ISSN - 2454-0471

9 788055 409443

AIR TRANSPORT DEPARTMENT

FACULTY OF OPERATION AND ECONOMICS OF TRANSPORT AND COMMUNICATIONS

UNIVERSITY OF ŽILINA

INAIR 2014

International Conference on Air Transport

Hogeschool van Amsterdam
Amsterdam University of Applied Sciences

13 - 14 November 2014

Prague, Czech Republic

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ORGANISATION MANAGEMENT AND COMPLIANCE MONITORING OF APPROVED TRAINING ORGANISATION

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Abstract *– Introduction of compliance monitoring in the approved training organisation leads to improvement of the training process and raises the level of safety. Legal obligation for implementing systems for monitoring compliance was introduced by accepting aviation regulations, and accepting the provisions of national and international aviation authorities. The process of introducing and updating compliance monitoring system requires comprehensive technical documentation and knowledge of strict regulations which can often cause problems for smaller approved training organisations. Current regulation for pilot training and licensing is Part-FCL regulation which is only a fragment of Commission Regulation (EU) No 1178/2011.*
The aim of this paper is to analyze in detail compliance monitoring system and ways of maintaining that system fresh and current with the regulations. It tries to show the process of performing audits and analyze the audits conducted in approved training organisation.
The paper will explain detailed analysis on audit reports and will introduce new technique of finding and solving problems called "Root Cause Analysis". This technique will be applied to solve the problem of audit finding reports of ATO`s.

Key words – quality system, compliance monitoring system (CMS), approved training organisation (ATO), root cause analysis.

INTRODUCTION

Although the compliance monitoring system (previously called quality system) is widely recognized and introduced in the last dozens of years, quality tracks human history from an early age. Each generation has sought to create something that would last.

During the second half of the twentieth century, quality is recognized as a science of its own with all its attributes.

We can say that grandfather of quality science is Walter Andrew Shewhart. Through his book *"Economic Control of Manufactured Product" (1931),* he introduced quality to the world. The second most important person is William Edwards Deming who fallowed Shewart in his work and issued *"Statistical Method from the Viewpoint of Quality Control"* (1939), the series of edited lectures delivered by Shewhart.

Thanks to Joseph Moses Juran ("*Quality Control Handbook*" 1951), who brought quality from Japan to the United States in the 1960's; quality had huge influence on industry. His work *"The Juran Trilogy",* published in 1986. has set some foundations of today's quality management.

In most recent years largest improvement in quality has been achieved by creating ISO standards (founded in 1947.) that are now universally recognized as a symbol of quality. First quality management standard, *ISO 9000*, was issued in 1987.

Quality system is still only an option (which improves the looks and recognition on the market) for all industries. In aviation it is mandatory. Making it mandatory it gives an extra layer of safety and unification to all air operations.

Part-FCL regulation is only a fragment of "Commission Regulation (EU) No 1178/2011" issued on 3rd November 2011 which lay down technical requirements and administrative procedures related to civil aviation aircrew pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council.

On 13th March 2014 the European Commission has issued Commission Regulation (EU) No 245/2014 amending Commission Regulation No 1178/2011. These revisions were only administrative corrections to some statements. There were no changes affecting requirements of regulation.

This paper will be divided into four sections. Fist section will give general information on regulations and its application in Approved Training Organizations (ATO). The second and the third part introduce Root Cause Analysis and the way it is applied to solve problems which are showed by audit finding. The last part brings data analysis and final conclusion of the paper.

Organization and Regulations

Commission Regulation No 1178/2011 is setting new ground rules in aviation as well as reinforcing Regulation (EC) No 216/2008 which aims at establishing and maintaining a high uniformed level of civil aviation safety in Europe [1]. It lays down detailed rules, conditions and requirements for issuing, maintaining, amending, limiting, suspending or revoking all different licenses and certifications for everyone included in civil aviation which includes: Pilots, Persons responsible for flight training or flight simulation training, Medical, Cabin crew members and Administration and management system. The whole document is split into seven annexes. Annex 1 brings regulation for flight crew licensing (PART-FCL). It is divided into eleven subparts (from A to K) and nine appendixes (from 1 to 9).

Approved training organizations comply with PART-FCL by developing manuals. Manuals are comprehensive and step-by-step guides to a particular topic. The manual details what is given and what is required, explains how to put the presented information into practice, and instructs how to solve problems as they occur.

In developing flight training manuals Regulation states only minimum hours that applicant for license must have. It is up to organization to decide how they will distribute training hours in phases of training and if they need more than Regulation prescribes.

To successfully monitor compliance an Approved Training Organization must establish organisation management and compliance monitoring system (previously called Quality management system). It must include a compliance monitoring program (previously called Quality Assurance Program) that contains procedures designed to verify that all operations that are being conducted in accordance with all applicable requirements, standards and procedures.

Best way to monitor compliance of an Approved Training Organization to Regulation is by performing audits [2]. Audit is a systematic and independent examination in order to determine whether the actions and results related to compliance monitoring are in accordance with the provisions laid down, whether these provisions are adequate to achieve the objectives and whether it was actually implemented.

Audit forms are created with checklist questions. There are usually from 10 to 14 questions per form and for each question there can be sub-question. Questions must be understandable, logical and unambiguous. Good practice is to submit question list to organization before executing an audit.

Performing of audit is done in 3 stages: Preparation (it should be 50% of total audit time), Execution (it should be 30% of total audit time), Final activities (it should be 20% of total audit time).

Audit reports are usually made in three parts. First part is general information about audit which includes name of audit, audit process, required documentation and personnel involved in audit. Second section is the working process of the audit, which includes tasks that will be performed. In third section we get detailed information of finding and what needs to be done to get them fixed.

If an audit has a finding it means there is some deviation from Regulation which means there is no compliance. There are four kinds of findings - failure to meet requirements (standards), regulation is inappropriate for achieving the goals, activity does not comply with regulation and regulation is not really implemented.

Root Cause Analysis

Problem solving tools are determined by the requirements of the problem and the amount of time to solve the problem. Simple problems will be easy to solve by using basic tools and solution will usually be obvious. A complex problem is likely to be complex when it is difficult to understand due to the web of interrelated issues.

Root cause analysis is a structured investigation that aims to identify the true cause of a problem and the actions to eliminate it. It is a relatively new tool introduced to quality system in recent years. With its new ideas and innovative thinking it shows that even complex problems can be easily solved [3].

Before we start with root cause analysis we need to understand what the problem is in general. A problem is a state of difficulty that needs to be resolved. It is often the result of multiple causes at different levels. If we attack and remove only the symptoms, the situation of problem can become worse. The problem is still there but there will be no longer symptoms to indicate it. By eliminating first or higher-level cause problem will temporarily be solved but it will manifest itself in the form of another problem.

To solve problems Root Cause analysis goes through seven-step process as showed in Figure 1.

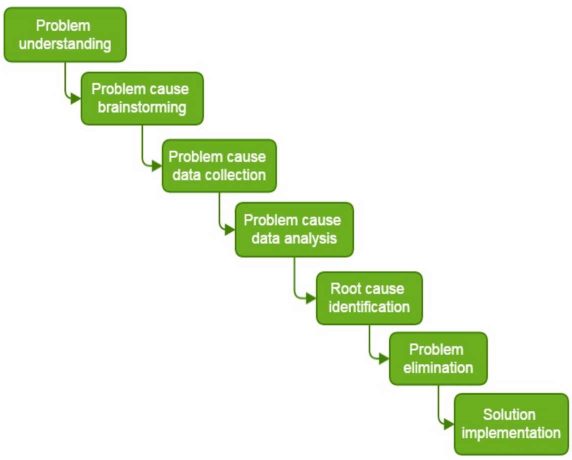

Figure 1 - Root cause analysis process

Each step of process describes various sets of tools which are best to use to get desired data.

Applying Root Cause Analysis

Root Cause Analysis can be applied to solve audit finding.

In this paper Root Cause Analysis is applied on two audit findings which should be corrected [4].

One of audit report findings indicates that problem involves students and their obligation in filling-up required documentation. The other audit report finding involves exceeding of available duty time for instructors.

First audit report

Problem Understanding – Using flowchart we can draft process from instructor-student flight arrangement till the end of the flight. Somewhere in that process there is a cause that makes the student not to fill in his/hers required documentation for flight.

