes of the departure and arrival airports. It is expressed by the Formula (5-4). Mathematical representation of I_{ga} is a positive integer number ranging from 0.2 to one.

$$I_{ga} = I_{gad} + I_{gaa} \quad [-] \tag{5-4}$$

Where:

I_{gad}…Departure Airport Geographical Index $[-]$

I_{gaa}…Arrival Airport Geographical Index $[-]$

Min I_{ga}= 0.2

Max I_{ga}= 1

5.3.5 Services Complexity Index I_{svc}

The I_{svc} is an index showing how difficult it is to arrange services for a flight considering ground services, permits and additional services. Based on the analysis of the available data set the average number of services per flight was identified to correspond to approximately five. The author proposes a division of indexes listed in Table 13.

Table 13 Complexity indexes proposal

Group	I_{svc}	
1	0.3	Ns<5
2	0.6	6<Ns<10
3	1	Ns>10

Source: Author

On the analysed set of data with the occurrences, it can be seen that there is no strong presence of one index. Based on the flight´s difficulty a lot of flights falling into the second group can be seen. The results are presented in Figure 17.

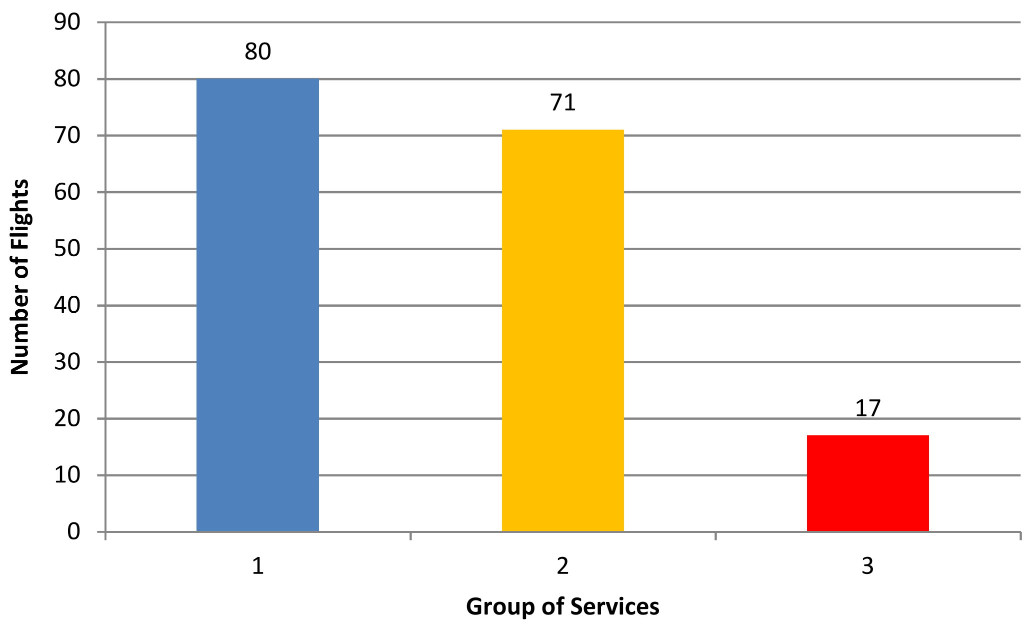


Figure 17 Divison of services complexity indexes

Source: Author

Mathematical representation of I_{svc} is a positive number ranging from 0.3 to one.

Min I_{svc}= 0.3

Max I_{svc}= 1

5.3.6 Number of Flight Changes Index I_{nch}

The N_{ch} represents the number of changes in significant pieces of information related to one flight between its confirmation and execution. The observed data are changes in times and dates, operating aircraft and any changes to airports of departure and arrival. The author analysed the available data and decided to base the index on the maximum amount of changes occurring on one flight N_{chMax}. In the case of this specific data, the results show that N_{chMax} is equal to eight. Graphical results of the analysis are shown in Figure 18. The index is suggested to reflect this amount by introducing Formula (5-5) Mathematical representation of I_{nch} is a positive number ranging from zero to one.

$$I_{nch} = \frac{N_{ch}}{N_{chMax}} \ [-] \qquad (5\text{-}5)$$

Where:

N_{ch}…Number of significant changes related to one flight between its confirmation and execution [number]

N_{chMax}…Maximum number of changes per flight occurring in the set of analysed records [number]

Min I_{nch}= 0

Max I_{nch}= 1

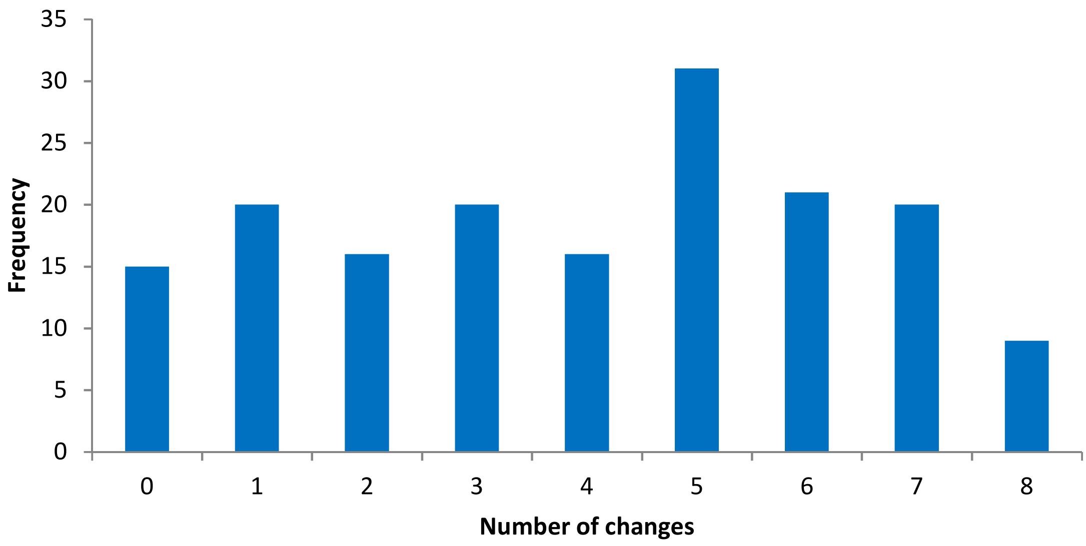


Figure 18 Occurrence of changes on flights

Source: Author

To be able to use I_{nch} in the Flight Complexity function to determine effects on the future flight, it is appropriate to use average I_{nch}= 0.5. If a flight is evaluated retrospectively, I_{nch} can be measured. In other cases, it is necessary to estimate it by using an average value, for example.

5.3.7 Knowledge of Flight Index I_{kn}

As soon as the value of date and time of notification and date and time of departure are known, a new variable is set up. It represents how much in advance, the OCC knows about a new flight. The variable is called Knowledge of flight T_{kn}. In business aviation, this parameter can easily range from days to hours. If values of this parameter are low, an extra pressure on the dispatchers may be expected. The author analysed the same set of yearly data again. The obtained values of T_{kn} ranged from 4h05 to 222h30. The average value of knowledge of flight was 48 hours 30 minutes. The most recurrent values are described in Figure 19 and they show that most flights are created just slightly over 22 hours before departure.

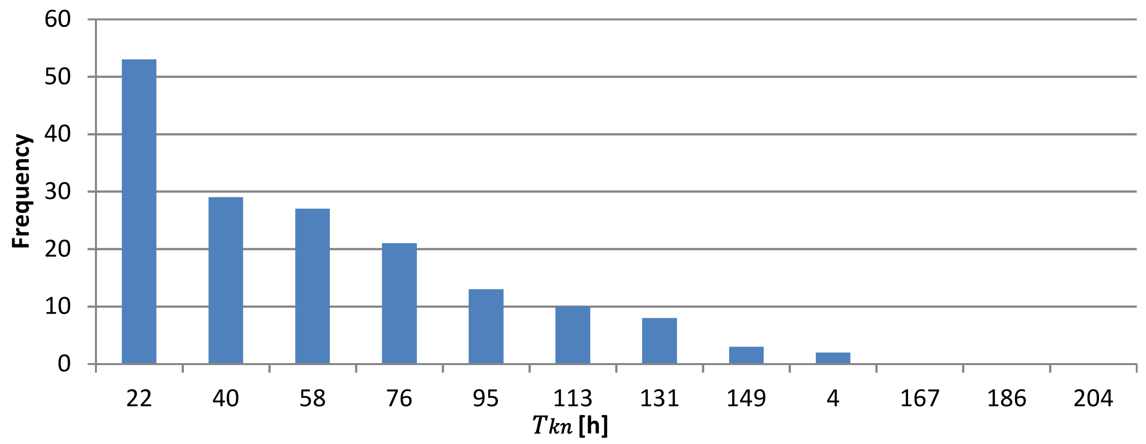


Figure 19 Histogram of flight knowledge based on yearly data

Source: Author

Another view on the full set of analysed data showing one value per flight and assigned to appropriate month is presented in Figure 20 from which it can be seen there are is no seasonality in the T_{kn} values and flights creation have a somewhat random character.

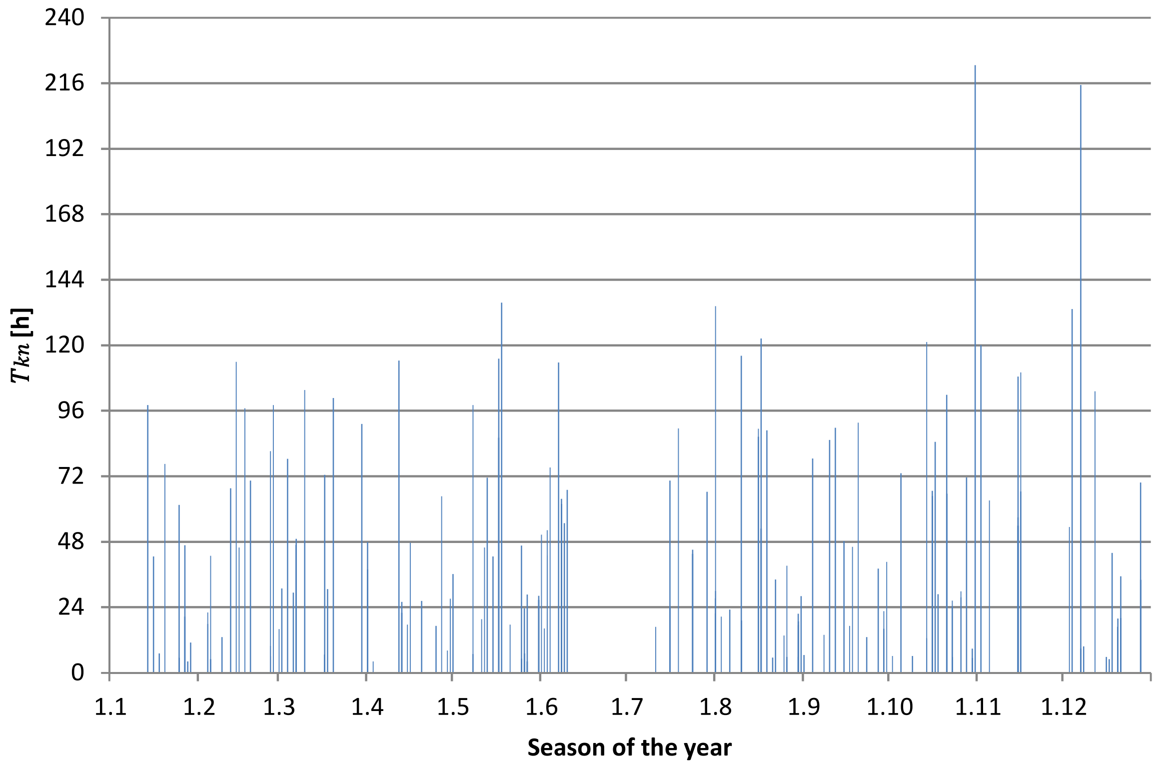


Figure 20 Seasonality in knowledge of flight

Source: Author

In order to be able to numerically evaluate future flights when their T_{kn} is known, an additional parameter Index of knowledge is set up. To correspond with the remaining previous functions, a representation of the index reaching values between zero and one was searched. The author assumes that there is a value of T_{kn} where the index approaches zero and does no longer decrease significantly with increasing T_{kn}. Dispatchers simply have enough time to prepare the trip and no additional time gives them any extra advantage. A function showing the dependence of increasing I_{kn} on decreasing T_{kn} is needed for this case. The author identified the available set of functions and selected the Monod equation (5-6) often used in environmental engineering as a suitable candidate. The initial form of the Monod functions is called I_{knA}. The Monod equation works with values of T_{kn} causing the medium value of I_{kn}. This value was fixed by the author at two days. In order to meet the specific criteria, the author has adjusted the equation by deducting the value of the function from I_{knmax} (5-7). The adjusted form of the Monod functions is called I_{knB}. For this simplified case where the mathematical representation of I_{knB} is a number ranging from zero to one and I_{knmax} is equal to one and T_S is equal to two, the final version of the index is expressed in Formula (5-8). Graphically, the adjusted Monod equation is shown in Figure 21.

$$I_{knA} = (I_{knmax} \cdot \frac{T_{kn}}{T_{kn}+T_s}) \ [-] \tag{5-6}$$

$$I_{knB} = I_{knmax} - (I_{knmax} \cdot \frac{T_{kn}}{T_{kn}+T_s}) \ [-] \tag{5-7}$$

$$I_{kn} = 1 - \frac{T_{kn}}{T_{kn}+2} \ [-] \tag{5-8}$$

Where:

I_{kn} …Knowledge of flight index [−]

I_{knmax}…Maximum knowledge of flight index (here $I_{knmax} = 1$) [−]

T_{kn}…Flight notification expressed in date and time [days]

T_s…Defined time in which I_{kn} reaches its medium intensity (here $T_s = 2$ days) [days]

Min I_{kn}= 0

Max I_{kn}= 1

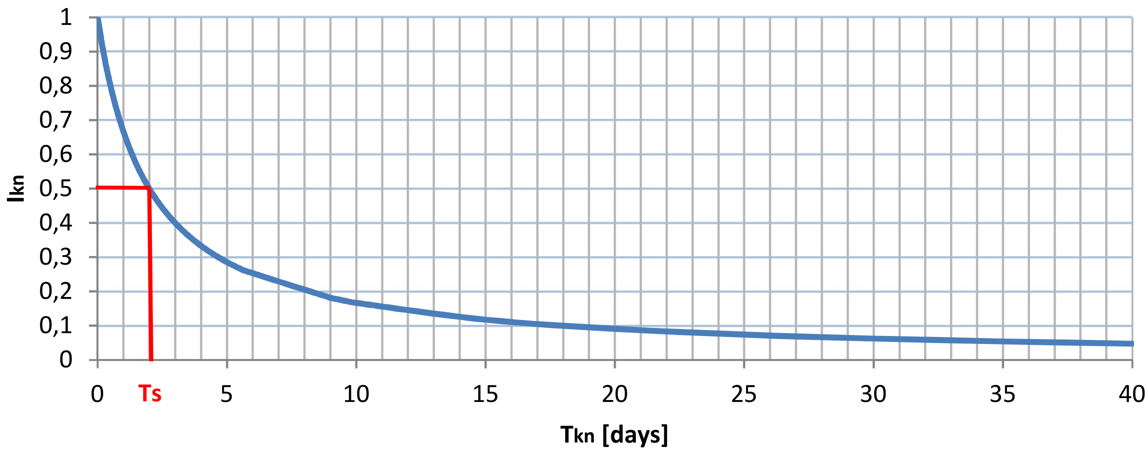


Figure 21 Adjusted Monod equation

Source: Author

5.3.8 Flight Preparation Duration T_{fp}

T_{fp} represents the time between flight confirmation and dispatching. In cases when values of flight knowledge are high, the flight preparation takes longer because only critical tasks are performed first, and the remainder of them is done continuously as the flight date and time approach. A flight is considered prepared when all its corresponding services are confirmed, the flight documentation is generated and the crew can take over the aeroplane to fly. The proposal is described by Formula (5-9). The author analysed how closely the values of Knowledge of Flight (T_{kn}) and Flight Preparation Duration (T_{fp}) are linked. The results are shown in Figure 22 where the red colour represents values of T_{kn} and the blue one shows values of T_{fp}, provide logical and expected results. The earlier the flights are notified, the longer takes their preparation. This is caused by the fact, that their preparation is done step by step (the most critical tasks are done immediately) and the final steps must always be done shortly before the flight ETD. T_{fp} is one of the parameters that are only measurable retrospectively. It is difficult to use it to evaluate a specific flight complexity, but it may be useful for the definition of typical values of T_{fp} when past data are available.

$$T_{fp} = T_{dis} - T_{kn} \ \ [h] \qquad (5\text{-}9)$$

Where:

T_{dis}…Dispatched flight expressed in date and time [−]

T_{kn}…Flight notification expressed in date and time [−]

Min = 0 (in practise min $T_{fp} > 0$)

Max = ∞ (in practise max $T_{fp} = T_{kn}$)

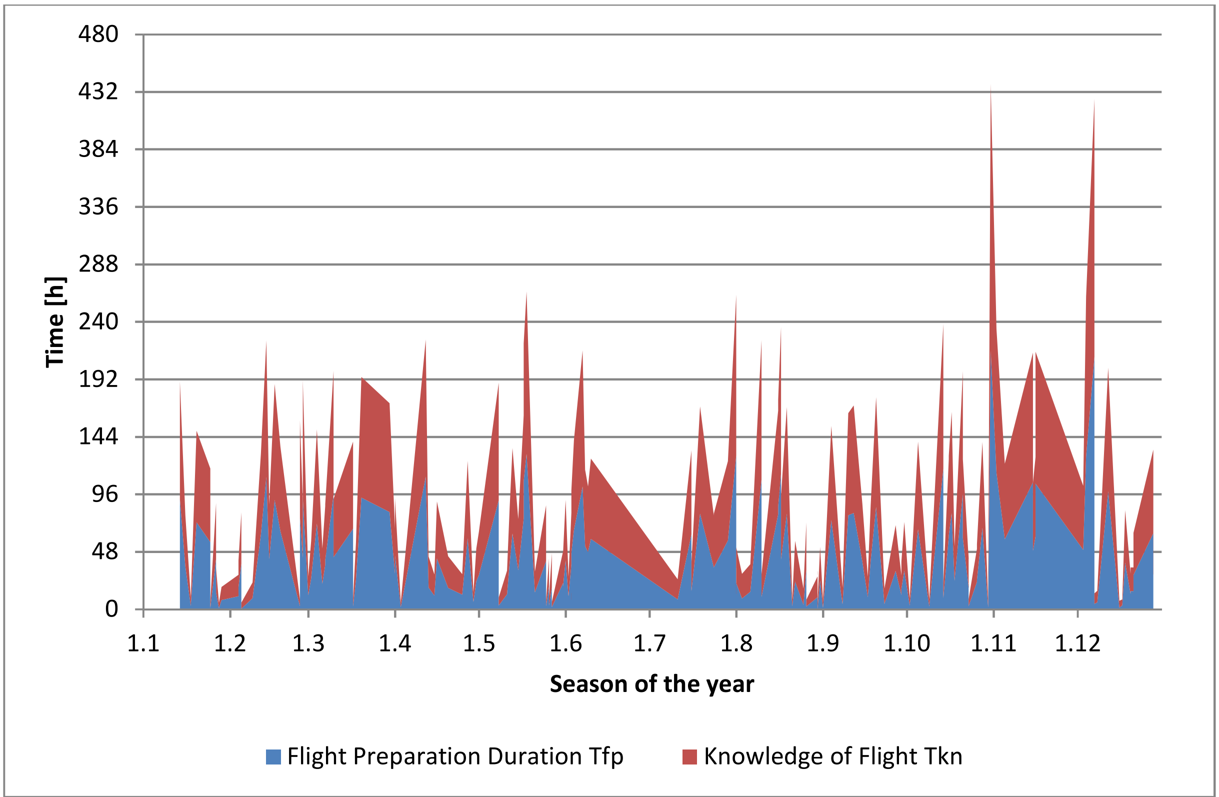


Figure 22 Dependency of knowledge of flights and their preparation duration

Source: Author

5.3.9 Flight Readiness T_{re}

Another collateral variable that can easily be calculated is Flight Readiness. The author performed an analysis of the available set of data to see what typical values of this parameter look like. Subsequently, yearly differences in season's patterns were observed. The outcome is available in Figure 23. It can be seen the obtained values are not constant throughout the whole measured period. There is a significant increase in flight readiness in the middle of the year. It increases in spring, reaches its maximum during the summer season and then decreases again in autumn to reach its minimum values in winter. The major contributor to the seasonality is the weather. Whereas many trouble free flights are prepared in the summer season where effects of adverse weather are much lower, in winter time due to more sensible weather patterns flight plans are re-calculated ad changed till the very last moment. This parameter is only measurable retrospectively (in the same way as T_{fp}).

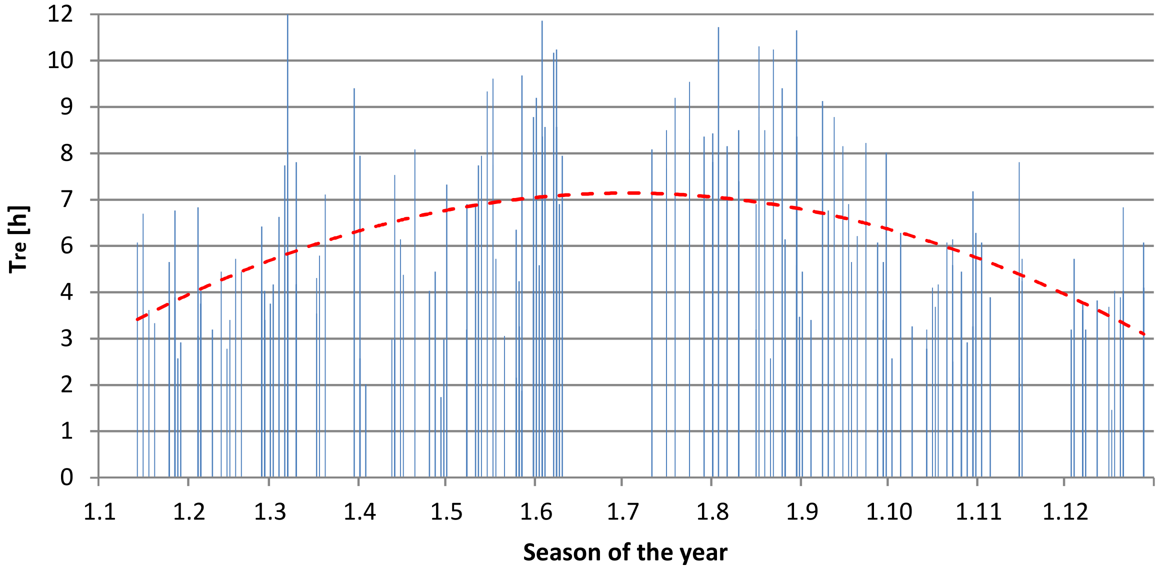


Figure 23 Flight readiness representation

Source: Author

The flight readiness is expressed by the Formula (5-10), and its mathematical representation is a positive number ranging from zero to T_{kn}.

$$T_{re} = ETD - T_{dis} \ [h] \tag{5-10}$$

Where:

ETD …Flight departure expressed in date and time [−]

T_{dis}…Dispatched flight expressed in date and time [−]

Min = 0

Max = T_{kn}

5.3.10 Flight Complexity Function I_{flc}

The flight complexity is affected by geographical, political, meteorological, organisational and technical factors. These factors together influence how complicated a flight is. It needs to be assessed which of them are predominant and which are not important and can be omitted from the calculation. To be able to calculate a function where I_{flc} is a dependent variable the author analysed data containing different values of the independent variables F_{da} (Familiarity of the departure airport), F_{aa} (Familiarity of the arrival airport), F_{cpa} (Familiarity of city pair), I_{ga} (Geographical area index), I_{svcs} (Services complexity index), I_{nch} (Number of flight changes index) and I_{kn} (Knowledge of flight index). T_{re} is not considered in the definition of I_{flc} because it is very difficult to predict its values in advance. The desired function is in the shape described in (5-11).

$$I_{flc} = \beta_1 + \beta_2 \cdot F_{da} + \beta_3 \cdot F_{aa} + \beta_4 \cdot F_{cp} + \beta_5 \cdot I_{ga} + \beta_6 \cdot I_{svc} + \beta_7 \cdot I_{nch} + \beta_8 \cdot I_{kn} \; [-] \qquad (5\text{-}11)$$

Where:

F_{da} …Familiarity of the departure airport $[-]$
F_{aa} …Familiarity of the arrival airport $[-]$
F_{cp} …Familiarity of city pair $[-]$
I_{ga} …Geographical area index $[-]$
I_{svc} …Services complexity index $[-]$
I_{nch} …Number of flight changes index $[-]$
I_{kn} …Knowledge of flight index $[-]$
$\beta_1 … \beta_8$…Regression parameters slope and intercepts $[-]$

To provide a numeric value of I_{flc} for the multiple linear regression (MLR), the author uses a ratio of an individual time of preparation and an average time of preparation as described in (5-12).

$$I_{flc} = \frac{T_{fp}}{T_{fpavg}} \; [-] \qquad (5\text{-}12)$$

The first question is to find out what is the relationship would be between the variables. This is done through the correlation analysis. From Table 14 it is evident there is a strong correlation between F_{aa} and F_{da}. This fact was logically expected due to the nature of the variables. A medium intensity correlation is additionally found between I_{svc} and I_{ga}.

Table 14 Correlation Analysis of Independent Variables

	Fda	Faa	Fcp	Iga	Isvc	Inch	Ikn
Fda	1						
Faa	-0.67544	1					
Fcp	0.240138	0.236893	1				
Iga	0.02151	0.06513	0.427522	1			
Isvc	-0.01811	-0.00888	-6.8E-05	0.582896	1		
Inch	0.04987	-0.16904	-0.11333	-0.04306	-0.08673	1	
Ikn	0.316256	-0.31697	-0.08884	-0.32412	-0.19034	0.144521	1

Source: Author

In the next step, the MLR is calculated in MS Excel combining all the variables at the same time (Enter method). It brings the results described in Table 15.

Table 15 Results of MLR (Enter method)

Model Summary	
R	0.922311
R Square	0.850658
Adjusted R Square	0.844124
Standard Error of the Estimate	0.368162
Observations	168

ANOVA

	Difference	*SS*	*MS*	*F*	Significance F
Regression	7	123.5293018	17.64704	130.1949134	1.04947E-62
Residual	160	21.68692176	0.135543		
Total	167	145.2162236			

	Coefficients	Standard error	*t Stat*	P-value	*Lower 95%*	*Upper 95%*
Intercept	3.018983	0.178241403	16.93761	1.6147E-37	2.666973561	3.370992
Fda	0.628692	0.246019628	2.555453	0.011536854	0.142827165	1.114556
Faa	0.390401	0.238708913	1.63547	0.103916288	-0.081025308	0.861828
Fcp	-3.58243	0.868852122	-4.12318	5.9872E-05	-5.298328897	-1.86653
Iga	1.625937	0.417985287	3.889937	0.00014675	0.800456734	2.451416
Isvc	-0.17382	0.170944102	-1.01682	0.310776356	-0.511416368	0.163779
Inch	-0.18249	0.099010498	-1.8431	0.067165379	-0.37802175	0.01305
Ikn	-4.12541	0.163639214	-25.2104	1.32709E-57	-4.448578714	-3.80224

Source: Author

The high value of R^2 shows the model is a good representation of the reality. The value of significance F is very low, which confirms the model is also significant. After the Enter MLR the function would have the following form:

$$I_{flc} = 3.02 + 0.63 \cdot F_{da} + 0.39 \cdot F_{aa} - 3.58 \cdot F_{cp} + 1.63 \cdot I_{ga} - 0.17 \cdot I_{svc} - 0.18 \cdot I_{nch} - 4.14 \cdot I_{kn} \quad (5\text{-}13)$$

Nevertheless, the P-values (higher than 0.05) marked by the red colour show there are variables which are not significant (F_{aa}, I_{svc} and I_{nch}). Because the model includes insignificant coefficients, it is necessary to look for its improvement.

5.3.11 Improvement and Simplification of Iflc

To improve and simplify the obtained model the stepwise approach of MLR is applied. In the first step F_{da} is removed from the regression due to its high level of correlation to F_{aa} discovered during the correlation analysis. In the next step, simple regression analyses are performed for each remaining variable, one by one and those with p-values higher than 0.05 are removed from the model for their low significance (marked with red colour in Table 16). In this case, it is F_{cp}. The variable with the lowest p-value is I_{kn}. The result of the Step 1 is a model with one independent variable I_{kn}.

During step 2 several models of MLR for a couple of regressors are calculated. It is always I_{kn} and one of the remaining variables. Identically with the first steps, the variables with p-value higher than 0.05 are removed from the model. The results of separate steps are recorded in Table 19.

Table 16 Partial results of MLR (Stepwise method)

	Step 1 - all	*Step 2 Ikn + 1*	
	p-value	**p-value**	**significance**
Faa	0.001	0.245803	3.77E-63
Fcp	0.719361		
Iga	5.31E-07	0.008002	2.18E-64
Isvc	0.002159	0.051152	1.1E-63
Inch	0.022495	0.165305	2.82E-63
Ikn	2.12E-64		

Source: Author

The result of the Step 2 is a model with two independent variables $\mathrm{I_{kn}}$ and $\mathrm{I_{ga}}$. Because there are no other variables left, this is also the last step of the stepwise MLR. The detailed results are shown in Table 20.

Table 17 Results of MLR (Stepwise method)

Model Summary	
R	0.911494
R Square	0.830822
Adjusted R Square	0.828771
Standard Error of the Estimate	0.385867
Observations	168

ANOVA

	Difference	*SS*	*MS*	*F*	Significance F
Regression	2	120.6488	60.3244	405.1515	2.18E-64
Residual	165	24.56742	0.148893		
Total	167	145.2162			

	Coefficients	Standard error	*t Stat*	P-value	*Lower 95%*	*Upper 95%*
Intercept	3.146253	0.142173	22.12972	2.97E-51	2.86554	3.426967
Iga	0.804353	0.299615	2.684625	0.008002	0.21278	1.395926
Ikn	-4.1206	0.158858	-25.9389	4.19E-60	-4.43425	-3.80694

Source: Author

After the Stepwise MLR application, the simplified function has the form expressed by the formula (5-14) with three coefficients.

$$\mathrm{I_{flc}} = 3.15 + 0.8 \cdot \mathrm{I_{ga}} - 4.12 \cdot \mathrm{I_{kn}}\ [-] \tag{5-14}$$

It can be stated that the flight complexity is a 83% function of the geographical area index and knowledge of flight index. This fact is very useful because its both parameters are very easy to obtain and they do not change in time.

5.4 OCC-related Functions and Indexes

To describe the OCC related processes in the best possible way a set of functions and indexes is needed again. The purpose to set them up is quantifying operational control in its every-day aspects. The author suggests the set of OCC related functions and variables listed in the following chapters. To make the proposed functions comparable to a maximum degree, even though most of them are dimensionless, the author uses a scale from zero to one in all cases.

5.4.1 Flight Amount Index I_{nfl}

The number of supported flights is a crucial and at the same time simple parameter to measure capacity. This parameter is directly proportional to the workload it creates. Because dispatchers are typically most loaded with flights that happen on the shift day and the one following, the author has simplified the measurement and defined I_{nfl} as the number of operated flights on the date of shift plus the number of planned flights on the following day divided by two (5-15). This could be made even more accurate by setting the denominator to two N_m where N_m represents the maximum number of flights in a predefined period (for example maximum of every Sunday) or a maximum number of flights in one day in one year. To cover seasonal changes, it is advisable to use maximums of shorter periods than one year. The same logic can be applied working with monthly, quarterly or yearly statistics. Each of the compared values bears, of course, a different degree of precision. To keep this indicator as simple as possible, the formula (5-15) is used without adjustments.

$$I_{nfl} = \frac{N_d + N_{d+1}}{2} \, [-] \qquad (5\text{-}15)$$

Where:

N_d ...Number of all flights operated on the day of the shift [number]

N_{d+1}...Number of all flights operated on the following day [number]

Having analysed the effects of counting with a number of flights compared to using Flight Complexity Function I_{flc} instead, the author decided not to use I_{nfl} in the algorithm. The disadvantage of I_{nfl} is in representing each flight equally, whereas by using I_{flc} the exact description of each flight is obtained.

5.4.2 OCC Shift Quality Index I_{sq}

I_{sq} mainly depends on the number of dispatchers on one shift. It is not an easy task to fully measure the quality of a dispatcher and there may be critical differences among various individuals performing in one team. The factors that contribute to a better readiness to react to repetitive and new situations are for example the dispatchers ‘personality, experience, time spent in the position or also age. The education, ability to multi-task and combine or perform in a team are also important. Typical dispatchers start their careers by following checklists and doing separate steps without the in-depth knowledge behind. With the growing on-hands experience the actions are based much more on knowledge. This is when dispatchers become independent and their quality index grows. The quality of a dispatcher can also worsen with time. To simplify this parameter in this thesis, the index I_{qal} is introduced showing one level assigned to each of the dispatchers in question. In the real working conditions, this may be obtained from annual or bi-annual professional evaluations, for example. Percentage of the best dispatcher who is represented by 100% is used to describe the quality of other team members. To describe the quality of each OCC shift the formula (5-16) is used.

$$I_{sq} = \frac{\sum_{i=1}^{N} I_{qali}}{N} \; [-] \tag{5-16}$$

Where:

I_{qal}…Performance and experience of dispatchers on the shift in percentages $[-]$

N…Number of dispatchers on shift [number]

Min I_{sq}= 0

Max I_{sq}= 1

5.4.3 OCC Day Quality Index I_{dq}

$I_{dq}$is a simple derivative form I_{sq} focusing on the whole day instead of separate shifts. It takes into account all shifts beginning on the same day. The formula (5-17) is used to describe I_{dq}.

$$I_{dq} = \frac{\sum_{i=1}^{S} I_{sqi}}{S} = \frac{\sum_{i=1}^{S} \frac{\sum_{j=1}^{N} I_{qalj}}{N}}{S} \; [-] \tag{5-17}$$

Where:

I_{qal}…Performance and experience of dispatchers on the shift in percentages $[-]$

N…Number of dispatchers on shift [number]

S... Number of shifts beginning on the same date (two or three are typical) [number]

Min D_{dq}= 0

Max D_{dq}= 1

To give an example of the logic, a day composed of two shifts with two dispatchers on each of them is taken. Their quality will be described as I_{qal1} = 0.95, I_{qal2} = 0.60 for the first shift and I_{qal3} = 0.70 and I_{qal4} = 0.60 for the second shift. I_{sq} of the first shift will be 0.775, I_{sq} of the second shift will be 0.65. The total I_{dq} will be just over 0.71.

5.5 Capacity Planning Indexes

The structure of the algorithm is based on the parameters described in the chapters 5.3 and 5.4. The logic counts with creating comparable indexes for Shift / Day demand and OCC shift/day capacity.

5.5.1 Demand Indexes D_{day} and D_{sft}

The day demand index D_{day} represents a combination of the number of supported flights and Index I_{flc} describing their complexity. D_{day} is calculated as the sum of flight complexities on the day of shift and flight complexities on the following day as per the proposed formula (5-18). Flight amount index I_{nfl} has been fully replaced by the flight complexity function I_{flc}. This solution is more precise because it does not assess two different flights with the same weight as would be the case should the I_{nfl} stay in the formula.

$$D_{day} = \sum I_{flc}(d) + \sum I_{flc}(d+1)\ [-] \qquad (5\text{-}18)$$

Where:

I_{flc} …Flight complexity function $[-]$

d … day of the shift $[-]$

$d+1$…following day after the shift $[-]$

One day is typically covered by two or three working shifts, depending on the working hours of the OCC. For example, for two shifts pattern covering 24h and having shift handover at 7 AM and 7 PM, one day counted is composed of one full day-shift and two half night-shifts (day shift = 7 AM-7 PM, night shifts = midnight-7 AM and 7 PM-midnight). For the purpose of this thesis, a day of shift represents the day of the shift start. This step makes things easier for future calculations and also the applicability of the algorithm. To simplify the situation, the fact that the flights are spread over the shift evenly is considered. This allows a significant simplification which helps divide D_{day} into several shift demand indexes D_{sft} as per the formula (5-19).

$$D_{sft} = \frac{\sum I_{flc}(d) + \sum I_{flc}(d+1)}{S} \; [-] \tag{5-19}$$

Where:

I_{flc} …Flight complexity function $[-]$

d … day of the shift $[-]$

$d+1$…following day after the shift $[-]$

S …Number of shifts beginning on the same date (two or three are typical) [number]

5.5.2 Capacity Indexes C_{day} and C_{sft}

The counterpart to the demand indexes is the capacity of OCC to dedicate their time to the given amount of flights. Two indicators are introduced again: Day Capacity C_{day} and Shift Capacity C_{sft}. OCC Shift Quality Index I_{sq} described in chapter 5.4.2 is a crucial contributor to C_{day} and C_{sft}. It is supposed the workload is divided equally among the dispatchers on the shift. This may not always be the case but it is anticipated that any significant differences in workload lead to natural re-distribution of flights and tasks among dispatchers that ensure they can cope with them more easily. C_{day} is composed of all C_{sft} included in one day. This is typically two or three shifts according to the chosen scheme. C_{sft} formula is proposed in (5-20). It is essential to define the number of flights with average I_{flc} ($I_{flc} = 1$) that a single business aviation dispatcher handles per shift without compromising quality. This information is called a dispatcher comfort index C_{dis}.

$$C_{sft} = C_{dis} \cdot I_{sq} \cdot N \; [-] \tag{5-20}$$

Where:

C_{dis}… Dispatcher comfort constant $[-]$

I_{sq}... OCC Shift Quality Index $[-]$

N... Number of dispatchers on shift [number]

The definition of Day Capacity C_{day} is very simple. It takes into account the C_{sft} and multiplies it by the number of shifts. Numerically it is shown in the equation (5-21).

$$C_{day} = (C_{dis} \cdot \sum_{i=1}^{S} Ni) \cdot I_{dq} \; [-] \qquad (5\text{-}21)$$

Where:

C_{dis}…Dispatcher comfort constant [−]

N…Number of dispatchers on shift [number]

I_{dq}…OCC Day Quality Index [−]

S…Number of shifts beginning on the same date (two or three are typical) [number]

5.5.3 Dispatcher Comfort Index C_{dis}

It is crucial to set up the C_{dis} to match the given operations. It may be done by guessing and consequent adjustments or by estimating based on on-hand experience. The proposed way to do so is to apply the set of data retrospectively on a known period of operation (for example one year, one month etc.) to define overexposure, underexposure and effective exposure. These settings may very easily change in time, by for example changing flight volumes and patterns significantly or by the introduction of new aeroplanes into the fleet. The goal of the algorithm is dynamic capacity planning and consequent savings on the human workforce. As a result, the indicators linked to days rather than shifts are used in the algorithm. They are more suitable because they allow deviations on the shifts levels where a manager can decide exactly which part of the day is overexposed and setup a dispatcher's working pattern accordingly. The basic non-equation is $C_{day} \geq D_{day}$. The chosen value of C_{dis} represents a boundary between comfort and discomfort due to high workload (overexposure). A quick analysis based on the author´s experience has been performed to assess the below situations. C_{dis} was setup by default to 15 resulting in $C_{day} = (15 \cdot \sum_{1}^{S} N) \cdot I_{dq}$. The possible situations that OCC can experience are listed below.

a) overexposed days-candidates to increase the number of dispatchers,
   - $C_{day} < D_{day}$
   - $\frac{D_{day}}{C_{day}} > 1$

b) effectively exposed days- a default number of dispatchers per shift will be kept,

- $C_{day} \geq D_{day}$
- $0.2 < \frac{D_{day}}{C_{day}} < 1$

c) underexposed days - candidates to decrease the number of dispatchers.

- $C_{day} \geq D_{day}$
- $\frac{D_{day}}{C_{day}} < 0.2$

5.6 Algorithm

The algorithm is built to provide a tool to managers to perform OCC shift planning based on dynamic calculation. The intention is to provide periodical recalculation of available indexes prior to each day and as a consequence manage the shift composition dynamically. The simple graphical representation of the steps is shown in Figure 24.

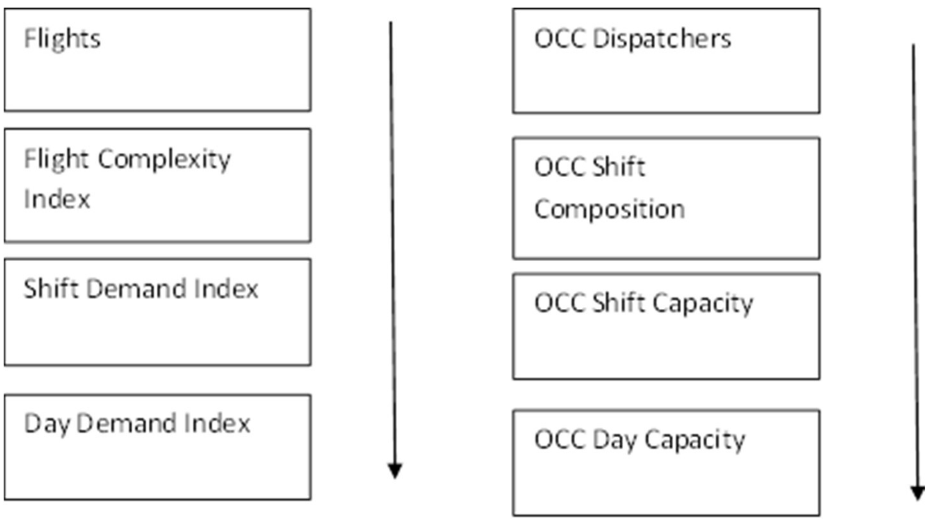


Figure 24 Algorithm steps

Source: Author

5.6.1 Application

The algorithm monitors each operations day from day + 1 until day + 30 and looks for candidates where a dynamic number of dispatchers could be used. The closer it gets to the date of operation, the more precise the information contained in the results is. There are several limiting conditions. The number of dispatchers on shift must have a minimum value. For example, in a situation where zero flights are programmed, more than zero dispatchers must be on shift. The decision whether to call for additional dispatchers or leave some of the previously planned unused must be made in an acceptable time frame (preferably one day in advance for the reductions and two days in advance for increases). The proposed format of the information about expected D_{day} and C_{day} is an automatically generated report which includes evidence about the number of flights N_d and N_{d+1}, their cumulative flight complexity I_{flc} and OCC shift quality index I_{sq}. The source data of the report is DWH linked to FOS and TNA. The two initiators for the report to be generated (or updated) are assignment (or re-assignment) of dispatchers to shifts and creation (or changes/cancellation) of flights. Each of these triggers essentially bears certain important attributes. Other attributes are very easy to derive consequently. There are also attributes that become available progressively. Their overview is listed in Table 18 and the simplified description of the process is presented in Figure 25.

Table 18 Attributes of algorithm triggering activities

Flight Creation	Assignment of dispatchers
Date and time of operation (immediate)	Names of dispatchers
Time of notification (immediate)	I_{qal} of all dispatchers on shift
The airport of departure from ICAO code (immediate)	Assigned days and shifts
The airport of arrival from ICAO code (immediate)	
I_{gad} and I_{gaa} from ICAO code (derived)	
I_{kn}	

Source: Author

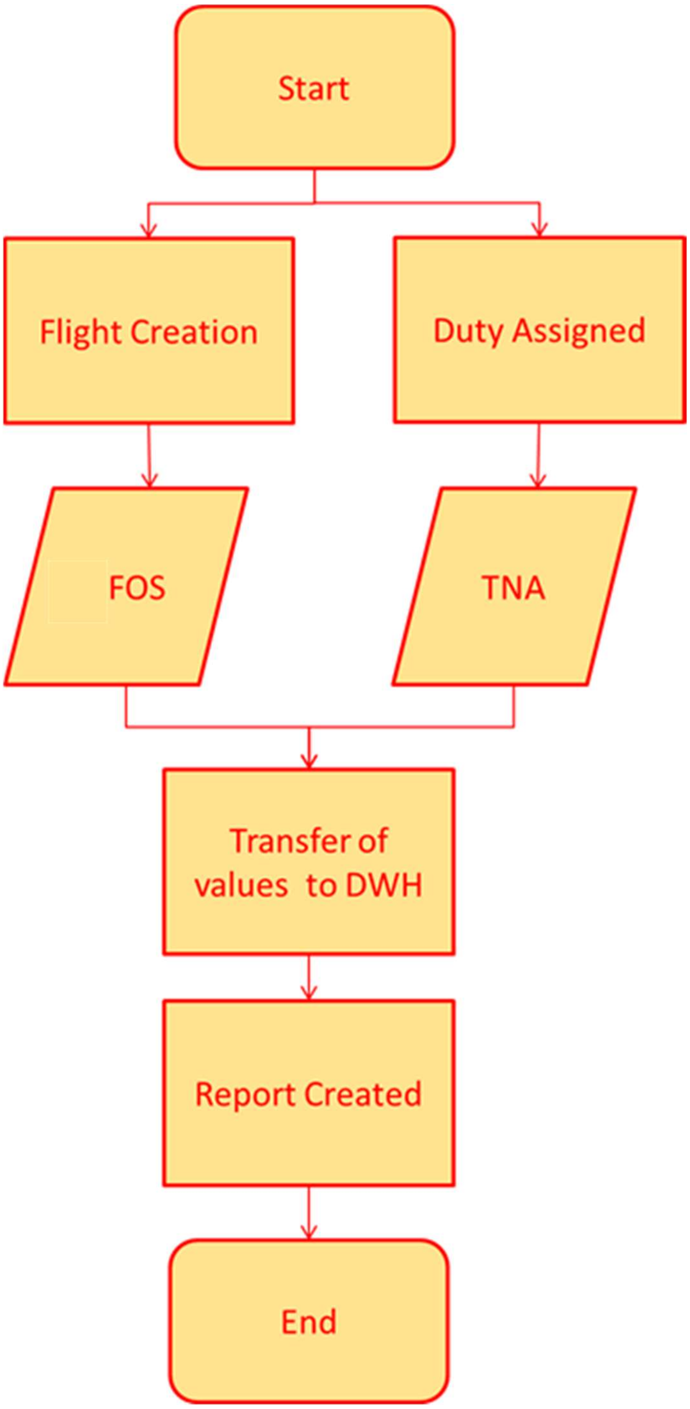


Figure 25 Report creation process logic

Source: Author

5.6.2 Steps

The proposal of the algorithm considers having fixed steps. Graphical interpretation in the form of diagrams in Figure 26 and Figure 27 is provided in addition to make the steps more comprehensible.

1. Obtaining of D_{day} for each required day (here from day + 1 until day + 30)

Based on the below-listed formulas the algorithm starts by looking into the appropriate FOS system with logged information for the available values to build the I_{flc} of each flight and then build D_{day}. The full process before simplification of I_{flc} is described graphically in Figure 26 and the steps described in Table 19.

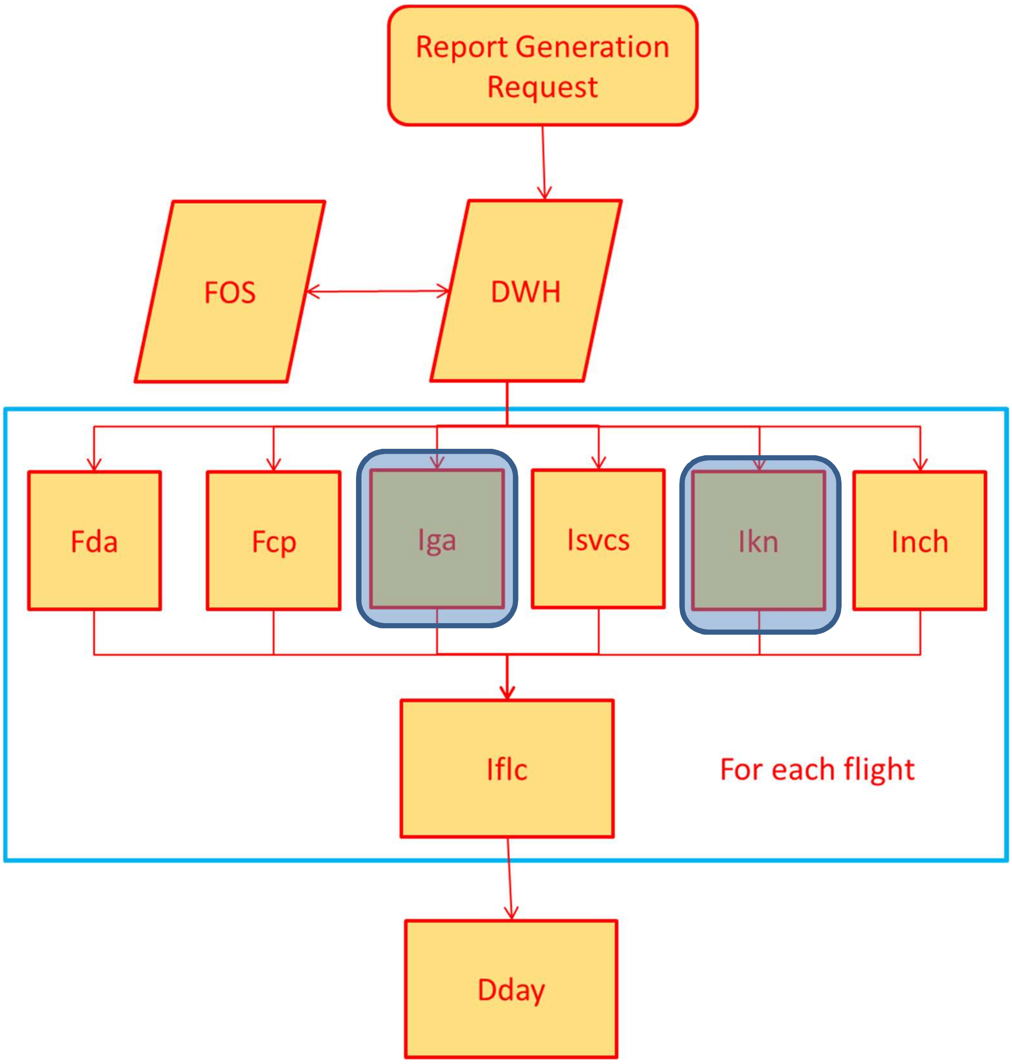


Figure 26 Diagram describing day demand index obtaining

Source: Author

Table 19 Steps description of day demand index obtaining

Description	Formula	Inputs from FOS
Getting I_{ga}	$I_{ga} = I_{gad} + I_{gaa}$	Geographical area indexes of departure and arrival airports taken from the Table 12 Geographical indexes proposal
Getting I_{kn}	$I_{kn} = 1 - \frac{T_{kn}}{T_{kn}+2}$	T_{kn} (flight notification expressed in date and time)
Calculation of I_{flc}	$I_{flc} = 3.15 + 0.8 \cdot I_{ga} - 4.12 \cdot I_{kn}$	N/A
Calculation of D_{day}	$D_{day} = \sum I_{flc}(d) + \sum I_{flc}(d+1)$	N/A

Source: Author

2. Obtaining of C_{day} for each required day (here from day + 1 until day + 30)

Based on the below-listed formulas the algorithm starts by looking into the appropriate TNA system for the available values to build the C_{day}. The process is described graphically in Figure 27 and the steps described in Table 20.