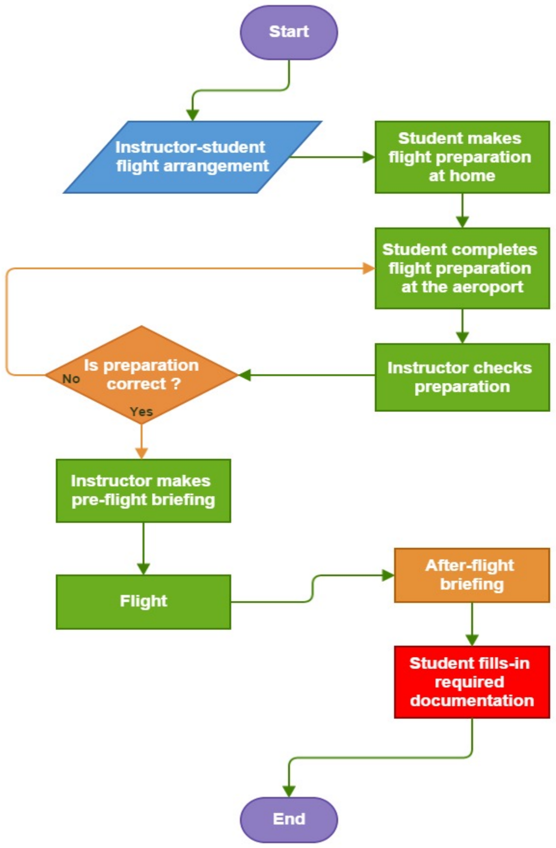

Figure 2 - Process of flight for students

From Figure 2 we can assume that problem happens somewhere in-between steps where instructor checks student's preparation and pre-flight briefing and between the steps of after-flight briefing and the end of the process. Possible places of root cause are marked in orange while more likely places are marked in red.

Problem cause brainstorming – using flowchart made in the first step we have located possible steps where errors could be made. Next step in solving our problem is problem cause brainstorming. In this step we brainstorm over all possible causes that could cause our problem. Some of these causes might be the ones from Figure 3.

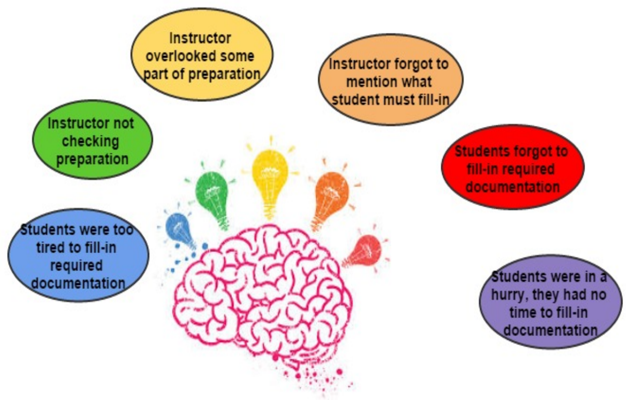

Figure 3 - Brainstorming source of problem

For this paper brainstorming was done by authors but it would be recommended practice that brainstorming is done with a group of instructors and students together. With the higher amount of participants the better ideas will come up. It is important that there are both instructors and students present so that the problem could be seen from both perspectives.

Problem data collection – Because our group is small we do not need to use special tools for collecting data. We can simply interview them individually. Most of our participants that had forgotten to fill-in required data said that they forgot or that they overlooked it. Some said that they were in a hurry and that they did not have time because they were late.

Problem cause data analysis – Since we are not dealing with a large sum of data this step can be skipped in the Root Cause Analysis.

Root cause identification – To identify cause we will use "5 Whys tool". We will keep asking why until the root cause is found. We can start from the most probable cause:

Why did students forget to fill-in required documentation?

→They were distracted.

Why were they distracted?

→They were still fresh from flying.

Why weren't they supervised?

→Instructors do not supervise them after briefing.

Why do they not supervise them?

→Flight process has been finished.

After going through "5 whys" identification tool, we have found the root of our problem. Students overlook their duty to fill-in documentation because they are still overloaded with flying lessons that have recently finished.

Root cause elimination – To eliminate the root cause there is one simple solution. We just need to add one more process in our flowchart marked in dark magenta colour.

Instructors should check whether the documentation is filled-in before students can go home. Solution to the problem is shown in Figure 4.

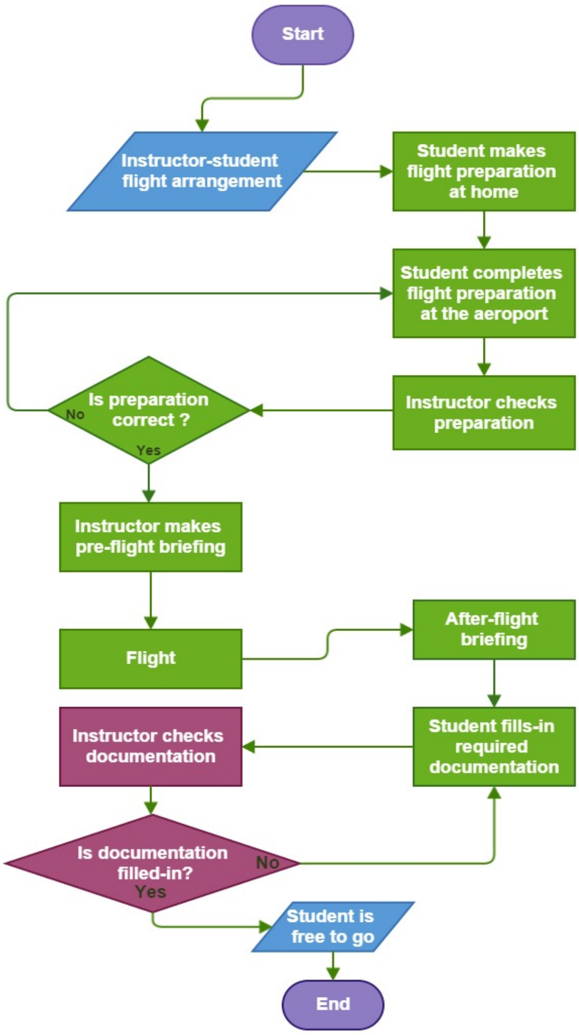

Figure 4 - Root cause elimination

Solution implementation – Solution implementation should start by changing the top of hierarchy. It must be supported by the Head of training first and everyone involved further on. The change in operation should be implemented in manual. Instructors must be notified first and students should be last in the chain.

For this solution to last, instructors must support the idea and take from their time to check documentation that students have filled in.

SECOND AUDIT REPORT

Problem Understanding – To better understand the problem we have drafted a flowchart (showed in Figure 5) of the planning process for weekly schedule.

As Figure 5 shows, duty time is checked only by Compliance Monitoring Manager (marked with red square in flowchart). Manager is not required to check duty time on a daily basis so there is possibility that some instructors exceed their allowed duty time.

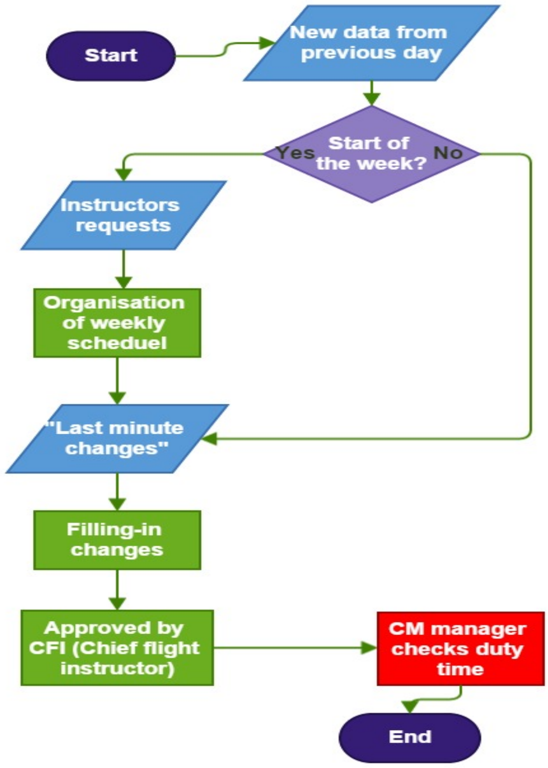

Figure 5 - Process of planning of weekly schedule

Problem cause brainstorming – Through brainstorming the problem we can find some possible causes to the problem:

•Instructor miscalculated duty hours

•Dispatch officer did not update duty hours from previous flights

•Dispatch officer miscalculated duty hours

•Dispatch officer did not consider duty time when planning flights

Problem Data collection – Since there is only one person that is creating tables for flight time there is no need for big data collection. Single interview would be sufficient.

Problem cause data analysis – From our interview we can make conclusion that most probable cause is that Dispatch officer did not consider the duty time when planning flights.

Root cause identification – To identify root cause, we can once again use “5 whys” technique:

Why did not Dispatch officer consider duty time when planning flights?

→He forgot.

Why was he not reminded?

→There was no warning.

Why was there no warning?

→There was no program to warn Dispatch officer.