Table 20 Steps description of day capacity index obtaining

Description	Formula	Inputs from TNA
Getting I_{qal}	N/A	I_{qal} (Performance and experience of dispatchers on the shift expressed in percentages)
Getting I_{sq}	$I_{sq} = \frac{\sum_1^N I_{qal}}{N}$	N (number of dispatchers on shift)
Getting I_{dq}	$I_{dq} = \frac{\sum_1^S I_{sq}}{S}$	S (number of shifts beginning on the same date)
Calculating C_{day}	$C_{day} = (C_{dis} \cdot \sum_1^S N) \cdot I_{dq}$	N/A

Source: Author

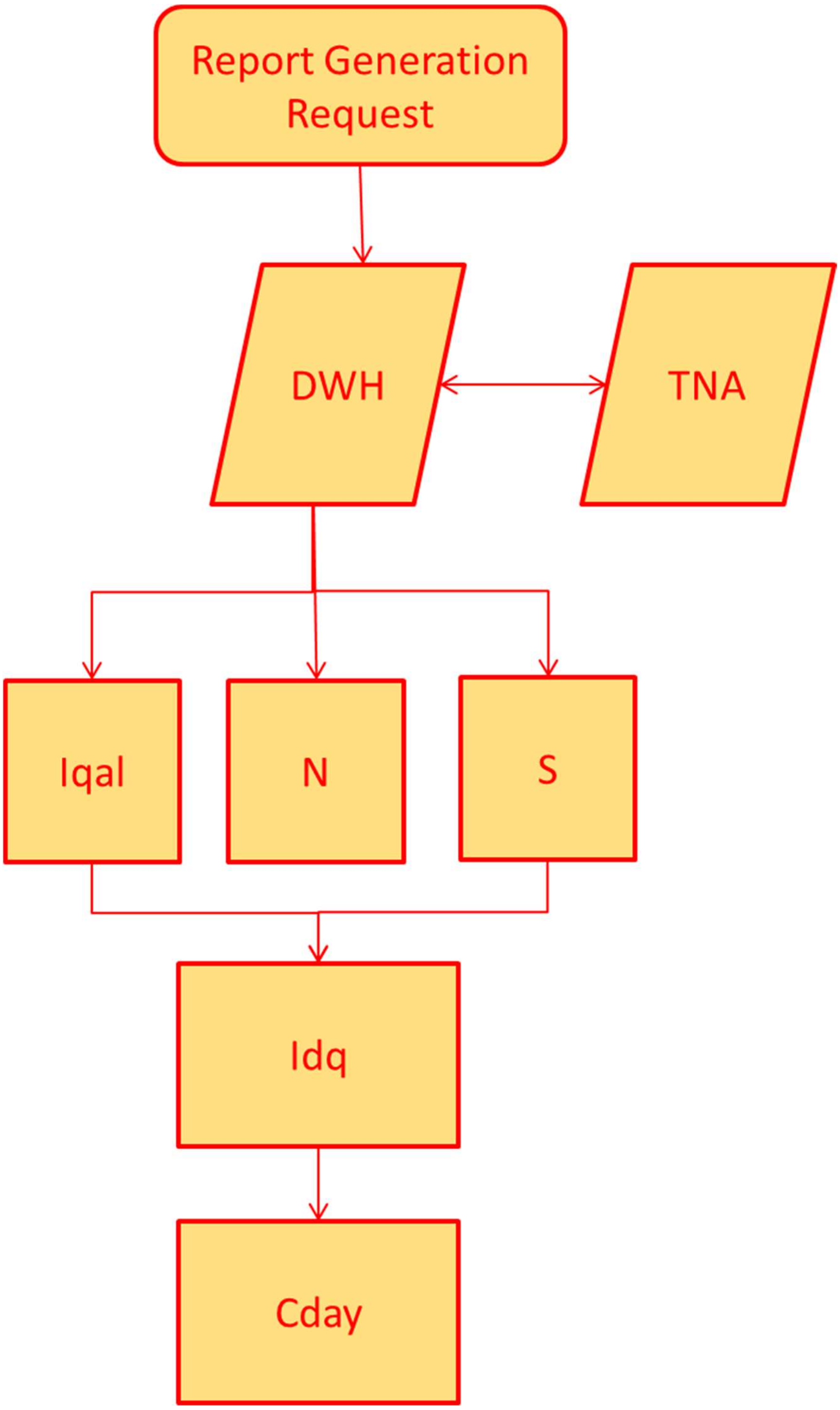


Figure 27 Diagram describing **day capacity index** obtaining

Source: Author

3. Report Generation

An example of the report was built up and is presented in Appendix 5. Apart from numerical information, it is suggested that it includes a graphical representation of the day situation. It is advisable that the report is generated automatically on a regular basis and also randomly in case of need. Logically, for closer dates, the information about flights will be quite complete, whereas further dates flights might not have been created yet. For this reason, it is advisable to set up a deadline to deal with capacity planning that is close to the day of report generation and at the same time will not cause unpleasant late notices for dispatchers.

4. Capacity Planning Application

Based on the expected D_{day} and default planned I_{dq} a decision is to be made on how many dispatchers are needed for reductions or increases. The basic questions are: How many dispatchers should be called to reduce an overexposed day to effective exposure and how many dispatchers can be left at home not to get to underexposure. This is be obtained by calculating $\frac{D_{day}}{C_{day}}$. The last part of the process for cases where $\frac{D_{day}}{C_{day}}$ >1 has the below-described phases. They are graphically shown in Figure 28 Algorithm flow chart

A. Swapping dispatchers

C_{day}will have to be increased to lower the whole fraction to at least one. To reach so the increase will have to be equal to $D_{day} - C_{day}$. This can be done by increasing I_{qal}which in practice means replacing dispatchers of lower performance with their better colleagues.

B. Adding dispatchers

A more appropriate method is adding dispatchers to shifts (increasing N). By increasing the number of dispatchers I_{dq}will be changed too. Paradoxically, increasing N can sometimes decrease I_{dq} (by using additional dispatchers with very low I_{qal}). To get an answer to the initial questions about numbers, the formula (5-22) is applied.

$$\Delta C_{day} = C_{dis} \cdot \sum_{1}^{S} (N + \Delta N)\ (I_{dq})\ [-] \quad (5\text{-}22)$$

To be able to solve this equation, ΔN is put equal to one, two…x (number of dispatchers) and $\Delta I_{dq}$is calculated according to formula (5-23).

$$I_{dq}=\frac{D_{day}-C_{day}}{C_{dis}\cdot\sum_{1}^{S}(N+\Delta N)}\,[-] \qquad (5\text{-}23)$$

For $\Delta N = 1$ a corresponding value of ΔI_{dq} is calculated. If the available dispatcher meets the quality criteria, the overexposure problem is resolved. If not, the process continues with setting up ΔN equal to two. The same is recalculated again to obtain the new value of I_{dq}.

C. Decreasing number of dispatchers

The steps for cases where $\frac{D_{day}}{C_{day}} < 0.2$ (underexposure) will be very similar. The formula (5-24) is applied to these cases. The equation is then applied for minus one dispatcher on shift and recalculated.

$$\Delta C_{day}= C_{dis}\cdot\sum_{1}^{S}(N+\Delta N)\cdot(I_{dq}) - \frac{D_{day}}{0.2}\,[-] \qquad (5\text{-}24)$$

The decision to decrease the number of dispatchers may be risky if flights are created at late notice unexpectedly and the decreased composition of dispatchers suddenly becomes overexposed. Another risk might occur for days with C_{day} and D_{day} very close to each other but still not overexposed. When flights are created at late notice, the manager does not have sufficient time to react. Some operators may choose the critical $\frac{D_{day}}{C_{day}}$ slightly lower than one to avoid such situations.

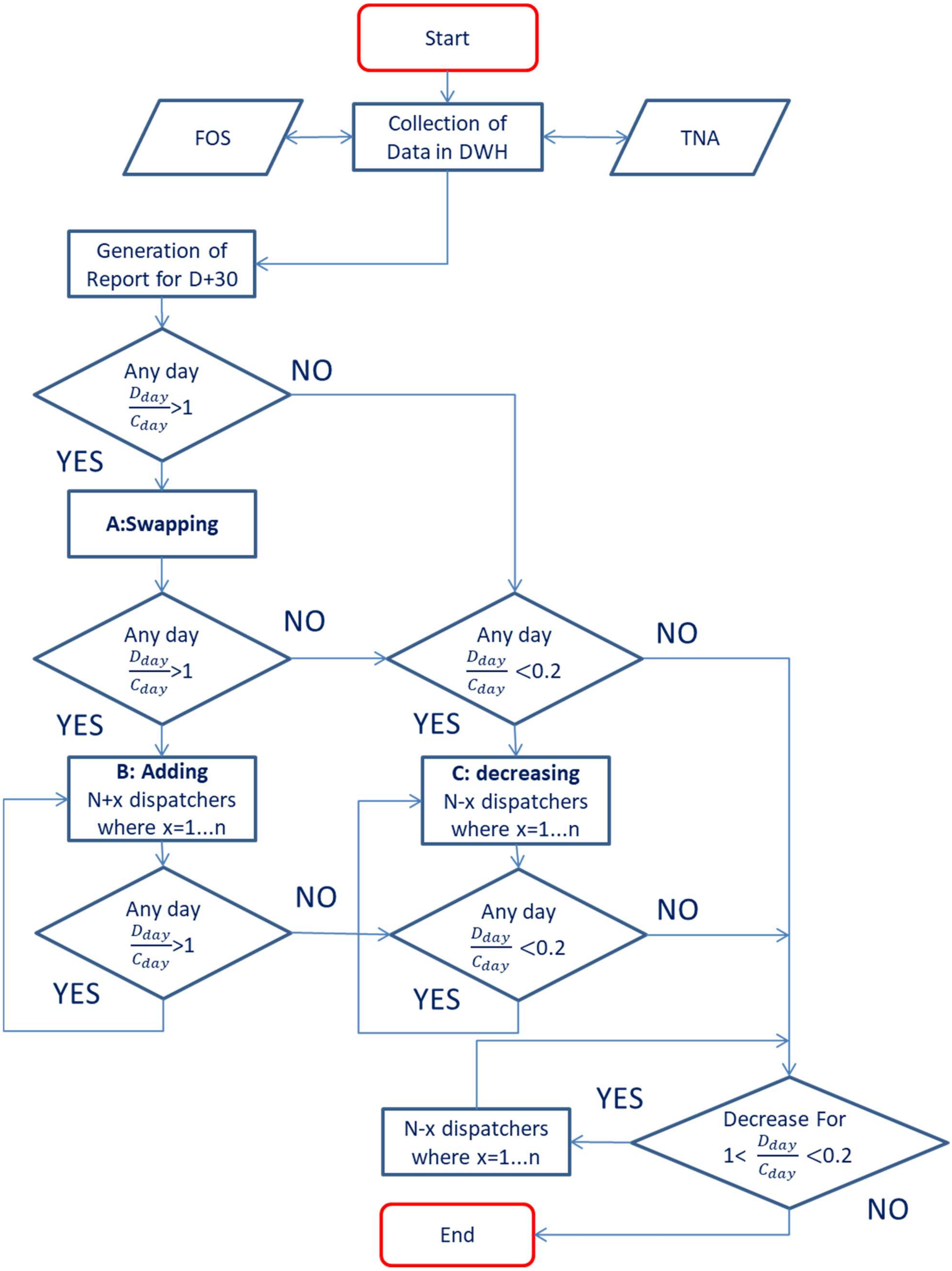


Figure 28 Algorithm flow chart

Source: Author

5.7 Case study

The aim of performing a case study is to confirm the functionality of the algorithm and the whole methodology that was used to approach the problem in this thesis. This case study also serves as a source of data for a simple financial analysis of the proposed methodology. A randomly selected operational data from 30 consecutive days were used to perform the study. The data, with their corresponding initial values listed in Table 21, describe the below situation.

- the OCC is composed of ten dispatchers with the different values of I_{qal} ranging from 0.5 to 0.95,
- two shifts pattern is used at the OCC,
- two dispatchers work on each shift,
- the data were taken retrospectively to avoid changes in their values.

Table 21 Case study initial entry data

Date	Number of dispatchers per shift (N1)	Number of dispatchers per shift (N2)	Number of Flights (Nd)	Total Iflc	Dday	Idq	Cda y	Dday/Cday
Day 1	2	2	32	22.4	44.8	0.84	50.4	0.89
Day 2	2	2	28	22.4	48.5	0.52	31.2	1.55
Day 3	2	2	29	26.1	52.5	0.71	42.6	1.23
Day 4	2	2	33	26.4	47.1	0.62	37.2	1.27
Day 5	2	2	23	20.7	38.2	0.83	49.8	0.77
Day 6	2	2	25	17.5	41.8	0.82	49.2	0.85
Day 7	2	2	27	24.3	54.9	0.75	45.0	1.22
Day 8	2	2	34	30.6	53.7	0.63	37.8	1.42
Day 9	2	2	33	23.1	39.2	0.57	34.2	1.15
Day 10	2	2	23	16.1	27.8	0.82	49.2	0.57
Day 11	2	2	13	11.7	22.9	0.6	36.0	0.64
Day 12	2	2	14	11.2	20.8	0.73	43.8	0.47
Day 13	2	2	12	9.6	28.5	0.74	44.4	0.64
Day 14	2	2	21	18.9	26.9	0.82	49.2	0.55
Day 15	2	2	10	8.0	22.4	0.78	46.8	0.48
Day 16	2	2	16	14.4	24.8	0.5	30.0	0.83
Day 17	2	2	13	10.4	27.2	0.6	36.0	0.76
Day 18	2	2	21	16.8	28.7	0.81	48.6	0.59
Day 19	2	2	17	11.9	20.7	0.54	32.4	0.64
Day 20	2	2	11	8.8	19.6	0.53	31.8	0.62
Day 21	2	2	12	10.8	19.9	0.87	52.2	0.38
Day 22	2	2	13	9.1	18.7	0.84	50.4	0.37
Day 23	2	2	12	9.6	14.5	0.53	31.8	0.46
Day 24	2	2	7	4.9	8.9	0.79	47.4	0.19
Day 25	2	2	5	4.0	10.3	0.76	45.6	0.23
Day 26	2	2	7	6.3	14.3	0.77	46.2	0.31
Day 27	2	2	10	8.0	15.2	0.55	33.0	0.46
Day 28	2	2	8	7.2	18.0	0.8	48.0	0.38
Day 29	2	2	12	10.8	14.8	0.7	42.0	0.35
Day 30	2	2	5	4.0	4.0	0.89	53.4	0.07

Source: Author

There are in total six cases of overexposure and two cases of underexposure. For the remaining 22 days, the shift composition was adequate to the demand. The total number of dispatchers initially needed to cover all shifts was 120 meaning 12 shifts are served by each dispatcher on average. The critical shifts are shown in Table 22.