Root cause elimination – Now that root cause has been identified we must eliminate it. To find how to eliminate it we will use “The theory of inventive problem thinking”. This theory tries to find solution to the problem in different disciplines.

By looking at our closest discipline, which is aircraft maintenance, we can see that they had (and solved) very similar problem to ours. They had to develop a program to alert them before the aircraft resource is about to expire.

Their problem has been solved by creating computer program that would flash warning message to the user with the required information.

Since the flight schedule is made in excel program, all what is needed is to write down function that would monitor duty time of instructor and show warning message next to the schedule when that time is exceeded.

Using sum option it is possible to sum all duty time of one instructor required for our function to work.

Excel function for solving problem:

IF(“cell number”<=100;"Ok";"Warning: Overduty")

Using Conditional Formatting tool we can add colour change for cell when allowed number is exceeded in desired cell (showed in Figure 6).

30	Ok		120	Warning:Overduty	

Figure 6 - Excel formula for solution implementation

In our case colour is scaling from yellow to red as it is approaching the limit which is 100 hours per month. After 100 hours are crossed, there would be a colour change and the information “Warning: Overduty” in our notification box.

If the schedule and duty table are not on the same excel worksheet there should be connection between the sheets in form of function: =”name of the sheet”!”cell with sum”. In this way data from sheet with duty time would be copied to the sheet containing schedule.

Solution implementation – all which is required to implement solution is to make required revisions into the excel table and to integrate it in the process of schedule planning.

Implemented solution is shown by flowchart in Figure 7 marked in dark magenta.

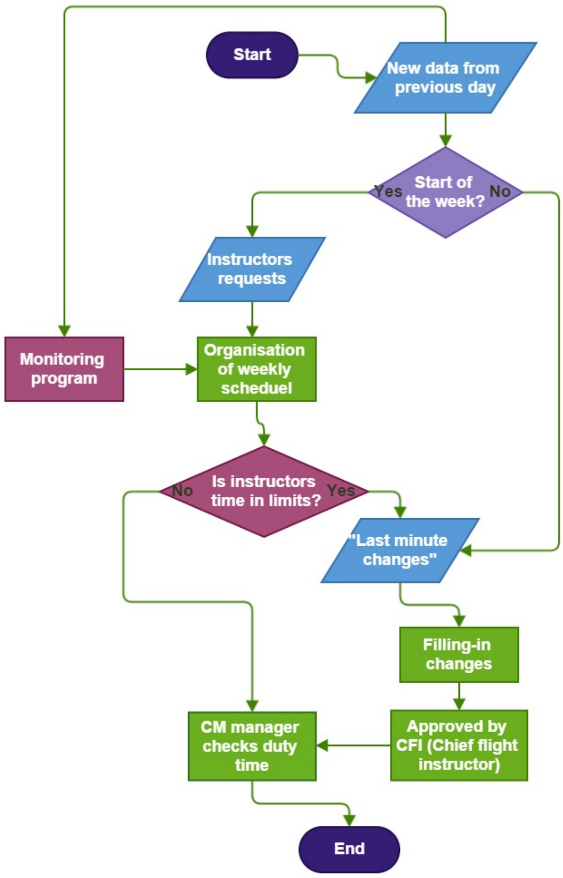

Figure 7 - Implemented solutions to the problem

CONCLUSION

As we have seen in the paper, compliance monitoring is something that is making our working system better. It improves safety of everything in which it is involved.

Monitoring has been a part of human history from the early ages, just as part of industries as trying to make product better than competitors. After that it became a science on its own. Now it is starting to influence every industry and is becoming mandatory.

Regulations provide limitations to which every organization must comply to keep up with the standards. Regulations are the ones that keep this system equal at its bare minimums. With every new regulation there are increases in required minimums and standards. Even though standards are increasing (and sometimes it is hard to keep up with them), with constant improvement and actualization, organizations can stay competitive with the growing competition and stay ahead.

Every day quality leaders discover and make new techniques and tools for problem solving and for improving current status. Quality and compliance monitoring are in high growth. Staying current with the progress will help to improve quality system of organization.

Applying new tools and techniques in solving problems, such as Root Cause Analysis, we can improve working environment and productivity. By understanding processes we can control them and make them better than they are.

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SIMULATION OF BOSNIA AND HERZEGOVINA AIRSPACE SECTORIZATION AND ITS INFLUENCE ON FAB CE

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Abstract - *The process of establishing new air navigation service provider (ANSP) and air traffic management system is a complex procedure that implies preliminary analysis and simulation of service provision within airspace concerned and its influence on air traffic flows within neighbouring airspaces. In such new conditions airspace structure and sector capacities should be analysed in terms of current and future air traffic demand as well as generated delay. This paper deals with the implementation of the new airspace structure and air traffic management (ATM) system within Bosnia and Herzegovina (BH) airspace as a part of Functional Airspace Block Central Europe (FAB CE). The transition from the current air traffic services provision to a service provided by a newly established ANSP will be simulated. Four different sectorization scenarios of BH airspace will be developed and their influence on the neighbouring FAB CE countries will be analysed. Sectorization will be vertical and geographical and include analysis of sector capacity, time distribution of air traffic and sector overload, that would result in generated ATFM delay. Results of the simulation will give basic directions how air traffic flows within FAB CE countries will be affected with the new BH sectorization.*

Key words – airspace structure, sectorization, simulation, air traffic management system, Bosnia and Herzegovina airspace, FAB CE.

INTRODUCTION

The process of establishing a new air navigation service provider (ANSP) and air traffic management system implies creation of regulations and airspace organization structure (sectorization) with clear division of responsibility that would balance traffic demand and airspace capacity. Airspace sectorization is based on predetermined parameters such as air traffic flows, traffic demand, air traffic management (ATM) system capacity and sector capacity. Traffic congestion, airspace overload and possible delay as a result of the new airspace structure influence the neighbouring airspace or a wider region such as functional airspace block.

In Bosnia and Herzegovina (BH) airspace the new ATM system and new national ANSP would take over the provision of air navigation services in years to come so it is necessary to make preliminary research and analysis how it would influence the neighbouring countries, i.e. Croatia, Serbia and Montenegro but also Functional Airspace Block Central Europe (FAB CE). There isn't any previous research made on this actual situation.

The purpose of this research is to present preliminary results in the terms of traffic load and capacity of BH airspace sectorization as a part of wider ATM system implementation.

AIR TRAFFIC SERVICES WITHIN BOSNIA AND HERZEGOVINA AIRSPACE

Air traffic service provision in Bosnia and Herzegovina, is still being delegated to Croatia Control ltd. (CCL - Croatian ANSP) and Serbia and Montenegro Air Traffic Services llc (SMATSA - Serbia and Montenegro ANSP), as shown in the Figure 1. [6]

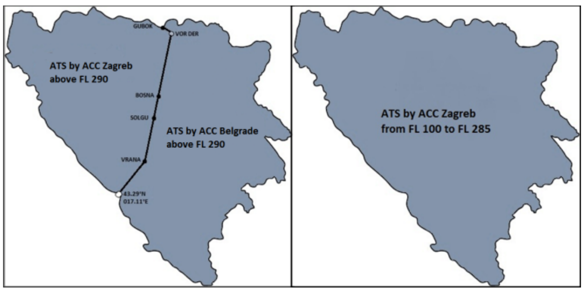

Figure 1 - *Bosnia and Herzegovina Airspace Bouderies and ATC Stations*

CCL is responsible for provision of air traffic services from FL 100 to FL 285 outside TMA areas. Air traffic service provision in the upper part of Bosnia and Herzegovina airspace (from FL 290 to unlimited) is split between CCL and SMATSA. The boundary is defined with the following navigation points:

- GUBOK
- DER - VOR Derventa

- BOSNA
- SOLGU
- VRANA
- Coordinate point 43.2900N - 017.1100E

In 2005 the Council of Ministers of Bosnia and Herzegovina adopted the Bosnia and Herzegovina ATM Strategy plan to create a national air navigation service provider and develop and implement the new BH ATM System. In the process of switching air traffic service provision from the CCL and SMATSA to the new national provider, Bosnia and Herzegovina Directorate of Civil Aviation (BHDCA) was established as a national supervisory authority, and Bosnia and Herzegovina Agency for Air Navigation Services (BHANSA) was established as a new national ANSP.[7]

The BH ATM system development comprised four major segments: the establishment of the ATM system, Institutional Transformation, Development of Human Resources and Civil Works. [2]

Establishment of BHANSA has to ensure safe, regular and efficient transition of the air traffic service provision (and wider air navigation services) by meeting all technical and operational conditions in every phase of transition.