Table 22 Overview of days to be dynamically adjusted

Date	Number of dispatchers per shift (N1)	Number of dispatchers per shift (N2)	Number of Flights (Nd)	Total Iflc	Dday	Idq	Cday	Dday/Cday
Day 2	2	2	28	22.4	48.5	0.52	31.2	1.55
Day 3	2	2	29	26.1	52.5	0.71	42.6	1.23
Day 4	2	2	33	26.4	47.1	0.62	37.2	1.27
Day 7	2	2	27	24.3	54.9	0.75	45.0	1.22
Day 8	2	2	34	30.6	53.7	0.63	37.8	1.42
Day 9	2	2	33	23.1	39.2	0.57	34.2	1.15
Day 24	2	2	7	4.9	8.9	0.79	47.4	0.19
Day 30	2	2	5	4.0	4.0	0.89	53.4	0.07

Source: Author

The formula (5-21) is applied to define how many increases will solve the problematic shifts. At first instance, the situation with an unchanged number of dispatchers is observed. This means covering problematic shifts with higher I_{dq}. The results in Table 23 show that, for example, the day two increase would mean an increase of I_{dq} of 0.29. On shifts with four dispatchers, this would mean to apply the total increase of I_{qal} equal to 1.16 which may be quite challenging. Other days show a similar tendency. Swapping dispatchers may be an option for shifts with a slight overexposure but will be very difficult to apply for more overexposed days. The application would be very hard for the approach with a safety margin where the critical ratio $\frac{D_{day}}{C_{day}}$ is setup even lower than one.

Table 23 Overview of the solution with planning better dispatchers

Date	Number of dispatchers per shift (N1)	Number of dispatchers per shift (N2)	Number of Flights (Nd)	Total Iflc	Dday	Idq New	Cday New	Dday/Cday
Day 2	2	2	28	22.4	48.5	0.81	48.5	1.00
Day 3	2	2	29	26.1	52.5	0.88	52.5	1.00
Day 4	2	2	33	26.4	47.1	0.79	47.1	1.00
Day 7	2	2	27	24.3	54.9	0.92	54.9	1.00
Day 8	2	2	34	30.6	53.7	0.90	53.7	1.00
Day 9	2	2	33	23.1	39.2	0.65	39.2	1.00
Day 24	2	2	7	4.9	8.9	0.79	47.4	0.19
Day 30	2	2	5	4.0	4.0	0.89	53.4	0.07

Source: Author

A more realistic option is adding dispatchers to the problematic days and calculate the necessary I_{dq} to minimise the exposure. Effects of the situation with one additional dispatcher to each critical day are shown in Table 24. It confirms that adding one dispatcher will solve the problem of three days. For those days (days three, seven and nine) appropriate I_{qal} is calculated showing how good dispatchers are needed (in this case $I_{qal3} = 0.66$, $I_{qal7} = 0.66$ and $I_{qal9} = 0.33$).

Table 24 Overview of the solution with additional dispatchers

Date	Number of dispatchers per shift (N1)	Number of dispatchers per shift (N2)	Number of Flights (Nd)	Total Iflc	Dday	Idq New	Cday New	Dday/Cday
Day 2	2	3	28	22.4	48.5	0.65	39.0	1.24
Day 3	2	3	29	26.1	52.5	0.70	53.5	0.99
Day 4	2	3	33	26.4	47.1	0.63	46.5	1.01
Day 7	2	3	27	24.3	54.9	0.73	56.25	0.98
Day 8	2	3	34	30.6	53.7	0.72	47.25	1.14
Day 9	2	3	33	23.1	39.2	0.52	47.75	0.92
Day 24	2	2	7	4.9	8.9	0.79	47.4	0.19
Day 30	2	2	5	4.0	4.0	0.89	53.4	0.07

Source: Author

The remaining three problematic days will be resolved by the same steps, but two added dispatchers will be needed here. Doing the same logic for the underexposed shifts, it is evident that two dispatchers can be taken out of each of those days. The final number of dispatchers on shifts after the dynamic planning applied is shown in Table 25.

Table 25 Final number of dispatchers after dynamic adjustments

Date	Number of dispatchers per shift (N1)	Number of dispatchers per shift (N2)
Day 2	3	3
Day 3	2	3
Day 4	3	3
Day 7	2	3
Day 8	3	3
Day 9	2	3
Day 24	1	1
Day 30	1	1

Source: Author

To shape the shifts composition very tightly, the last step that can be done is to look at days where effective exposure is obtained and look whether the number of dispatchers on shifts can be decreased without exceeding $\frac{D_{day}}{C_{day}} = 1$. Having applied this approach a total of 18 dispatchers can be saved. This approach is, however, very sensible because very tiny changes can turn the days into overexposure. The number of dispatchers after the dynamic planning steps corresponds to the below numbers and is also described in Table 26

.

- shifts without dynamic planning: 120 shifts to be covered,
- shifts with an increased number of dispatchers: 129 shifts to be covered,
- shifts with increased and decreased number of dispatchers:125 shifts to be covered,
- shifts with increased and decreased number of dispatchers: 107 shifts to be covered.

Table 26 Final numbers for a solution with additional decreases

Date	Number of dispatchers per shift (N1)	Number of dispatchers per shift (N2)
Day 1	2	2
Day 2	3	3
Day 3	3	3
Day 4	3	3
Day 5	2	2
Day 6	2	2
Day 7	3	3
Day 8	3	3
Day 9	3	3
Day 10	1	2
Day 11	1	2
Day 12	1	2
Day 13	1	2
Day 14	1	2
Day 15	1	2
Day 16	1	2
Day 17	1	2
Day 18	1	2
Day 19	1	2
Day 20	1	2
Day 21	1	2
Day 22	1	2
Day 23	1	2
Day 24	1	1
Day 25	1	2
Day 26	1	2
Day 27	1	2
Day 28	1	2
Day 29	1	2
Day 30	1	1

Source: Author

The results of the previous case study were used as a source of data for the defined financial impact of the scenarios. For the first option with the same composition of dispatchers where obtaining higher I_{dq} is managed only by increasing I_{qal}, no differences in financial demand will be achieved. For the other three scenarios, the financial demand will be different. For the first two, a slight increase in cost (about one per cent) will be seen. With the last one saving of about slightly below ten per cent will be manageable. These results do not guarantee dramatic savings. Each operator can decide whether it will accept overexposures and risk errors. For cases with added the dispatchers much of the overexposure can be lowered. To decrease dispatchers on low volumes shifts is financially interesting but it bears the risk of last minute flights creation. The proposed way tackling the issue is to replace all decreased shift numbers by standby dispatchers who can be activated shortly before the shift. Standby dispatchers are typically cheaper than those with assigned fixed shifts.

6 RESULTS

The author focused on a topic very rarely touched by information sources. The steps and the direction taken in the dissertation thesis were heavily based on the author's experience combined with interest and general information available about the industry.

The area of business aviation has a tremendous contribution to the relative random character of operations. Operational control represented by OCCs has many specifics linked to human ability and capacity to respond to the created demand. Oceanic flights were supposed to be the primary focus, but during the analytical part, it was found out that the problem of capacity planning and training is spread out on the entire level. The training requirements for dispatchers in Europe today are benevolent, the responsibility is left to the operators, and the applicable syllabuses are old-fashioned. For this reason, the author decided to turn his attention to the area of capacity planning fully and proposed a global tool based on analysing all the flights (out of which oceanic flights undoubtedly represent one of the most complicated operations). At first, a detailed description of the process was needed in the form of the flight-related functions, OCC-related functions and Capacity planning indexes. The mathematical description was not easy in all cases, and simplifications and generalisation were sought. Based on the functions and indexes an algorithm was built and tested on a case study.

6.1 Descriptive Part

The complex set of activities related to the dynamic concepts of operational control, business aviation and oceanic planning were described from several viewpoints. At the first stage, it was the dispatchers´ views and examples of what the practice shows. Typical activities, tools, software and limitations were introduced. Associated hazards were sought and identified. The primarily recognised hazard was the capacity management of OCCs. The author looked for answers in the legal part. He described documents provided on the Czech, European and Worldwide level. During the next steps, it was discovered and reconfirmed that OCC activities affect the safety significantly and should be backed by a robust system and requirements. Unfortunately, it is not the case today. The author believes the operators look for a better solution to manage their operational control. That is why he proposed a methodology to tackle the capacity management issues.

6.2 Methodological Part

With the operators looking for a safety-enhancing solution in mind, the author proposed a methodology. It was initially also meant to bring significant financial savings, but the results showed later that the amount of money saved is negligible.

The first idea was to mine historical data so they could help evaluate similar situations taking place in the future. This would not be possible without expecting the operators have several necessary tools in place. Six basic assumptions were introduced. An analysis of the business was done to reconfirm the assumptions. The validated and corrected results helped create the methodology. In the next step available historical flight data were analysed, and information obtained from them was classified. This helped create functions and indexes to provide numerical results. Some of the functions and indexes are based on the author´s experience. This is the case of the Geographical area index I_{ga}or Services complexity index I_{svc}. This set of functions provided a definition of what information could be either measured or calculated in advance to provide a numerical evaluation of each flight. This was named Flight complexity function I_{flc}. The author excluded some functions from the final version of I_{flc} after having applied the multiple linear regression (MLR). The mathematical analysis of I_{flc} and created weights for each of its sub-functions helped to understand their individual contribution to the final result.

After having obtained the flights data, it was crucial to set up their counterpart in OCC shifts and dispatchers. In a very similar way, a set of functions was sought to describe how individual quality of dispatchers who have a certain capacity to work on a given number of flights affect their performance. The Dispatcher Comfort Index C_{dis} was introduced and provided the necessary border between comfort and discomfort. A day was decided to be a better representation of time rather than shifts because all necessary changes in the number of dispatchers on different shifts of the same day could be obtained more easily. With flights and OCC-related indexes already defined, demand and capacity indexes could be described and a definition of their specific ratio leading to overexposure (in this case $\frac{D_{day\cdot}}{C_{day}} > 1$), underexposure (in this case $\frac{D_{day\cdot}}{C_{day}} < 0.2$) and effective exposure setup. The resulting algorithm suggests a periodically generated report containing flights 30days in advance. The report helps managers of OCCs take strategic decisions. The algorithm increases accuracy with the growing number of available historical flight data.

The results may easily be used for different operations by simply adjusting the entry parameters. For beginning operations with lack of operational data all of the indexes can be replaced by constant average values and provide more straightforward outputs with a reasonable degree of accuracy. The algorithm can be easily implemented in real operation. The described source inputs from FOS and TNA will be required. Afterwards, the definition of iteration of how often the report will be generated and evaluated will be needed. The resulting tool has the ambition to be a supportive functioning universal tool helping OCCs to manage their capacity in a better way.

7 CONCLUSION

With the growing numbers of business aviation volumes, managing capacity of OCC to meet the operations volumes becomes increasingly important. Oceanic flights are by nature complicated. The risk to commit an error when performing operational control is high, and the consequences can be disastrous. The analysis of the current approaches confirmed the understanding of the principles is different across the industry. The legal system is not strict and provides space for a variety of setups. Not all of them are safe, and not all of them correspond to the nature of business aviation. Capacity management was identified as a way to increase safety. To the author´s knowledge, no similar publications have been dedicated and choosing this topic for his dissertation thesis was a logical step. The challenge of the thesis was to propose a system that would describe the reality well and would be adjustable in case of different inputs.

The aims defined in Chapter 3 to set up a methodology for OCCs capacity management and to provide a tool for business aviation operators to help them structure their OCCs´ size dimensioning have been fulfilled. The saving on the financial part is surprisingly very low and is not be a driving force to apply the algorithm. The methodology is based on operational data collection and their application in the designed algorithm to provide an estimate as of which days have the potential of low and high exposures to workload. The main contribution of the dissertation thesis is seen in the following areas:

- proposal of flight and OCC related functions,
- design of methodology helping operators streamline their OCCs,
- preliminary design of the operational report,
- development of algorithm leading to better shifts coverage,
- increasing safety.

The future consideration for the topic to be developed would be focusing on demand and capacity of each individual shift instead of days and look for seasonality specifics. Another enhancement would be combining the aspects of capacity planning with training to the degree where I_{qal} of individual dispatchers will be manageable and predictable in time. To fully confirm the hypothesis, partial and entire results of the thesis and live application of the methodology in a real OCC will be necessary. The dissertation´s additional contribution is describing flight preparation processes quite profoundly.

8 REFERENCES

(1) PAZOUREK, Michal. The Challenges of Operations Control Centres (OCC) in European Business Aviation. Perner´s Contacts, 2013, number 4, volume 8, p.60-66

(2) *ICAO Addresses Shortage of Skilled Aviation Professionals* [online]. [cit. 2015-08-19]. Available at: http://www.icao.int/Newsroom/Pages/ICAO-Addresses-Shortage-of-Skilled-Aviation-Professionals.aspx

(3) *EBAA Call for tenders: Analysis of the shortage of skills in the European Business Aviation sector* [online]. In: Brussels: EBAA, 2015 [cit. 2015-08-19]. Available at: http://www.ebaa.org/documents/document/20150407140225-shortage_of_skills_call_for_tenders_final.pdf

(4) *COMMISSION REGULATION (EU) No 965/2012*. 2012. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:296:0001:0148:EN:PDF

(5) ŘASA, Lukáš. *Enhancing Safety at Operations Control Centre.* Prague, 2015. 81 p. Master thesis. Czech Technical University Prague, Faculty of Transportation Sciences, supervised by Ing. Vladimír Plos

(6) IOSA Standards Manual. *11th Edition*. 2017. Available at: https://www.aviation-quality-services.com/fileadmin/files/IOSA_Standards_Manual__ISM__Ed._11.pdf

(7) FAR. *Part 65 - Certification: Airmen other than flight crewmembers, Subpart C*. Federal Aviation Authority, 1999. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2011-title14-vol2/pdf/CFR-2011-title14-vol2-part65.pdf

(8) HERTZLER, Joe. *Operational Control Untangled* [online]. [cit. 2015-08-19]. Available at: http://www.aviationpros.com/article/10378547/operational-control-untangled

(9) WALL, Christina. *Aircraft Dispatchers — Working Behind the Scenes* [online]. [cit. 2015-08-12]. Available at: http://www.avweb.com/news/careers/182995-1.html?redirected=1 *D-7192 - AN/857 Part D3, Training Manual: Flight Operations Officers/Flight Dispatchers*. Montreal, Canada: ICAO, 1998.

(10) LEHR, Helmut. COMLUX AVIATION. *Scheduling and Dispatch in Business Aviation*. London, 2010. BA Meetup Conference presentation.

(11) CORDES, Andreas. *Job profile and training requirements for European Flight Dispatchers.* London, 2007. 68 p. Master thesis. City University London, supervised by prof. Roger Wootton, available at: http://eufalda.org/wp-content/uploads/2016/11/Dispatch-Study.pdf

(12) TA Software. [online]. 2018, [cit. 2018-04-01]. Available at: http://www.tasoftware.co.uk

(13) SW AIRPLANE MANAGER. [online]. 2018, [cit. 2018-04-01]. Available at: https://www.airplanemanager.com

(14) SW SMARTSHEET. [online]. 2018, [cit. 2018-04-01]. Available at: https://www.smartsheet.com

(15) *What they're saying* [online]. Airline Dispatchers Federation [cit. 2015-08-19]. Available at: https://www.dispatcher.org/dispatcher/what-they-re-saying

(16) L. MCFADDEN, Kathleen a Elizabeth R. TOWELL. Aviation human factors: a framework for the new millenium. *Journal of Air Transport Management*.1999, volume5, p.177-184

(17) *D-7192 - AN/857 Part D3, Training Manual: Flight Operations Officers/Flight Dispatchers*. Montreal, Canada: ICAO, 1998.

(18) ORNATO, Joseph and Marry Ann PEBERDY. Applying lessons from commercial aviation safety and operations to resuscitation. *Resuscitation.* 2014, volume 85, p.173-176

(19) J.ALVERSON, Warren. Businessmen in the blue [or is it in the red?]. *Business Horizons*. 1972, volume 15, p.79-88.

(20) BUD, Lucy a Brian GRAHAM. Unintended trajectories: liberalization and the geographies of private business flight. *Journal of Transport Geography*.2009, volume 17, p.285-292

(21) LINZ, Marco. Scenarios for the aviation industry: A Delphi-based analysis for 2025. *Journal of Air Transport Management*. 2012, volume 22, p.28-35

(22) PAZOUREK, Michal. Business Aviation in Europe. Perner´s Contacts, 2011, number 5, volume 6, p.236-243

(23) ZIMA, Ondřej. *Flight Planning – Pilot versus professional provider*. Prague, 2015. 122 p. Master thesis. Czech Technical University Prague, Faculty of Transportation Sciences, supervised by Ing. Jakub Hospodka, Ph.D., Ing. Michal Pazourek

(24) PEAFORD, Alan. *2013 Pocket Guide To Business Aircraft*. North Stifford: Aerocomm Ltd, 2012. ISBN 978-09-564-1793-0.