Implementation of the new BH ATM System and establishment of BHANSA, are divided in the two phases of air traffic service provision:[4]

1. Phase I - expected to become operational by the end of 2014;
2. Phase II - it should be completed by the end of 2015.

Phase I

In this phase, BH ATM System implementation considers following BH airspace sectorization within control area (CTA): two sectors Lower sector up to FL285 and Upper sector from FL 285 to FL325, while above FL325 the service provision remains delegated to CCL and SMATSA.

All technical preconditions are expected to be completed by the end of 2014, when the first phase of BH ATM system implementation should become operative.

Phase II

In this phase, BH ATM system implementation should become operable by the end of 2015. The second phase includes taking the control over complete upper part BH airspace above FL325.

Since the technical preconditions should be fulfilled in the Phase I, the main task of the second phase of BH ATM system implementation would be the adaption of the existing system and insuring the sufficient number of air traffic controllers (ATCOs) and supporting personnel. The number of ATCOs needed is a direct function of the expected traffic load and the number of activated sectors. Expected air traffic flows which vary during time, airspace and route structure are also major parameters that influence type of airspace sectorization.

Therefore, the simulation of the Phase II of BH airspace sectorization will be analysed further in the text to observe its possible influence of the neighbouring countries and functional airspace block.

Methodology of Capacity Determination and Traffic Forecast Simulation

Analysis and simulation of the BH Implementation Phase II are made by using EUROCONTROL NEST software (Network Strategic Tool) where various scenarios are developed with different airspace sectors and traffic loads. Prior to the analysis it is necessary to prepare the input data and set the initial prerequisites. Then the reference capacity values are calculated and maximum sector capacity is determined as the parameter of future ATCO workload. One of the prerequisites is the fact that Bosnia and Herzegovina is a member state of FAB CE, and therefore the preliminary sector capacity was determined as an average value of sector capacities taking into consideration all sectors of FAB CE member states. The calculation is based on NEST sector capacity data declared in AIRAC 1405 dataset. Calculated value of average sector capacity was 38 operations per hour.[3]

For preliminary analysis, a safety buffer (rate reduction) must be taken into consideration when determining sector capacity. In this analysis the reduction rate of 25% was taken for BH sector capacity reduction (it is a mid-value of rate reduction in sector capacity between 15% and 35%, scaling down which were caused by major airspace or ATM system change projects in winter 2013/2014).[5] Therefore, the determined BH sector capacity is:

$$\text{Capacity}_{\text{BH}} = 38 - 25\% \text{ [operations/h]}$$

$$\text{Capacity}_{\text{BH}} \approx 28 \text{ [operations/h]}$$

This value of 28 operations per hour is assumed to be preliminary BH sector capacity, and will be used for further simulations. Real sector capacity calculations are far more complex and include various factors and detailed analyses which can be provided only within national ANSP taking into consideration ATCO workload and air traffic complexity assessments.

Since Phase II is scheduled for the end of 2015, for more accurate results it is necessary to simulate the traffic forecasted for 2016. STATFOR traffic forecasts provided by EUROCONTROL are available as a part of each AIRAC dataset at the end of each AIRAC cycle. Forecasts of traffic growth provided by STATFOR are used to generate future traffic samples. For simulation of air traffic inside BH airspace, AIRAC 1407 dataset is used and traffic growth is simulated according to STATFOR forecast rates for all the traffic which affects ECAC member states. Traffic forecast simulation applies STATFOR forecast rates to the AIRAC dataset used for the simulation, without adapting the calendar. Therefore AIRAC 1407 dataset used before the simulation will be referred to as Original data, while the dataset used after the simulation of 2016 traffic will be referred to as Adapted data.

The busiest day of AIRAC 1407 dataset in Europe is June 27th, counting 34537 operations in Original data, and 36521 operations in the Adapted data. Growth rate for 2016 simulation is rather constant, with the minimum value of 5.57% on July 3rd and the maximum value of 6.33% on June 28th.

On the other hand, the busiest day in BH airspace occurs on July 5th counting 1200 operations in Original 2014 data and 1274 operations in Adapted data. The growth rate tends to be constant; however it varies more than the total growth rate for entire Europe, extending from 4.43% which occurs on July 9 up to 7.21% on July 11th.

To present the impact of the simulation on traffic, July 11th is chosen as an example day. This day is the busiest day of July for total ECAC traffic from AIRAC 1407 dataset (July 1st – July 23rd) both in the Original data and in the Adapted data after the simulation of STATFOR traffic growth rate for 2016. The results of simulation for July 11th 2016 are presented in the Table 1, showing the comparison of Original data and Adapted data of total ECAC air traffic for the busiest day in July. In the table airspaces are presented by Area Control Centres (ACC). BH ACC is ACC Sarajevo-Banja Luka.

***Table 1** - Results of Traffic Forecast Simulation*

	Air traffic 2014 [operations]	Air traffic 2016 [operations]	Difference [%]
ECAC	33546	35480	5,76
FAB CE	7205	7632	5,93
ACC Bratislava	1710	1848	8,07
ACC Budapest	2561	2761	7,81
ACC Ljubljana	1358	1426	5,01
ACC Prague	2564	2743	6,98
ACC Sarajevo-Banja Luka	1101	1178	6,99
ACC Vienna	4193	4395	4,82
ACC Zagreb	2061	2288	11,01

The data show that the air traffic growth rate for each ACC is not directly related to total ECAC growth rate, but rather varies, while values of the growth rate for wider areas such as FAB CE are closer in number to the total ECAC growth rate value. Since the total ECAC traffic growth is comprised of numerous local changes in growth rate, it is directly dependent of any change in each local air traffic growth rate. The relation and the dependence of local traffic between ACCs, showing the impact of BH airspace on neighbouring countries and FAB CE will be presented in further analysis.

Simulation of Airspace Sectorzation

To make different BH airspace organization (sectorization) analysis, it is needed to make a Preliminary scenario that would show traffic load within BH airspace, as single sector, taking into consideration traffic for a peak day from Original AIRAC1407 dataset as shown in the Figure 2

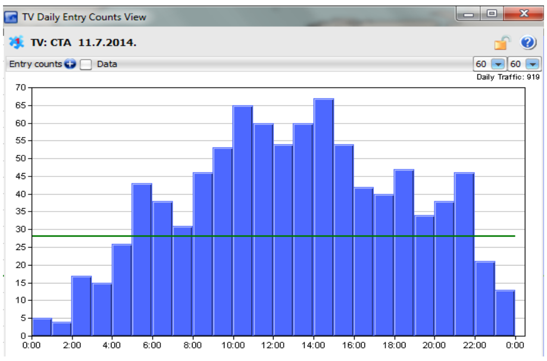

***Figure 2** – Daily Entry Count for Preliminary Scenario*

Figure shows the number of aircraft entering the observed airspace in one day, where the x-axis indicates the time; the y-axis indicates the number of aircraft while the green line represents set sector capacity (28 operations/h).

It is visible in the top right corner of the Graph that the daily traffic crossing the BH airspace on the observed day is 919 aircraft. The highest number of aircraft entering the area in one hour is 67 aircraft.

Taking into account that the calculated maximum sector capacity is 28 operations/h, it is concluded that one sector cannot handle analysed historical traffic volume. So, it is necessary to make further sectorization of BH airspace.

Four scenarios are created with following airspace sectorizations:

- Scenario 1 – BH airspace (CTA) is divided into two sectors vertically separated at FL 365;
- Scenario 2 - BH airspace (CTA) is divided to Lower sector (FL 100 or above terminal areas to FL 355), High sector (FL 355 to FL 375) and Top sector (above FL 375);
- Scenario 3 - BH airspace (CTA) is divided vertically into Lower sector from above the uncontrolled zone and TMA areas to FL 345, Upper sector from FL 345 to FL 365, High sector from FL 365 to FL 375 and Top sector from FL 375 upwards; and
- Scenario 4 - BH airspace (CTA) is divided geographically into North and South sector, both of which were further divided vertically at FL 365 resulting with four sectors: High North, High South, Low North and Low South.

Scenario 1 and Scenario 3 were, after preliminary analysis, considered inadequate due to high traffic overloads and inadequate technical solution, leaving only two possible sectorization scenarios to be considered: Scenario 2 and Scenario 4

Result Analysis

Scenario 2

Distribution of traffic on July 11th simulation tends to be even for each sector, counting 426 aircraft operating through Low sector, 516 aircraft in High sector and 457 aircraft in Top sector (Figure 3).

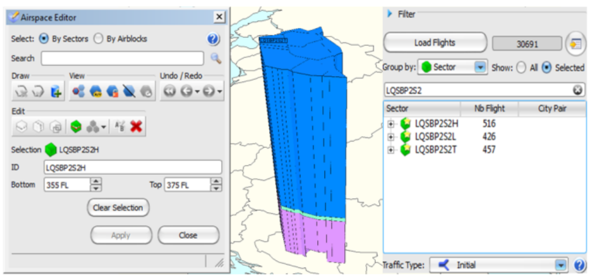

***Figure 3 –** Scenario 2 Airspace Sectorization*

Analysing Top sector (Figure 4) it can be noticed that the traffic peaks between 10:00 and 11:00, counting 40 aircraft in the sector, that consequently cause 12 overload flights in that hour.