(25) MOUČKA, Jiří. Flight Optimization is a Necessity. In: *New Trends in Civil Aviation*. Brno: AKADEMICKÉ NAKLADATELSTVÍ CERM, 2013, p. 70-72. ISBN 978 - 80 - 7204 - 843 - 4. Available at: http://lu.fme.vutbr.cz/NTCA2013/_files/Proceedings.pdf

(26) PRUŠA, Jiří. and team of authors including PAZOUREK, Michal, *Svět letecké dopravy II*, Prague: Galileo, 2015. ISBN 9788026083092

(27) Discipline, Proper Procedures Key to Reducing NAT Operational Errors. In: *Business Aviation Insider* [online]. 2012 [cit. 2015-08-15]. Available at: https://www.nbaa.org/news/insider/2012/09/preventing-north-atlantic-navigation-errors.php

(28) LEARMOUNT, David. Safety warning for UK's corporate jets, Flight Global, 2007, available at: http://www.flightglobal.com/news/articles/safety-warning-for-uks-corporate-jets-214243

(29) *NAT Doc 007 North Atlantic Operations and Airspace Manual*. ICAO, 2018. Available at: https://www.icao.int/EURNAT/EUR%20and%20NAT%20Documents/NAT%20Documents/NAT%20Doc%20007/NAT%20Doc%20007%20%20(EN)%20-%20Edition%20V.2018-1,%20Amd%200.pdf

(30) *North Atlantic International General Aviation Operations Manual*. 2004. Available at: http://tfmlearning.faa.gov/publications/media/NAT%20IGA%202004.pdf

(31) PAZOUREK, Michal. *Provoz letadel Business letectví nad oceány.* Prague, 2010. 102 p. Master thesis. Czech Technical University Prague, Faculty of Transportation Sciences, supervised by Ing. Jakub Chmelík PhD.

(32) VOLNER, Rudolf. *Flight planning management*. Vyd. 1. Brno: Akademické nakladatelství CERM, 2007. ISBN 978-80-7204-496-2.

(33) CHMELÍK, Jakub. Úloha letového dispečinku v letecké společnosti. In: *Nové trendy v civilním letectví: sborník příspěvků mezinárodního odborného semináře*. Brno: Akademické nakladatelství CERM, [199-]-2009, p. 53-57. ISBN 80-7204-450-8.

(34) MIKL, Tomáš, Marek TÝBL a Vladimír DANĚK. *Plánování a provedení letu*. Brno: Akademické nakladatelství CERM, 2002, 88 p. Učební texty pro teoretickou přípravu dopravních pilotů ATPL(A) dle předpisu JAR-FCL 1. ISBN 80-7204-237-8.

(35) CANNON, R.James and.Franklin D. RICHEY. *Practical Applications in Business Aviation Management*, Lanham: Government Institutes, 2012. ISBN 9781605907703

(36) SHEEHAN, John. *Business and Corporate Aviation Management*, New York: McGraw-Hill Education, 2012, ISBN 9780071801901

(37) MARSH, David. Getting to the Point: Business Aviation in Europe, Eurocontrol, Brussels 2006, available at:

http://www.ebaa.org/documents/document/20130125105144-eurocontrol_study_on_business_aviation.pdf

(38) PWC ECONOMICS. *The economic impact of business aviation in Europe* [online]. BOMBARDIER. 2008 [cit. 2015-08-14]. Available at: http://www.ebaa.org/documents/document/20130124163641-20081120-ebaa-finalreport.pdf

(39) *EDUCAIR: Assessing the EDUcational Gaps in Aeronautics and AIR Transport* [online]. [cit. 2015-08-31]. Available at: http://web.tecnico.ulisboa.pt/~vascoreis/projects/educair/

(40) JALOVECKÝ, Martin, *Letecké zkratky.* Prague: Vydavatelství ČVUT, 2008. ISBN 8001018962

(41) GINGRICH, Paul. *Introductory Statistics for the Social Sciences* [online]. Dept. of Sociology and Social Sciences, University of Regina, 1992 [cit. 2018-08-12]. Available at: http://uregina.ca/~gingrich/regr.pdf

(42) WAN, Alan. *Statistical Methods for Business Research* [online]. Hong Kong: City University of Hong Kong [cit. 2018-08-12]. Available at: http://personal.cb.cityu.edu.hk/msawan/teaching/FB8916/FB8916Ch1.pdf

(43) BROŽ, Vladimír and Václav Bezvoda. *Excel 2007: Vzorce, funkce, výpočty*. Praha: Grada, 2008. ISBN 80-251-1088-5.

(44) ŠALÁT, Tibor, *Malá encyklopédia matematiky*. 2., Bratislava: Obzor, 1978. Malé encyklopédie vydavateľstva Obzor.

(45) MOC, Ondřej, Jana ŠIMSOVÁ and Marta ŽAMBOCHOVÁ. *Matematika pro ekonomy*. Ústí nad Labem: Univerzita J.E. Purkyně v Ústí nad Labem, 2013. ISBN 978-80-7414-599-5.

(46) ŽAMBOCHOVÁ, Marta. *Závislost mezi spojitými veličinami* [online]. p. 2-38 [cit. 2018-08-12]. Available at: http://fsetest.ujep.cz/img/upload/9/files/T%C3%A9ma%204%20-%20Z%C3%A1vislost%20dvou%20metrick%C3%BDch%20n%C3%A1hodn%C3%BDch%20veli%C4%8Din.pdf

9 PUBLICATION ACTIVITY

[1] PAZOUREK, M.,VÁCLAVÍK, V. Assessment of Business Aviation OCC´s Capacity Issues. In Procedia Engineering, Vol.187, Elsevier, 2017, p.46-52. ISSN: 1877-7058

[2] ŠOUREK, D., PAZOUREK, M. Comparison of Commercial and Business Aviation.In Transport Means : proceedings of the international scientific conference. Kaunas, 2017. p. 1012-1016. ISSN: 1822-296X

[3] ŠOUREK, D. , PAZOUREK, M. Koncepce využití simulátorů při výcviků pracovníků operačních řídících center. In *Aplikace simulátorů ve výcviku leteckých specialistů*. Ostrava: LET'S FLY s.r.o, 2016. p. 375-385. ISBN 978-80-270-0053-1.

[4] PRUŠA, J. and team of authors including PAZOUREK, M., Svět letecké dopravy II, Prague: Galileo, 2015. ISBN 9788026083092

[5] PAZOUREK, Michal and Michal BERAN. Dispečer plánování letů. *Flying Revue*. 2015, 3/2015. p 32-35. ISSN 1802-9027

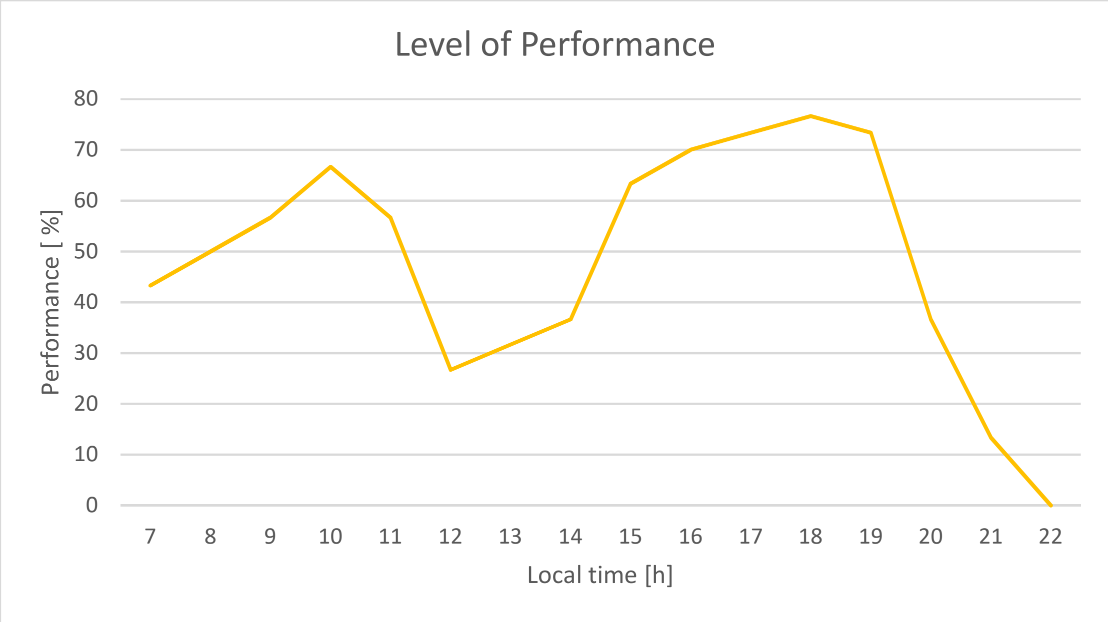
[6] PAZOUREK, Michal. Dynamic Airborne Reroute Program (DARP) application in Business Aviation. Perner´s Contacts, 2014, number 2, volume.9, p.58-66

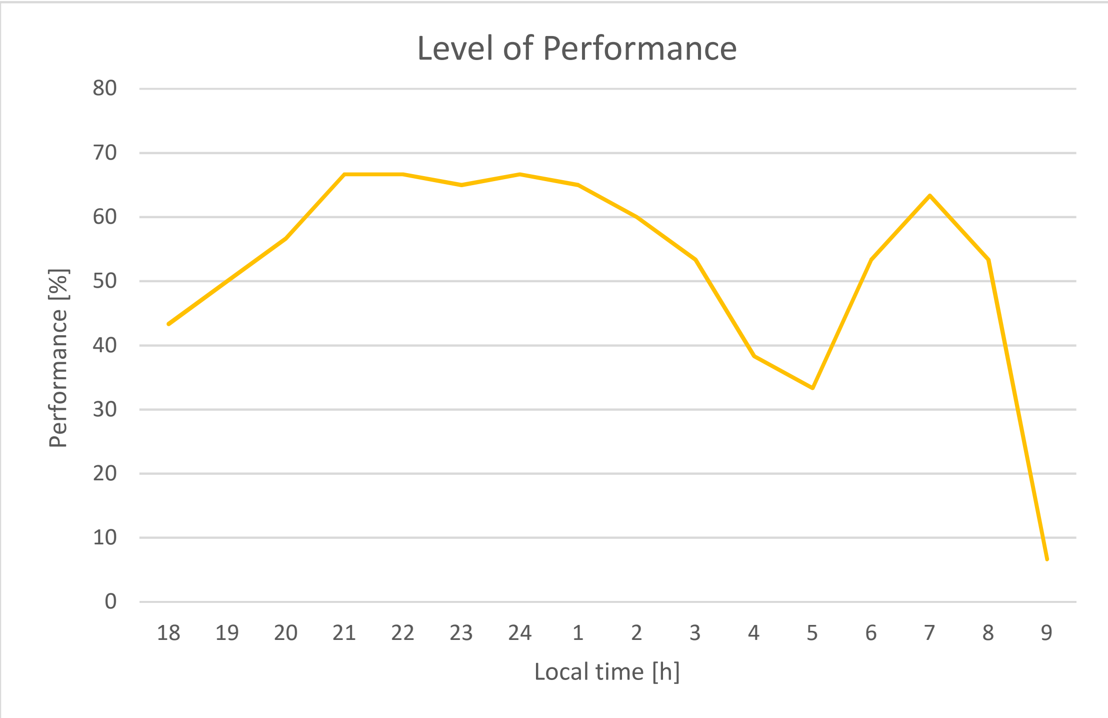
[7] PAZOUREK, Michal. The Challenges of Operations Control Centres (OCC) in European Business Aviation. Perner´s Contacts, 2013, number 4, volume 8, p.60-66

[8] PAZOUREK, Michal. Business Aviation in Europe. Perner´s Contacts, 2011, number 5, volume 6, p.236-243

LIST OF APPENDICES

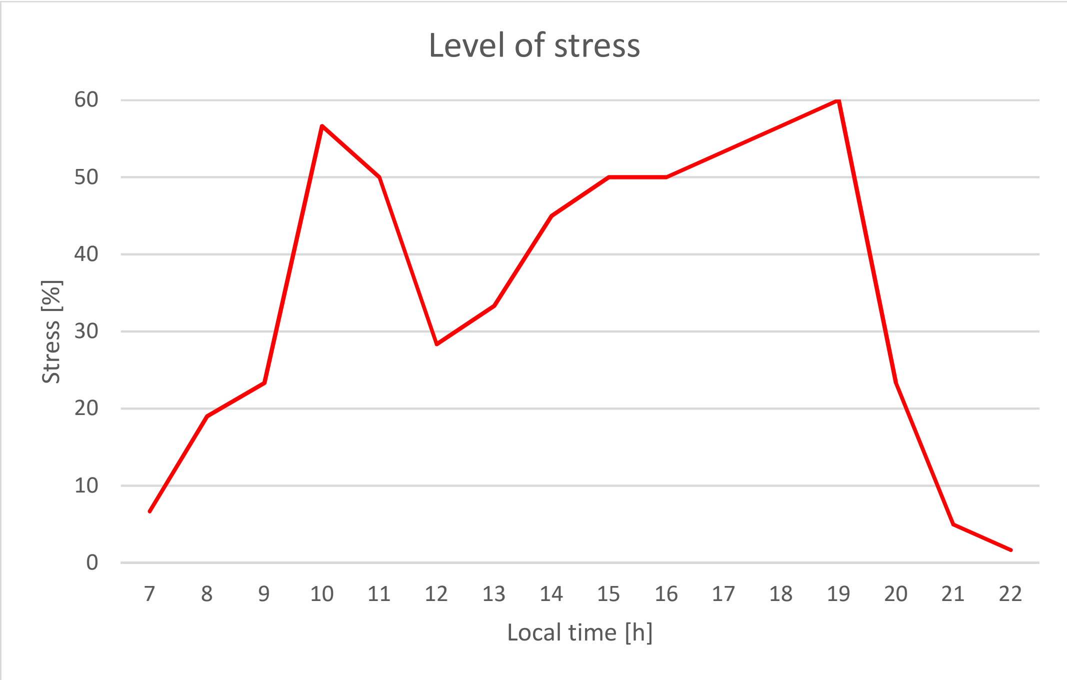
Appendix 1 Day and night measured level of performance

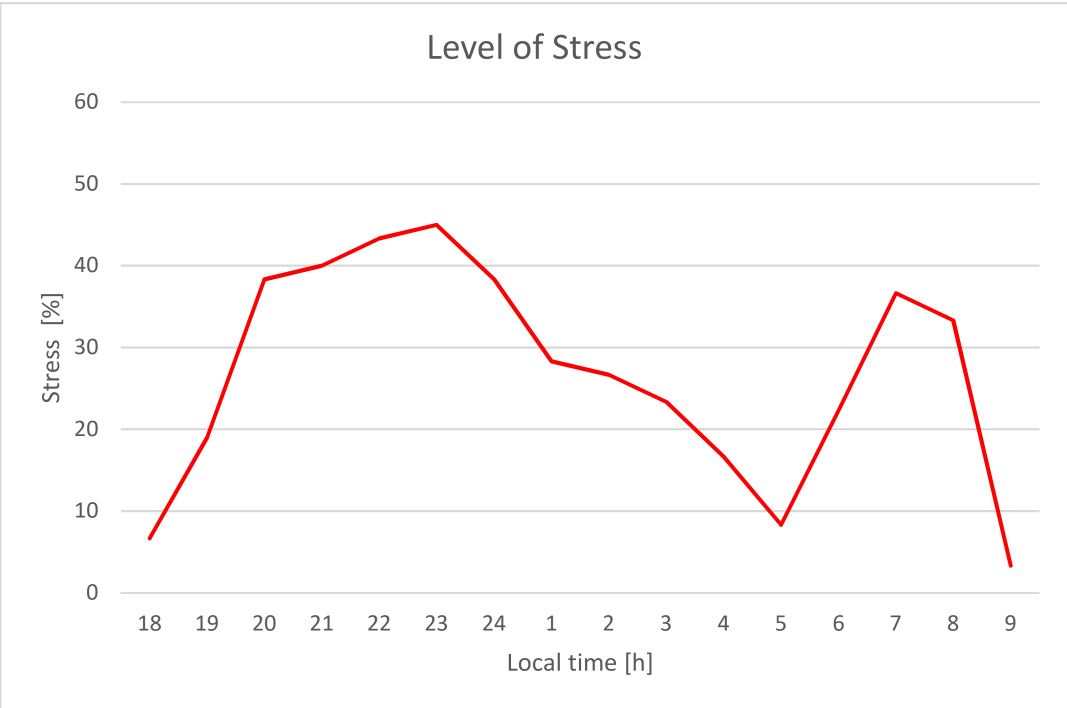




Source:(25)