Airspace overload occurs in three hours in the given day, causing 17 aircraft to be regulated or delayed. In other words, considering the traffic demand of 424 aircraft 4.01% of total traffic is causing sector overload.

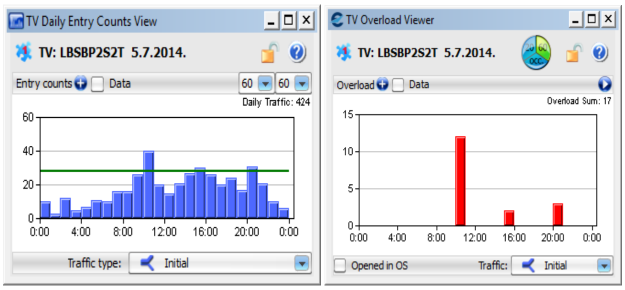

***Figure 4** - Daily Entry Count and Traffic Volume Overload for Scenario 2 – Top Sector*

High sector (Figure 5) is counting 482 operations in examined day, in spite of being the smallest of three sectors (FL 355- FL 375) and containing only two flight levels. The peak traffic occurs between 13:00 and 14:00, counting 37 entries in an hour and causing 9 overload flights.

The total overload is 27 aircraft distributed through six hours of a day, causing the sector to be overloaded 25% of the time. The amount of overload flights in total traffic demand is 5.6%.

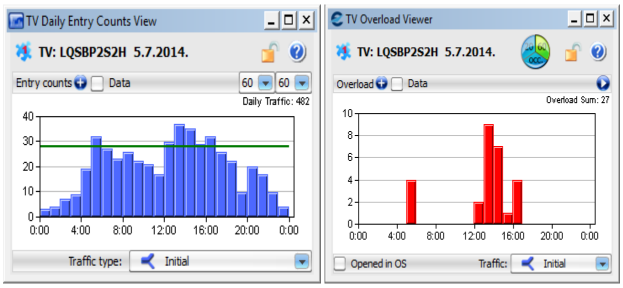

***Figure 5** - Daily Entry Count and Traffic Volume Overload for Scenario 2 – High Sector*

On the observed day Lower sector (Figure 6) counts 410 operations with peak hour from 08:00-09:00, when 36 flights enter the sector and cause an overload of 8 aircraft in that hour

Sector has the sum of 10 overload flights, which is 2.44% of total traffic demand and occurs in 3 hours of the day. Such traffic allows the sector to operate without causing delays and regulations in 87.5% of the day.

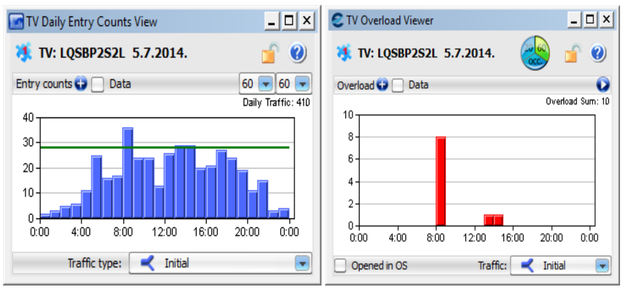

***Figure 6** - Daily Entry Count and Traffic Volume Overload for Scenario 2 – Lower Sector*

Comparing traffic distribution in Top, Lower and Upper sector, it can be seen that each sector has peak hours at different time of a day, leaving the opportunity to solve overload flights by changing their flight level and passing them to other sectors.

SCENARIO 4

Analysis of the traffic distribution in the configuration for simulation of 2016 on July 11th, show that from 1041 flights operating through the BH airspace, 336 will fly within Lower North sector, 358 High North, 356 Lower South and 415 High South (Figure 7).

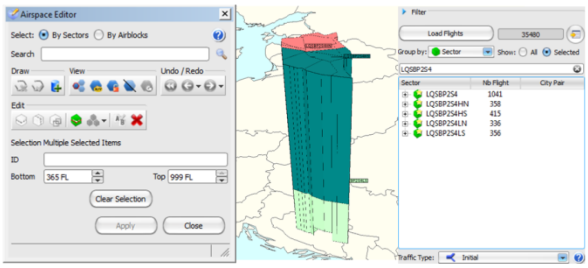

***Figure 7** - Scenario 4 Airspace Sectorization*

The peak hour of High North sector appears from 10:00 to 11:00 and counts 41 operations, causing an overload of 13 flights, as presented in Figure 8.

Sector overload appears in seven hours of a day, causing total of 36 flights to be regulated or delayed. The share of 7.48% of total 481 flight operating through High North sector is in overload and it causes the sector to be overloaded in 29% of its working time.

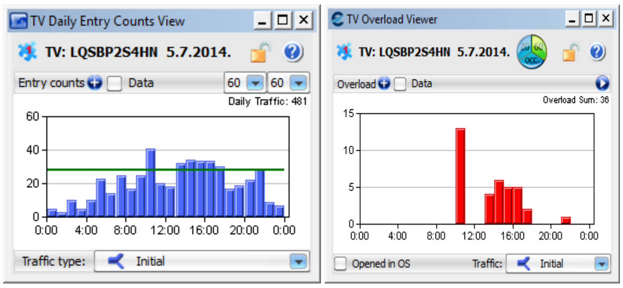

***Figure 8** - Daily Entry Count and Traffic Volume Overload for Scenario 4 – High North Sector*

Lower North sector (Figure 9) has slightly less dense traffic with 397 flights. The peak hour appears between 08:00 and 09:00 when 34 aircraft are entering the sector, causing 6 overload operations.

Being the only overloaded hour, the 6-operation overload in the peak hour take part of 1.5% of the overall traffic.

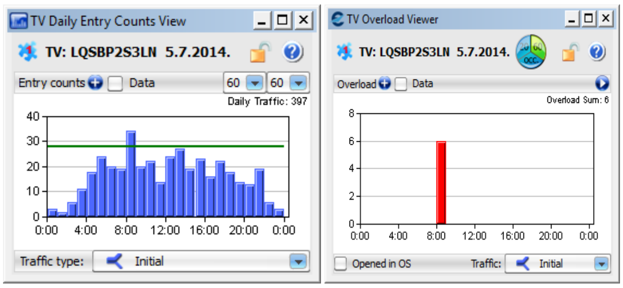

***Figure 9** - Daily Entry Count and Traffic Volume Overload for Scenario 4 – Lower North Sector*

High South sector (Figure 10) counts 453 aircraft in the observed day and had two afternoon peak hours of 34 aircraft entering the sector from 14:00 to 15:00 and from 20:00 to 21:00. Sector overload caused by the peak hours is 6 aircraft in each hour.

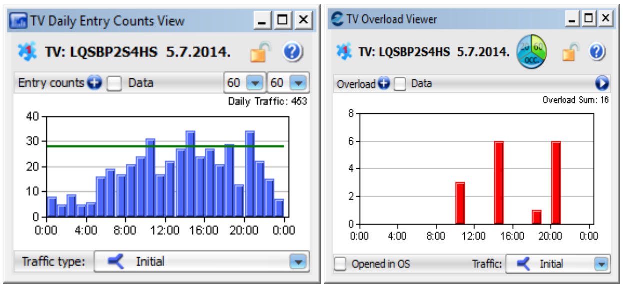

Figure 10 - *Daily Entry Count and Traffic Volume Overload for Scenario 4 – High South Sector*

Being the sector with the least traffic, Lower South sector counts 382 aircraft entering the airspace in the observed day. Entries are distributed in a day as shown in Figure 11.

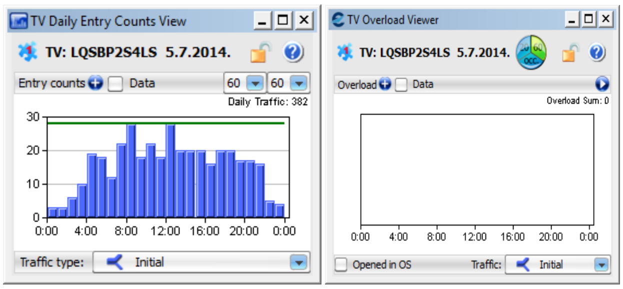

Figure 11 - *Daily Entry Count and Traffic Volume Overload for Scenario 4 – Lower South Sector*

It can be seen that two peak hours stand out, from 08:00 to 09:00 and from 12:00 to 13:00, both counting 28 entries, which is the same as calculated sector limitation per hour, owing to which there are no overloads in that sector.

As in the Scenario 2, peak hours in each sector of Scenario 4 appear at a different hour in a day.

Impact of Bosnia and Herzegovina Airspace Sectorization on FAB CE

FAB is a block of airspace established regardless of State boundaries and it includes several ANSPs in order to achieve better performance and cooperation in provision of air navigation services. Europe is divided to nine FABs, one of which is Functional Airspace Block Central Europe (FAB CE). Member states of FAB CE are: Austria, Bosnia and Herzegovina, Croatia, Czech Republic, Hungary, Slovakia and Slovenia.[1]

The aim of FAB CE incentive mechanism is to improve cooperation between states in order to improve Capacity performance, while keeping high quality services. The main Key Performance Indicator (KPI) for Capacity performance is en route air traffic flow management (ATFM) delay per flight. The pan-European performance target for the delay is defined with 0.5 minutes for 2014, while FAB CE wide target delay is planned to be maximally 0.15 minutes per flight, with capacity performance targets set individually for each State.

For the FAB CE Performance Plan for the second Reference Period (2015 - 2019) shown in the Table 2 Bosnia and Herzegovina is the only state not being a member of EU and therefore has no national capacity target published. [4]

Table 2 - *Targets for ATFM delay on National and FAB CE Level*

		2015	2016	2017	2018	2019
FAB reference values		0.32	0.31	0.31	0.30	0.29
National targets:	Austria	0.23	0.23	0.23	0.22	0.21
	Czech Republic	0.14	0.13	0.12	0.11	0.11
	Slovak Republic	0.10	0.10	0.10	0.11	0.10
	Hungary	0.0649	0.0549	0.0549	0.0449	0.0549
	Slovenia	0.21	0.21	0.22	0.23	0.22
	Croatia	0.23	0.22	0.21	0.21	0.19

Each FAB CE State should provide its performance plan, except for states not being member of EU at the time when the regulation is applicable.

Due to NEST system limitations, in the field of delay calculation and its inability to simulate rerouted flights, ATFM delay results for the performed simulation are considered unwarrantable, and they are not presented in this paper. Therefore, the number of shared flights remains the only valid indicator of impact of BH sectorization on FAB CE member states.

Table 3 - *Shared number of flights of BH traffic and each FAB CE member state*

	Bosnia and Herzegovina [flights]	Percentage of BH TV [%]	Percentage of FAB CE member state TV [%]
Austria	850	66.7	26.5
Croatia	1256	98.6	48.2
Czech Republic	15	1.2	0.8
Hungary	15	1.2	0.5
Slovak Republic	17	1.3	1.2
Slovenia	652	51.2	47.6

Since Croatia and Slovenia share high percentage of traffic with Bosnia and Herzegovina (>45%), it is expected for them to be significantly influenced by possible BH ATFM delay. Austria, with 25.5% of traffic shared with BH could expect lower impact resulted by BH ATFM delay, while the impact on Czech Republic, Hungary and Slovak Republic with less than 1.5% of traffic shared with BH should be negligible.

Conclusion

Sectorization of the newly established control areas is a complex process which depends of numerous factors, most of which dynamically change in time, therefore it is usually performed by an ANSP responsible for provision of air traffic services in the observed area. The purpose of this research was to present preliminary results of BH airspace sectorization within BH ATM implementation Phase II.

Sectorization scenarios were created based on the traffic demand simulated according to STATFOR forecast for 2016 and BH sector capacity calculated as an average value of FAB CE member states sector capacity. After analyses of several sectorization scenarios for Phase II implementation, the results have shown that Bosnia and Herzegovina has a heavy traffic load in the summer season. In order to accommodate future traffic demand, it is important for BHANSA to ensure accurate sector capacity calculations and adapt the sectorization analysis for the possible scenarios accordingly.

This research has showed that the majority of flights within Bosnia and Herzegovina airspace operate between FL 345 and FL375, which is limiting factor for vertical division of airspace. Therefore it is recommended to consider two scenarios with the proposed airspace sectorizations: Scenario 2 with three vertically separated sectors and Scenario 4 with four sectors vertically and geographically separated. Both scenarios ensure similar capacity with the approximately same values of sector overloads. The further analysis should include flight rerouting and accurate calculations of ATFM delay generated due to sector overloads but also Costs Benefit Analysis of both Scenarios.

As a FAB CE member state, Bosnia and Herzegovina should ensure a standard level of ATS quality in order to meet the requirements and a target set for FAB CE level, even though it is not an EU member and is not obliged to present a Performance Plan.

The main indicator for airspace capacity is ATFM en-route delay per flight. Although the delay simulation couldn't be done in this research because of the NEST system limitation, it can be assumed that the most of FAB member states wouldn't be significantly affected by the situation in BH airspace. This is assumed according to the simple analysis of number of the shared flights between Bosnia and Herzegovina and other FAB CE member states. Croatia and Slovenia are the only two FAB CE members with almost 50% of their traffic shared with BH, hence they are influenced by BH air traffic services.

Regardless of the low impact of BH on other FAB CE members individually, any delay caused by BH directly influences the overall FAB CE ATFM delay. For that reason, it is advisable for BH to develop national Performance Plan during the implementation of Phase I, in order to positively contribute to FAB CE targets and objectives in the future.

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COMPARISON OF HELICOPTER SIMULATORS AND MODELLING

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***Abstract** – Flight Simulation Training Devices basically come in two different types - Flight Training Device (visual motion) and Full Flight Simulator (visual and motion device). Both types are designed to replicate the aircraft instruments, equipment, panels and flight controls either in a fully enclosed or partially open flight deck. The device uses a computer program and a visual projection system to represent the aircraft operations and environment both ground and flight. The major difference between the two devices is in the way motion is replicated. In a Flight Training Device motion is only represented on a visual screen whereas a Full Flight Training Simulator provides for both visual and flight deck motion. The mathematical modelling of rotorcraft dynamics is a very difficult task that has represented a challenge for many researchers. Nowadays, this research area is extremely wide, as it entails advanced studies in computational fluid dynamics (CFD) and flexible multibody dynamics.*

Key words – helicopter simulator, pilot training, mathematical model.

INTRODUCTION

Flight simulator´s main task is to simulate flight of the aircraft as much as possible. The first simulators appeared before World War I. in 1909 and simulated only rolling and pitching. The first significant development was during the World War I. After WW I. and between the wars the development continued and there was also the first commercially sold simulator device. These simulators were simulating movement around all three axis and offered flight simulation with using the instruments to practice this kind of rules (IFR). During World War II there was development of specific types of aircraft simulators to offer special training for army purposes. After few years the market offered simulators of commercial aircraft also with moving platform. Also during Cold War the army needed to develop simulators for jet aircraft. Last era of simulation research brings new computerized technology. All systems were improved and simulations become very realistic also in non-standard procedures.

First flight simulator had no imaging system, but only a wooden stick in front of the pilot, which represented the horizon. Several years the projection systems more or less did not develop because simulators were designed to instrument flying. The first visual systems consisted of terrain model, where was the camera capturing the image and this was then displayed to the pilot. This system was used until the digital image generation systems came into usage. During development of simulators there were couple of different projection systems used until these days. Developers had to deal with many problems in bringing the real image into projection to the pilots.

Nowadays the simulation is on very high level of realistic and there are expected only changes in projection improvements. Simulation should bring realistic three-dimensional view to simulate flight on the highest possible level. [1]

FAA	EASA
PC ATD	
NG DSD	
Basic ATD	BITD
Adv ATD	
FTD 1	FNPT 1
FTD 2	FNPT 2
FTD 3	FNPT MCC
FTD 4	FTD 1
FTD 5	FTD 2
FTD 6	
FTD 7	
A	A
B	B
C	C
D	D

ICAO
I
II
III
IV
V
VI
VII

Figure 1 – Classification of flight simulator

Flight Simulator Training Devices bring various benefits such as:

- Safety
- Extended training scope compared to actual helicopters
- Special manoeuvers training possibility
- Availability 24/7
- Progressive learning
- High cost effectiveness
- Environmental issues

REQUIREMENTS FOR SIMULATION – HELICOPTERS

The topic of requirements is very complex and there is no space in this article to describe is into depth. The main documents which tell all the requirements regulations are: ICAO Doc 9625 which was formed from JAR-FSTD-H: Helicopter flight simulation training devices issued in 2008. This regulation was previously formed from Federal Regulation FAR document 14 CFR FAR Part 60: Flight simulation training device initial and continuing qualification and use. European Aviation Safety Agency took JAR Regulation under own administration and created CS-FSTD (H): Certification Specifications for Helicopter Flight Simulation Training Devices issued in 2012. In these documents all the requirements and technical specification standards for simulation devices and equipment are issued. There is also defined the licensing of pilots using flight simulation training devices (FSTD) and the acceptable means of compliance with the defined standards. [2]

In EASA CS-FSTD (H) are defined three different qualification levels:

1. FNPT I, II, III (Flight Navigational Procedures Trainer)
2. FTD 1, 2, 3 (Flight Training Device)
3. FFS A, B, C, D (Full Flight Simulator)

FNPT

FNPT – Flight Navigational Procedures Trainer is the first qualification level defined by EASA. This kind of device is very cost effective solution. Its usage is very wide and is very often used in flight training.