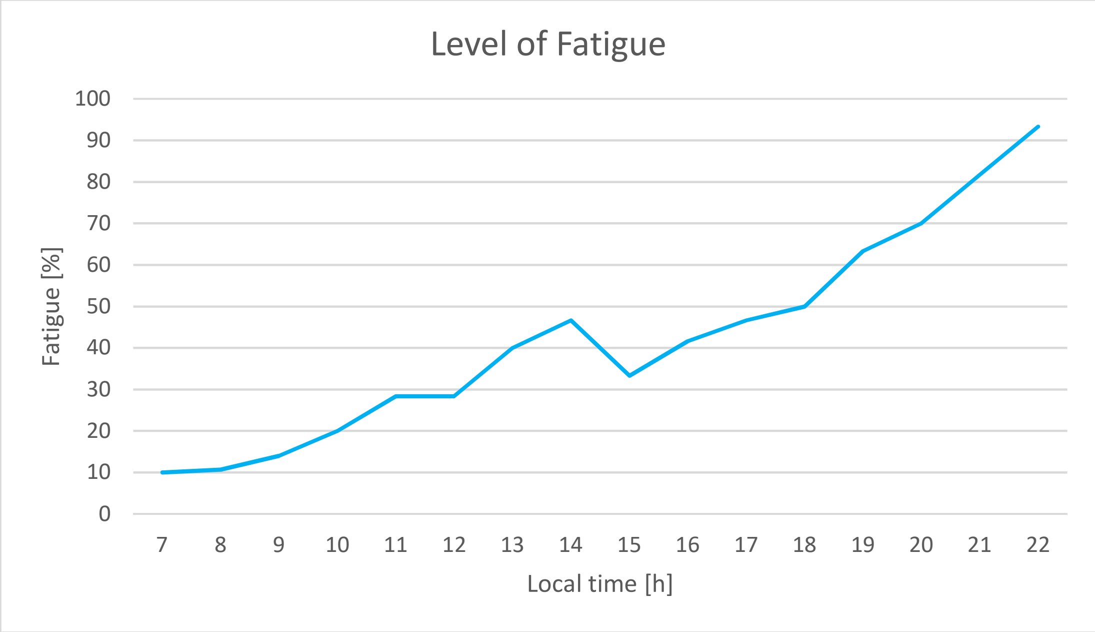
Appendix 2 Day and night measured level of stress

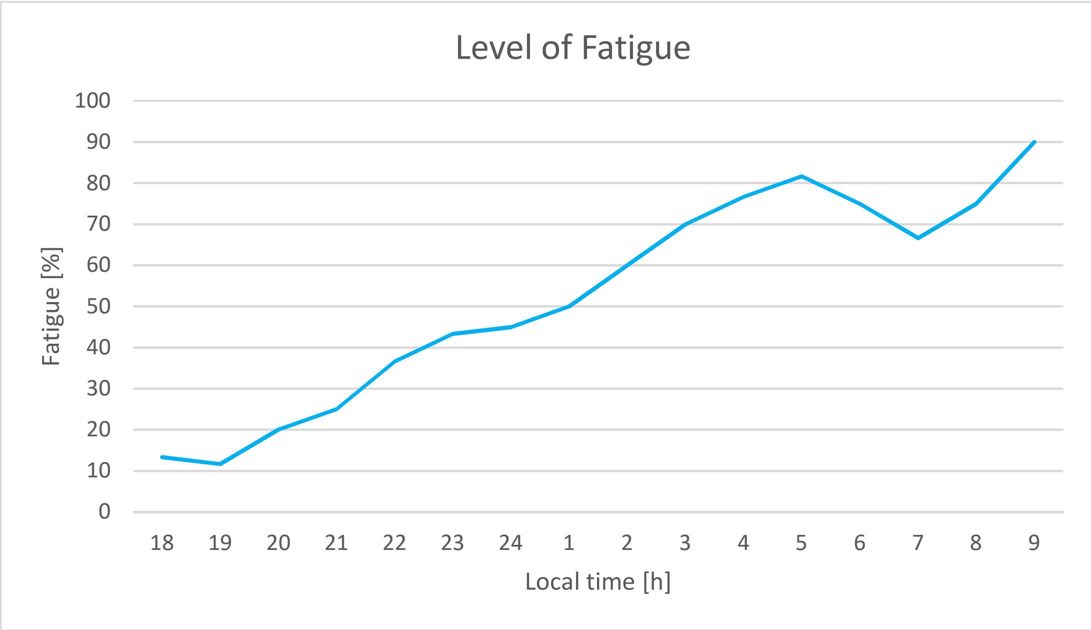




Source:(25)

Appendix 3 Day and night measured level of fatigue





Source:(25)

Appendix 4 Source data

Date and Time	ADEP	Igaa	ADES	Igad	Isvc	Inch	Tfn	Tdis	Tre	Tfp	Ikn
14.1. 12:05	OMDB	0.3	LKMT	0.1	0.6	7	10.1. 10:00	14.1. 6:00	6:05	92:00	98:05
16.1. 13:05	LKMT	0.1	LFPB	0.1	0.1	7	14.1. 18:30	16.1. 6:15	6:50	35:45	42:35
18.1. 9:35	LFPB	0.1	LKMT	0.1	0.1	5	18.1. 2:30	18.1. 5:15	4:20	2:45	7:05
20.1. 12:05	LKMT	0.1	UUDD	0.3	0.6	3	17.1. 7:35	20.1. 8:05	4:00	72:30	76:30
25.1. 7:05	UUDD	0.3	LKMT	0.1	0.6	1	22.1. 17:35	25.1. 1:30	5:35	55:55	61:30
25.1. 14:05	LKMT	0.1	LFBD	0.1	0.1	5	25.1. 8:40	25.1. 9:30	4:35	0:50	5:25
27.1. 7:20	LFBD	0.1	LKMT	0.1	0.1	4	25.1. 8:40	27.1. 2:40	4:40	42:00	46:40
27.1. 9:35	LKMT	0.1	LSZR	0.1	0.1	5	26.1. 13:00	27.1. 2:40	6:55	13:40	20:35
28.1. 16:05	LSZR	0.1	EDDS	0.1	0.1	5	28.1. 12:00	28.1. 13:00	3:05	1:00	4:05
29.1. 8:05	EDDS	0.1	LSZR	0.1	0.1	1	28.1. 21:00	29.1. 4:35	3:30	7:35	11:05
4.2. 5:50	LSZR	0.1	LKMT	0.1	0.1	2	3.2. 12:00	3.2. 22:50	7:00	10:50	17:50
4.2. 10:05	LKMT	0.1	UUDD	0.3	0.6	5	3.2. 12:00	4.2. 6:25	3:40	18:25	22:05
5.2. 6:50	UUDD	0.3	LKMT	0.1	0.6	3	3.2. 12:00	5.2. 2:00	4:50	38:00	42:50
5.2. 15:05	LKMT	0.1	EDHL	0.1	0.6	4	5.2. 10:05	5.2. 10:35	4:30	0:30	5:00
9.2. 10:05	EDHL	0.1	LKMT	0.1	0.6	4	8.2. 21:00	9.2. 6:15	3:50	9:15	13:05
12.2. 12:05	LKMT	0.1	UUDD	0.3	0.6	3	9.2. 16:30	12.2. 6:45	5:20	62:15	67:35
14.2. 10:20	UUDD	0.3	LKMT	0.1	0.6	5	9.2. 16:30	14.2. 7:00	3:20	110:30	113:50
15.2. 9:35	LKMT	0.1	LFPB	0.1	0.1	7	13.2. 11:45	15.2. 5:30	4:05	41:45	45:50
17.2. 12:35	LFPB	0.1	UUDD	0.3	0.6	5	13.2. 11:45	17.2. 6:55	5:40	91:10	96:50
19.2. 10:10	UUDD	0.3	LKMT	0.1	0.6	5	16.2. 11:45	19.2. 4:50	5:20	65:05	70:25
26.2. 13:05	LKMT	0.1	LIPZ	0.1	0.6	6	26.2. 7:05	26.2. 9:30	3:35	2:25	6:00
26.2. 16:50	LIPZ	0.1	LKMT	0.1	0.6	0	26.2. 7:05	26.2. 10:20	6:30	3:15	9:45
26.2. 19:20	LKMT	0.1	KEWR	0.2	1	7	23.2. 10:10	26.2. 14:30	4:50	76:20	81:10
27.2. 9:05	KEWR	0.2	LKMT	0.1	1	7	25.2. 10:10	27.2. 5:00	4:05	42:50	46:55
27.2. 15:05	LKMT	0.1	LGAV	0.1	0.1	3	23.2. 13:05	27.2. 10:15	4:50	93:10	98:00
1.3. 5:05	LGAV	0.1	LKMT	0.1	0.1	5	28.2. 13:05	1.3. 0:35	4:30	11:30	16:00
2.3. 15:05	LKMT	0.1	UUDD	0.3	0.6	3	1.3. 8:15	2.3. 10:05	5:00	25:50	30:50
4.3. 14:35	UUDD	0.3	LKMT	0.1	0.6	0	1.3. 8:15	4.3. 7:50	6:45	71:35	78:20
6.3. 16:05	LKMT	0.1	LZKZ	0.1	0.1	7	5.3. 10:45	6.3. 8:00	8:05	21:15	29:20
7.3. 11:50	LZKZ	0.1	LKMT	0.1	0.1	4	5.3. 10:45	6.3. 23:50	12:00	37:05	49:05
7.3. 21:05	LKMT	0.1	LFPB	0.1	0.1	4	5.3. 22:15	7.3. 15:15	5:50	41:00	46:50
10.3. 5:50	LFPB	0.1	LKMT	0.1	0.1	2	5.3. 22:15	9.3. 21:40	8:10	95:25	103:35
10.3. 11:35	LKMT	0.1	UUDD	0.3	0.6	3	8.3. 11:05	10.3. 6:35	5:00	43:30	48:30
17.3. 14:35	UUDD	0.3	LKMT	0.1	0.6	5	14.3. 14:05	17.3. 9:25	5:10	67:20	72:30
17.3. 16:35	LKMT	0.1	LIRQ	0.1	0.6	8	17.3. 10:00	17.3. 12:20	4:15	2:20	6:35
18.3. 16:35	LIRQ	0.1	LKMT	0.1	0.6	3	17.3. 10:00	18.3. 10:50	5:45	24:50	30:35
20.3. 14:35	LKMT	0.1	LIRQ	0.1	0.6	2	16.3. 10:00	20.3. 7:15	7:20	93:15	100:35
30.3. 5:05	LIRQ	0.1	LKMT	0.1	0.6	1	26.3. 10:00	29.3. 19:00	10:05	81:00	91:05
1.4. 5:05	LKMT	0.1	UUDD	0.3	0.6	5	30.3. 15:15	31.3. 20:45	8:20	29:30	37:50
1.4. 15:05	UUDD	0.3	LKMT	0.1	0.6	1	30.3. 15:15	1.4. 12:00	3:05	44:45	47:50
3.4. 15:05	LKMT	0.1	LZKZ	0.1	0.1	3	3.4. 11:00	3.4. 12:40	2:25	1:40	4:05

Date and Time	ADEP	Igaa	ADES	Igad	Isvc	Inch	Tfn	Tdis	Tre	Tfp	Ikn
12.4. 8:35	LZKZ	0.1	LKMT	0.1	0.1	2	7.4. 14:15	12.4. 5:00	3:35	110:45	114:20
13.4. 8:35	LKMT	0.1	LFPB	0.1	0.1	5	12.4. 10:40	13.4. 5:00	3:35	18:20	21:55
13.4. 12:35	LFPB	0.1	LKMT	0.1	0.1	6	12.4. 10:40	13.4. 4:45	7:50	18:05	25:55
15.4. 7:05	LKMT	0.1	UUDD	0.3	0.6	8	14.4. 13:30	15.4. 0:55	6:10	11:25	17:35
16.4. 13:05	UUDD	0.3	LTAI	0.1	1	4	14.4. 13:30	16.4. 7:50	5:15	42:20	47:35
20.4. 11:05	LTAI	0.1	LKMT	0.1	0.6	4	19.4. 8:45	20.4. 2:35	8:30	17:50	26:20
25.4. 11:05	LKMT	0.1	LEMG	0.1	0.6	7	24.4. 18:00	25.4. 6:15	4:50	12:15	17:05
27.4. 10:35	LEMG	0.1	LKMT	0.1	0.6	4	24.4. 18:00	27.4. 5:15	5:20	59:15	64:35
29.4. 14:05	LKMT	0.1	UUDD	0.3	0.6	0	29.4. 6:00	29.4. 12:00	2:05	6:00	8:05
30.4. 9:05	UUDD	0.3	LKMT	0.1	0.6	0	29.4. 6:00	30.4. 5:30	3:35	23:30	27:05
1.5. 9:05	LKMT	0.1	LFBD	0.1	0.1	3	29.4. 21:00	1.5. 1:30	7:35	28:30	36:05
8.5. 13:05	LFBD	0.1	LKMT	0.1	0.1	0	4.5. 11:00	8.5. 6:00	7:05	91:00	98:05
8.5. 17:20	LKMT	0.1	LZIB	0.1	0.1	0	8.5. 10:30	8.5. 13:30	3:50	3:00	6:50
11.5. 6:05	LZIB	0.1	LKMT	0.1	0.1	5	10.5. 10:30	10.5. 23:00	7:05	12:30	19:35
12.5. 13:05	LKMT	0.1	UUDD	0.3	0.6	1	10.5. 15:10	12.5. 5:00	8:05	37:50	45:55
13.5. 14:35	UUDD	0.3	LKMT	0.1	0.6	5	10.5. 15:10	13.5. 6:15	8:20	63:05	71:25
15.5. 13:05	LKMT	0.1	LIML	0.1	0.6	3	13.5. 18:30	15.5. 3:05	10:00	32:35	42:35
17.5. 8:35	LIML	0.1	LKMT	0.1	0.6	5	13.5. 18:30	16.5. 22:15	10:20	75:45	86:05
17.5. 12:05	LKMT	0.1	EGKB	0.1	0.6	4	12.5. 17:05	17.5. 4:00	8:05	106:55	115:00
18.5. 8:35	EGKB	0.1	LKMT	0.1	0.6	2	12.5. 17:05	18.5. 2:55	5:40	129:50	135:30
21.5. 11:05	LKMT	0.1	UUDD	0.3	0.6	6	20.5. 17:30	21.5. 7:25	3:40	13:55	17:35
25.5. 9:05	UUDD	0.3	LKMT	0.1	0.6	3	23.5. 10:30	25.5. 2:40	6:25	40:10	46:35
25.5. 11:35	LKMT	0.1	LFBD	0.1	0.1	7	25.5. 6:30	25.5. 9:00	2:35	2:30	5:05
26.5. 6:05	LFBD	0.1	LKMT	0.1	0.1	7	25.5. 6:30	26.5. 1:00	5:05	18:30	23:35
26.5. 15:05	LKMT	0.1	LIRA	0.1	0.1	6	26.5. 8:00	26.5. 11:10	3:55	3:10	7:05
27.5. 12:35	LIRA	0.1	LKMT	0.1	0.1	6	26.5. 8:00	27.5. 2:10	10:25	18:10	28:35
27.5. 13:35	LKMT	0.1	LKKV	0.1	0.1	5	27.5. 9:30	27.5. 11:20	2:15	1:50	4:05
31.5. 14:05	LKKV	0.1	LFBD	0.1	0.1	2	30.5. 11:30	31.5. 9:15	4:50	21:45	26:35
31.5. 15:40	LFBD	0.1	LKKV	0.1	0.1	5	30.5. 11:30	31.5. 6:20	9:20	18:50	28:10
1.6. 14:05	LKKV	0.1	LKMT	0.1	0.1	6	30.5. 11:30	1.6. 4:15	9:50	40:45	50:35
2.6. 3:45	LKMT	0.1	UUDD	0.3	0.6	5	1.6. 11:30	1.6. 22:15	5:30	10:45	16:15
3.6. 6:20	UUDD	0.3	LKMT	0.1	0.6	6	1.6. 11:30	3.6. 1:10	5:10	37:40	42:50
3.6. 7:35	LKMT	0.1	LZIB	0.1	0.1	0	2.6. 11:45	2.6. 19:45	11:50	8:00	19:50
3.6. 10:05	LZIB	0.1	LKMT	0.1	0.1	5	2.6. 11:45	3.6. 1:15	8:50	13:30	22:20
3.6. 13:05	LKMT	0.1	LERS	0.1	0.6	7	1.6. 8:55	3.6. 8:05	5:00	47:10	52:10
4.6. 12:05	LERS	0.1	LZIB	0.1	0.6	7	1.6. 8:55	4.6. 3:00	9:05	66:05	75:10
7.6. 8:35	LZIB	0.1	LKMT	0.1	0.1	7	2.6. 15:00	6.6. 21:35	11:00	102:35	113:35
8.6. 11:05	LKMT	0.1	LFPB	0.1	0.1	3	5.6. 21:25	8.6. 2:00	9:05	52:35	61:40
8.6. 13:05	LFPB	0.1	LKMT	0.1	0.1	2	5.6. 21:25	8.6. 2:00	11:05	52:35	63:40
9.6. 17:35	LKMT	0.1	UUEE	0.3	0.6	4	7.6. 10:45	9.6. 10:30	7:05	47:45	54:50
10.6. 5:45	UUEE	0.3	LKMT	0.1	0.6	5	7.6. 10:45	9.6. 21:25	8:20	58:40	67:00