FTP

FTP – Flight Training Device is more developed FNPT and brings possibility to use specific helicopter type and it is possible to perform type rating training. FTD does not include motion and vibration system. All levels of FTD brings different capabilities up to IR Training.

FFS

FFS – Full Flight Simulator is most developed flight simulator and also the most expensive. It brings highest level of complexity and training capability. It provides vibration and cabin motion capability.

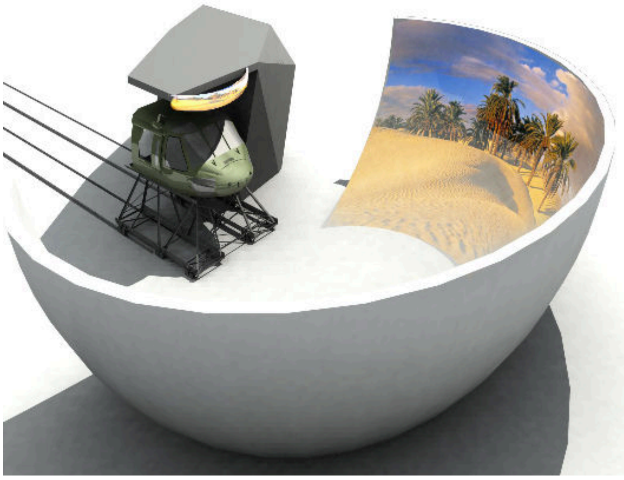

Figure 2 – HeliFlight-M simulator (can be certified to FAA Level D) [3]

THE MATHEMATICAL MODELLING OF ROTORCRAFT

The mathematical modeling of rotorcraft dynamics is a very difficult task that has represented a challenge for many researchers since age ’60s. The availability of performant computers and a deeper theoretical knowledge in the late 80’s dramatically improved the results achieved in this field. Nowadays, this research area is extremely wide, as it entails advanced studies in computational fluid dynamics and flexible multibody dynamics as well. [4]

ROTORCRAFT MODEL

Flight dynamic simulation software

The core of the flight dynamic simulation is the subroutine that calculates the rotorcraft equations of motion and navigation. The former set of equation, transforming external forces and moment’s into linear and angular accelerations, is based on a standard rigid body 6 DoF model using quaternions to avoid singularities at unusual attitudes. The model is successfully used in all the simulation mathematical models ranging from helicopters to fighter jets.

The earth gravity model is based on the “NIMA/NASA EGM96 Gravity Model” (Earth Geopotential Model 1996). The navigation differential equations (to calculate the aircraft position in terms of latitude, longitude and altitude) are based on a WGS84 rotating Earth model accurate for long range navigation.

BASELINE HELICOPTER MODEL

Dynamic model of a helicopter system may contain four interacting subsystems: main rotor, tail rotor, fuselage and empennage. The helicopter has six degree of freedom in its motion and it has nine state variables in general, which are u,v,w the aircraft velocity components at center of gravity, p,q,r, the aircraft roll, pitch and yaw rates about body reference axes, and q,f,y the Euler angles. To derive the equations of the translational and rotational motions of a helicopter, the helicopter is assumed to be rigid body referred to an axes system fixed at the center of mass of the aircraft, so the axes move with time varying velocity components under the action of the applied forces.

The basic helicopter model used for the simulation is directly derived, with minor modifications [5].

Together with a 6 DoF model for fuselage rigid–body motion, the model features the following characteristics:

- a first order longitudinal and lateral response is assumed for tip–path–plane (TPP) dynamics, described in terms of longitudinal and lateral flapping coefficients;
- a first order longitudinal and lateral response is assumed for tip–path–plane (TPP) dynamics, described in terms of longitudinal and lateral flapping coefficients;
- a uniform induced velocity distribution is assumed, evaluated at every time step by means of momentum theory;
- rotor angular speed is a state variable driven by difference between aerodynamic torque with respect to the shaft axis acting on rotor blades and torque delivered by the engine;
- tail rotor thrust is evaluated by means of actuator disc theory, neglecting tail rotor flapping;
- a simple aerodynamic model for the fuselage is assumed, based on equivalent flat plate area;
- main rotor wake interaction with fuselage is accounted for, evaluating the position of the fuselage center of pressure as a function of wake skew angle χ;
- horizontal and vertical tail surfaces are modeled as finite wings of small aspect ratio; the aerodynamic loads developed include the effect of stall at high (local) angle of attacks.

Conclusion

There is no doubt that aviation training using simulators offers a cost effective and safe alternative to training during actual flight. The real cost of helicopter training consists of many variables but includes the hourly costs associated with fuel, maintenance and insurance. Training in simulators provides a low cost virtually risk-free alternative allowing pilots to be trained for emergencies and other dangerous real world experiences. Historically a large number of serious accidents have occurred when training in helicopters. Pilots and crew members have died or become seriously injured and expensive equipment has been damaged, often beyond repair. Training in a simulator is totally safe even when practicing the most severe malfunctions under adverse weather conditions. Simulation based training allows for the training of maneuvers or situations that may be impractical (or even dangerous) to perform in the helicopter, while keeping the pilot and instructor in a relatively low-risk environment on the ground. For example, electrical system failures, instrument failures, hydraulic system failures, engine fires and even flight control failures can be simulated without risk to the pilots or helicopter. Flight simulation provides a significant economic advantage over training in an actual helicopter. Once fuel, maintenance, and insurance costs are taken into account, the costs of using a flight simulator are usually substantially lower than the operating costs of flying the helicopter for training purposes.

Acknowledgments

This paper is published as one of the scientific outputs of the project: ***„The research on virtual reality elements application: the significant improvement of simulator performance characteristics“, ITMS: 26220220167“.***

Operačný program VÝSKUM a VÝVOJ

Európska únia
Európsky fond regionálneho rozvoja

We support research activities in Slovakia/

Project is co-financed by EU

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HOW TO EXPLAIN THE IMPORTANCE OF HAVING A REGIONAL AIRPORT

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Abstract *– Pardubice Airport is a former military base. In spite of the fact that certain time has passed since the commencement of civil operations here, many people still do not know about its existence. Apart from the clients (passengers, airlines) for whom standard marketing tools are created, there is a need to convince the owner (the public sector)as well that the airport is indeed useful. Given that it is owned by the municipality and regional government, it is essential to find and present supporting arguments to the owner. The airport of a relatively low performance requiring public sector investments is bound to convince representatives of the owner (usually politicians) that these measures are necessary. However, the politicians frequently demand airport to be equipped with evidence that the airport is beneficial also to their voters. The article addresses such particular PR activities of the airport and endeavours to clearly answer the question posed as a title: How to explain the importance of having a regional airport?*

Key words – airport infrastructure, benefit, public funds, regional airport .

INTRODUCTION

Political development after 1989 has brought not only political, but also economic changes. These changes led to a reduction in military spending and the subsequent reduction of armies, including the Air Force. The states to the west and east of the Iron Curtain went through the same development. By reducing Air Force the army has left some airports (Franfurt Hahn, Brussels Charleroi, Wroclaw, Sczeczin, Ostrava, Brno), or allowed civilian and military traffic (Oslo Rygge, Pardubice) to join together. These airports usually had not infrastructure suitable for civil traffic. It was necessary to establish the Airport companies, to invest in the terminal, runways, navigation and lighting equipment, parking, access roads etc. Low-cost carriers are operating at many of these airports. It is often difficult to achieve positive economic results, especially in the first years of operation when the airport does not generate sufficient income from non-airline activities. EU Funds are often used for building infrastructure, but the participation of public budgets is also important. To obtain these resources the airport must first convince the owners. The regional airports in Europe are owned mostly by public sector, very often with a majority share. It is therefore necessary to convince the politicians (as a representatives of the owner) about benefits the airport can have for the region.

There are many studies showing the benefits of the airport for the region (e.g. York Aviation, ACI, EC, etc.). If we succeed in this first step, i.e. explaining of the importance and usefulness of airport for region to politicians, we must do the second step - explain to ordinary people in the region (voters) why public investment in airports is preferred instead of the investment in transport infrastructure, hospitals, schools, etc. This question becomes especially up-to-date in the peripheral areas of the region that are often situated far from the airport.