Date and Time	ADEP	Igaa	ADES	Igad	Isvc	Inch	Tfn	Tdis	Tre	Tfp	Ikn
11.7. 7:05	LKMT	0.1	LFSB	0.1	0.1	6	10.7. 14:20	10.7. 22:35	8:30	8:15	16:45
16.7. 9:35	LFSB	0.1	LFBD	0.1	0.1	1	13.7. 11:15	16.7. 1:35	8:00	62:20	70:20
16.7. 15:35	LFBD	0.1	LKKV	0.1	0.1	8	15.7. 15:35	16.7. 6:35	9:00	15:00	24:00
19.7. 9:05	LKKV	0.1	LKMT	0.1	0.1	3	15.7. 15:35	18.7. 23:15	9:50	79:40	89:30
24.7. 11:35	LKMT	0.1	LGKF	0.1	1	1	22.7. 16:05	24.7. 2:50	8:45	34:45	43:30
24.7. 13:05	LGKF	0.1	LKMT	0.1	1	0	22.7. 16:05	24.7. 2:50	10:15	34:45	45:00
29.7. 10:05	LKMT	0.1	LFBD	0.1	0.1	0	26.7. 15:50	29.7. 1:15	8:50	57:25	66:15
1.8. 6:05	LFBD	0.1	LKMT	0.1	0.1	5	26.7. 15:50	1.8. 0:10	5:55	128:20	134:15
1.8. 9:05	LKMT	0.1	EGKB	0.1	0.1	4	31.7. 11:25	1.8. 0:10	8:55	12:45	21:40
1.8. 14:35	EGKB	0.1	LIPQ	0.1	0.1	0	31.7. 11:25	1.8. 9:10	5:25	21:45	27:10
1.8. 17:20	LIPQ	0.1	LGKO	0.1	1	4	31.7. 11:25	1.8. 9:10	8:10	21:45	29:55
3.8. 8:35	LGKO	0.1	LKMT	0.1	1	2	2.8. 12:00	2.8. 20:55	11:40	8:55	20:35
6.8. 12:05	LKMT	0.1	UUDD	0.3	0.6	4	5.8. 13:00	6.8. 3:30	8:35	14:30	23:05
10.8. 9:05	UUDD	0.3	LKMT	0.1	0.6	2	5.8. 13:00	10.8. 1:25	7:40	108:25	116:05
10.8. 11:20	LKMT	0.1	LFBD	0.1	0.1	8	9.8. 16:10	10.8. 2:20	9:00	10:10	19:10
16.8. 6:35	LFBD	0.1	LKMT	0.1	0.1	2	12.8. 16:10	15.8. 23:30	7:05	79:20	86:25
16.8. 9:35	LKMT	0.1	LFBD	0.1	0.1	8	12.8. 16:10	16.8. 5:45	3:50	85:35	89:25
17.8. 18:35	LFBD	0.1	LKMT	0.1	0.1	1	12.8. 16:10	17.8. 9:15	9:20	113:05	122:25
17.8. 21:05	LKMT	0.1	LFBD	0.1	0.1	7	15.8. 16:15	17.8. 9:55	11:10	41:40	52:50
19.8. 9:05	LFBD	0.1	LKMT	0.1	0.1	1	15.8. 16:15	19.8. 0:05	9:00	79:50	88:50
21.8. 14:05	LKMT	0.1	LFBD	0.1	0.1	3	21.8. 8:30	21.8. 11:00	3:05	2:30	5:35
22.8. 20:35	LFBD	0.1	LKMT	0.1	0.1	6	21.8. 10:30	22.8. 9:30	11:05	23:00	34:05
25.8. 7:05	LKMT	0.1	UUDD	0.3	0.6	5	24.8. 17:25	24.8. 21:00	10:05	3:35	13:40
26.8. 8:35	UUDD	0.3	LKMT	0.1	0.6	1	24.8. 17:25	26.8. 2:25	6:10	33:00	39:10
26.8. 15:55	LKMT	0.1	LGKR	0.1	1	5	26.8. 10:10	26.8. 12:20	3:35	2:10	5:45
30.8. 8:35	LGKR	0.1	LGKF	0.1	0.1	3	29.8. 15:15	30.8. 1:15	7:20	10:00	17:20
30.8. 10:05	LGKF	0.1	LGKR	0.1	1	3	29.8. 15:15	30.8. 1:15	8:50	10:00	18:50
30.8. 12:50	LGKR	0.1	LKMT	0.1	1	1	29.8. 15:15	30.8. 1:15	11:35	10:00	21:35
30.8. 15:45	LKMT	0.1	LFBD	0.1	0.1	1	30.8. 10:00	30.8. 10:15	5:30	0:15	5:45
31.8. 14:05	LFBD	0.1	LKMT	0.1	0.1	4	30.8. 10:00	31.8. 9:55	4:10	23:55	28:05
1.9. 14:05	LKMT	0.1	EGKB	0.1	0.1	3	1.9. 7:35	1.9. 8:45	5:20	1:10	6:30
4.9. 14:05	EGKB	0.1	LFBD	0.1	0.1	6	1.9. 7:35	4.9. 10:00	4:05	74:25	78:30
8.9. 8:35	LFBD	0.1	LKMT	0.1	0.1	2	7.9. 18:45	7.9. 22:50	9:45	4:05	13:50
10.9. 9:05	LKMT	0.1	UUDD	0.3	0.6	0	6.9. 19:50	10.9. 2:10	6:55	78:20	85:15
12.9. 13:35	UUDD	0.3	LZKZ	0.1	0.6	7	8.9. 19:50	12.9. 4:15	9:20	80:25	89:45
15.9. 12:05	LZKZ	0.1	LKMT	0.1	0.1	8	13.9. 11:50	15.9. 3:30	8:35	39:40	48:15
17.9. 9:05	LKMT	0.1	LIRA	0.1	0.1	1	16.9. 16:00	17.9. 2:00	7:05	10:00	17:05
18.9. 14:05	LIRA	0.1	LFBD	0.1	0.1	6	16.9. 16:00	18.9. 8:30	5:35	40:30	46:05
20.9. 11:35	LFBD	0.1	LKMT	0.1	0.1	1	16.9. 16:00	20.9. 5:20	6:15	85:20	91:35
23.9. 10:05	LKMT	0.1	LFPB	0.1	0.1	7	22.9. 21:05	23.9. 1:25	8:40	4:20	13:00
27.9. 9:35	LFPB	0.1	LKMT	0.1	0.1	1	25.9. 19:30	27.9. 3:30	6:05	32:00	38:05

Date and Time	ADEP	Igaa	ADES	Igad	Isvc	Inch	Tfn	Tdis	Tre	Tfp	Ikn
29.9. 9:05	LKMT	0.1	LFBD	0.1	0.1	4	28.9. 17:00	29.9. 5:00	4:05	12:00	16:05
29.9. 15:35	LFBD	0.1	EGKB	0.1	0.1	2	28.9. 17:00	29.9. 10:00	5:35	17:00	22:35
30.9. 9:35	EGKB	0.1	LKMT	0.1	0.1	5	28.9. 17:00	30.9. 1:10	8:25	32:10	40:35
2.10. 14:05	LKMT	0.1	LGKR	0.1	0.6	6	2.10. 8:00	2.10. 11:00	3:05	3:00	6:05
5.10. 9:05	LGKR	0.1	LKMT	0.1	0.6	3	2.10. 8:00	5.10. 2:45	6:20	66:45	73:05
9.10. 14:05	LKMT	0.1	LFBD	0.1	0.1	5	9.10. 8:00	9.10. 10:10	3:55	2:10	6:05
14.10. 9:05	LFBD	0.1	LKMT	0.1	0.1	0	9.10. 8:00	14.10. 5:15	3:50	117:15	121:05
14.10. 10:05	LKMT	0.1	LKPR	0.1	0.1	5	13.10. 21:30	14.10. 6:45	3:20	9:15	12:35
16.10. 14:05	LKPR	0.1	LFBD	0.1	0.1	6	13.10. 21:30	16.10. 10:00	4:05	60:30	64:35
16.10. 16:05	LFBD	0.1	LKPR	0.1	0.1	6	13.10. 21:30	16.10. 11:10	4:55	61:40	66:35
17.10. 10:05	LKPR	0.1	LKMT	0.1	0.1	1	13.10. 21:30	17.10. 5:40	4:25	80:10	84:35
18.10. 4:05	LKMT	0.1	LGAV	0.1	0.6	7	16.10. 23:20	17.10. 23:05	5:00	23:45	28:45
21.10. 5:05	LGAV	0.1	UUDD	0.3	0.6	5	16.10. 23:20	21.10. 0:15	4:50	96:55	101:45
21.10. 8:35	UUDD	0.3	LKMT	0.1	0.6	7	18.10. 15:00	21.10. 2:30	6:05	59:30	65:35
23.10. 14:05	LKMT	0.1	LFBD	0.1	0.1	6	22.10. 13:55	23.10. 7:55	6:10	18:00	24:10
23.10. 16:20	LFBD	0.1	LKMT	0.1	0.1	5	22.10. 13:55	23.10. 10:50	5:30	20:55	26:25
23.10. 18:05	LKMT	0.1	LOWW	0.1	0.6	6	23.10. 12:25	23.10. 15:05	3:00	2:40	5:40
26.10. 13:35	LOWW	0.1	LKMT	0.1	0.6	7	25.10. 10:00	26.10. 8:45	4:50	22:45	27:35
26.10. 15:20	LKMT	0.1	LIPO	0.1	0.1	8	25.10. 9:30	26.10. 10:00	5:20	24:30	29:50
28.10. 9:05	LIPO	0.1	LKMT	0.1	0.1	5	25.10. 9:30	28.10. 5:35	3:30	68:05	71:35
30.10. 14:35	LKMT	0.1	LZKZ	0.1	0.1	2	30.10. 9:15	30.10. 10:40	3:55	1:25	5:20
30.10. 18:05	LZKZ	0.1	LKMT	0.1	0.1	6	30.10. 9:15	30.10. 10:40	7:25	1:25	8:50
31.10. 16:35	LKMT	0.1	VVNB	0.4	1	0	22.10. 10:05	31.10. 10:15	6:20	216:10	222:30
2.11. 10:05	VVNB	0.4	LKMT	0.1	1	0	28.10. 10:05	2.11. 4:00	6:05	113:55	120:00
5.11. 10:05	LKMT	0.1	UUDD	0.3	0.6	3	2.11. 19:00	5.11. 5:25	4:40	58:25	63:05
15.11. 8:05	UUDD	0.3	LKMT	0.1	0.6	0	10.11. 19:40	15.11. 5:30	2:35	105:50	108:25
15.11. 16:05	LKMT	0.1	LGAV	0.1	0.6	2	13.11. 10:15	15.11. 10:55	5:10	48:40	53:50
15.11. 19:05	LGAV	0.1	LKMT	0.1	0.6	3	13.11. 10:15	15.11. 10:55	8:10	48:40	56:50
16.11. 4:35	LKMT	0.1	LGAV	0.1	0.6	6	13.11. 10:15	15.11. 22:55	5:40	60:40	66:20
16.11. 12:35	LGAV	0.1	FACT	0.5	1	7	11.11. 22:35	16.11. 7:30	5:05	104:55	110:00
3.12. 18:05	FACT	0.5	LKMT	0.1	1	6	1.12. 12:40	3.12. 14:15	3:50	49:35	53:25
4.12. 6:05	LKMT	0.1	FIMP	0.5	1	2	28.11. 16:50	4.12. 0:25	5:40	127:35	133:15
7.12. 16:05	FIMP	0.5	LKMT	0.1	1	5	28.11. 16:50	7.12. 11:35	4:30	210:45	215:15
7.12. 19:25	LKMT	0.1	EGLF	0.1	0.6	1	7.12. 10:35	7.12. 15:05	4:20	4:30	8:50
8.12. 9:05	EGLF	0.1	UUDD	0.3	0.6	8	7.12. 23:30	8.12. 5:15	3:50	5:45	9:35
12.12. 6:35	UUDD	0.3	LKMT	0.1	0.6	5	7.12. 23:30	12.12. 2:00	4:35	98:30	103:05
16.12. 12:45	LKMT	0.1	LSGG	0.1	0.6	1	16.12. 7:00	16.12. 8:20	4:25	1:20	5:45
17.12. 12:05	LSGG	0.1	LKMT	0.1	0.6	6	17.12. 7:05	17.12. 10:20	1:45	3:15	5:00
18.12. 10:05	LKMT	0.1	LFBD	0.1	0.1	8	16.12. 14:15	18.12. 5:15	4:50	39:00	43:50
20.12. 10:05	LFBD	0.1	UUDD	0.3	0.6	7	19.12. 17:15	20.12. 6:00	4:05	12:45	16:50
20.12. 13:05	UUDD	0.3	LKMT	0.1	0.6	6	19.12. 17:15	20.12. 8:25	4:40	15:10	19:50
21.12. 3:40	LKMT	0.1	UUDD	0.3	0.6	1	20.12. 7:45	20.12. 22:50	4:50	15:05	19:55

Date and Time	ADEP	Igaa	ADES	Igad	Isvc	Inch	Tfn	Tdis	Tre	Tfp	Ikn
21.12. 19:05	UUDD	0.3	LGAV	0.1	0.6	1	20.12. 7:45	21.12. 12:05	7:00	28:20	35:20
28.12. 9:05	LGAV	0.1	LKMT	0.1	0.6	2	25.12. 11:25	28.12. 3:00	6:05	63:35	69:40
28.12. 19:05	LKMT	0.1	OMAD	0.3	1	4	27.12. 9:05	28.12. 14:10	4:55	29:05	34:00

Source:(25)

Appendix 5 Capacity planning report proposal

Date	Number of Shifts (S)	Number of dispatchers per shift (N)	Number of Flights (Nd)	Total Iflc	Dday	Idq	Cday	Ddty/Cdty
1.1.2018	2	2	17	15.30	36.90	0.60	36.00	1.03
2.1.2018	2	2	24	21.60	35.20	0.90	54.00	0.65
3.1.2018	2	2	17	13.60	36.10	0.80	48.00	0.75
4.1.2018	2	2	25	22.50	47.00	1.00	60.00	0.78
5.1.2018	2	2	35	24.50	36.50	0.60	36.00	1.01
6.1.2018	2	2	15	12.00	28.80	0.90	54.00	0.53
7.1.2018	2	2	21	16.80	48.30	0.70	42.00	1.15
8.1.2018	2	2	35	31.50	51.50	0.80	48.00	1.07
9.1.2018	2	2	25	20.00	44.50	1.00	60.00	0.74
10.1.2018	2	2	35	24.50	35.70	1.00	60.00	0.60
11.1.2018	2	2	16	11.20	27.40	0.70	42.00	0.65
12.1.2018	2	2	18	16.20	23.90	0.60	36.00	0.66
13.1.2018	2	2	11	7.70	18.90	0.90	54.00	0.35
14.1.2018	2	2	16	11.20	20.30	0.70	42.00	0.48
15.1.2018	2	2	13	9.10	23.50	1.00	60.00	0.39
16.1.2018	2	2	16	14.40	23.40	0.90	54.00	0.43
17.1.2018	2	2	10	9.00	16.00	0.90	54.00	0.30
18.1.2018	2	2	10	7.00	16.80	0.80	48.00	0.35
19.1.2018	2	2	14	9.80	15.20	0.90	54.00	0.28
20.1.2018	2	2	6	5.40	9.90	0.70	42.00	0.24
21.1.2018	2	2	5	4.50	10.10	0.90	54.00	0.19
22.1.2018	2	2	8	5.60	14.00	0.90	54.00	0.26
23.1.2018	2	2	12	8.40	18.20	0.60	36.00	0.51
24.1.2018	2	2	14	9.80	13.30	1.00	60.00	0.22
25.1.2018	2	2	5	3.50	9.10	0.90	54.00	0.17
26.1.2018	2	2	8	5.60	12.60	0.90	54.00	0.23
27.1.2018	2	2	10	7.00	15.00	0.60	36.00	0.42
28.1.2018	2	2	10	8.00	16.80	0.90	54.00	0.31
29.1.2018	2	2	11	8.80	16.90	1.00	60.00	0.28
30.1.2018	2	2	9	8.10	8.10	0.70	42.00	0.19

Source:(25)