BENEFITS OF REGIONAL AIRPORT EXISTENCE

The benefits of regional airports existence can be found in several areas. Airports are a part of the useful infrastructure for a wide range of economic activities. This important economic role is known as the catalytic impact, arising from the effect that air service accessibility can have the positive influence on the region served by the airport. Access to markets and external and international transport links are understand as absolutely essential to businesses making location decisions. The catalytic effect of an airport operates largely through the enhancing business efficiency and productivity by providing better access to suppliers and customers, particularly over medium to long distances. Global accessibility is a key factor for the business location and success in all regions of Europe [4].

Although airports are major generators of the economic prosperity through their direct and measurable economic impact, their most important function is the role they play in securing accessibility that allows other businesses to develop in the catchment area. Airports are an essential part of the regional economic infrastructure and it is important that the growth of airports is seen as crucial part of national and regional economic development strategies.

Airports support the economic growth at regional and national levels. They also function as magnets for a wide range of economic activities. This wider economic role of airports is known as the catalytic impact, resulting from the effect that air service accessibility can have on the region served by the airport. The principles through which airport operates relate largely to enhancing the business efficiency and productivity by providing easy access to suppliers and customers [2]. The effects are observed through the role of the airport in:

- Influencing the company location decisions and competitiveness.

The presence of an international airport can be a critical factor in:

● Attracting new inward investments from outside of the area, and especially companies from overseas;

● Staying of the already existing companies in the area, whether they had previously been inward investors or indigenous operations;

● Securing the expansion of existing companies in the face of competition with other areas;

● Promoting the export success of companies located in the area by the provision of passenger and freight links to key markets;

● Enhancing the competitiveness of the economy and the companies in it through the provision of fast and efficient passenger and freight services;

● And adding to the quality of the life of citizens by enabling travelling, notwithstanding local environmental implications.

1.2 THE MEASURABLE IMPACT OF AIRPORT ACTIVITIES

Social benefits can be used as arguments supporting the existence of airport. The air transport contributes to sustainable developments. By facilitating tourism and trade, it generates economic growth, provides jobs, improves living standards and increases revenues from taxes. Increasing cross-border travelling is a reflection of the closer relationships between countries, both from an individual perspective and at a country level. Air services are particularly important in situations where physical access is problematic [4].

The air transport helps to a sustainable generation through purchases of goods and services from companies in its supply chain. The air transport invests substantially in vital infrastructure. Unlike other transport modes, the air transport industry pays for a vast majority of its own infrastructure costs (runways, airport terminals, air traffic control), rather than being financed through taxation and public investment or subsidy (as is typically the case for road and railways).

● Jobs generation

According York studies each one million handled passenger means 900 - 1000 created jobs. The number of jobs generated by air transport sector (including air transport supported tourism) can vary according to the local conditions (CAA or airline headquarters).

1.2.1 Direct impacts

Aviation industry itself is a major direct generator of employment and economic activities, in airline and airport operations, aircraft maintenance, air traffic management, head offices and activities such as check-in, baggage handling, on-site retail and catering facilities, which directly serve air passengers,. Direct impacts also include the activities of aerospace manufacturers selling aircraft and components to airlines and related businesses.

The air transport also has an important ‘multiplier’ effect, which means that its overall contribution to the global employment and GDP is much larger than its direct impact alone [2].

1.2.2 Indirect impacts

These include employment and activities of suppliers of the air transport industry - for instance, aviation fuel suppliers; construction companies that build airport facilities; suppliers of sub-components used in aircraft; manufacturers of goods sold in airport retail outlets; and a wide variety of activities in the business services sector (such as call centers, information technology and accountancy).

1.2.3 Induced impacts

The spending of those directly or indirectly employed in the air transport sector supports jobs in industries such as retail outlets, companies producing consumer goods and a range of service industries (such as banks and restaurants) [5].

1.2.4 Other (catalytic) impacts

Among other impacts belongs the stimulating effect of air transport on tourism. Tourism makes a major contribution to the global economy. By 2021, the World Travel & Tourism Council (WTTC) expects the direct employment in the tourism industry to be more than 120 million people globally. Aviation plays a central role in tourism support. Over 51% of international tourists now travel by air. Tourism is especially important in many developing countries, where it is a key part of economic development strategies. This includes jobs in industries such as hotels, restaurants, visitor attractions, local transports and car rentals, but it does not include air transport industry jobs [2].

In 1998 according the York Aviation study the European airports created on average 1000 on-site jobs per million handled passengers per year [4]. This number was reduced to approximately 950 on-site jobs per million passengers per annum in 2003. The reason of this lower number was caused by reducing costs and increasing productivity. Other factors i.e. the development of low cost carriers, also supports these trends. [4].

The study also estimates that, on average, for every 1,000 on-site jobs supported by European airports there are around 2,100 indirect/induced jobs supported nationally, 1,100 indirect/induced jobs supported regionally, or 500 indirect/induced jobs supported sub-regionally. Given that there are 950 on-site jobs created per million passengers, European airports support around:

- 2,950 jobs nationally;
- 2,000 jobs regionally;
- or 1,425 jobs sub-regionally.

Tourism is the second main element of the catalytic impact. For the EU as a whole, tourism accounts for 5% of the total employment and of GDP, and as much as 30% of the total external trade in services [2].

SELECTED REGIONAL AIRPORTS

The author with team writing the article have researched the effect of the number of employees at selected airports in relation to the number of passengers handled per year. They have also taken into account the diversity of the traffic structure at the airports. Bratislava and Brno airports are used by low-cost and charter carriers. There is the presumption of a lower cost for the check-in operation (due to the check-in computerization and less willingness of passengers to spend money) with fewer staff required. On the other hand there are almost 100% of customers travelling on regular flights at the Karlovy Vary airport, with a large number of Russian clients who require increased care and travel with more luggage. The figures regarding developments at the Bratislava Airport in years partly confirm the conclusions of the above mentioned studies [2], [4], The number of employees is affected by the fact that at national organizations and entities such as the Civil Aviation Authority and Air Traffic Control operate at the airport. An interesting element was the operation of the low-cost airline Sky Europe, which had a base at the airport in 2004-2009. The termination of its activities significantly affected the number of passengers and employees.

Data from the Brno Airport confirmed the conclusions of the studies [2], [3], [4]. It is likely to monitor the increasing number of passengers with the beginning of the low-cost carriers operation and the gradually increasing airport staff (internal and external) number. The number of passengers was about 560 000 in 2011. This corresponds to about 790 employees. The real number of employees was 436 due to the significant share of passengers of low-cost carriers. This confirms a less labor intensity and higher efficiency of the check-in associated with the computerization of the operation [4].

Data from the Karlovy Vary airport map the situation of a small regional airport, where the number of employees in relation to handled passengers is higher than at the other airports. This difference is caused due to the fact that despite the lower traffic at the airport, it is necessary to employ workers in the jobs related to the operation in terms of safety (fire and security control) and the staff ensuring air traffic control. According to a study of York Aviation in 1998, the average number of jobs created was 1000 per million of checked in passengers [1]. According to the report of York Aviation 2004, the average number of jobs created fell to 950 per million of checked in passengers. The authors have investigated the influence of the smaller regional airports. In 2012, at the airport in Bratislava, the number of direct created jobs per million passengers amounted to 1668. If we miscalculated (extrapolated) the number of direct employees per million at Brno Airport, then we can come to 790 of checked in passengers.

. With the increasing number of passengers at the airport, the number of direct jobs created per million passengers is further reducing. In the calendar year for 2012 the airport was expecting to handle 10.2 million passengers. Meanwhile, it is estimated that Luton will drive an additional 440 direct on-site jobs for every extra million passengers that pass through the airport, and as a result, an estimated additional 1,750 indirect jobs [5].

The data presented in Table 1 show that the existence of the airport demonstrably creates jobs. People who work at the airport have often higher qualifications. Airports keep these people in the region. Many airports located in structurally affected regions become significant employer. However, it must be taken into account that a low number of passengers will lower the efficiency of the airport. Higher number of passengers will not be directly proportional to the number of jobs created.

Table 1 *– Relationship between number of jobs and passengers [3]*

Airport	Criterion	Year		
		2009	2010	2011
Bratislava	INTERNAL	630	601	600
	EXTERNAL	2370	1899	2044
	TOTAL	**3000**	**2500**	**2644**
	PASSENGERS	1710018	1665704	1 585 064
	ER	1 754	1 501	1 668
Brno	INTERNAL	126	133	136
	EXTERNAL	260	262	303
	TOTAL	**386**	**395**	**439**
	PASSENGERS	440850	396589	557952
	ER	876	996	787
Karlovy Vary	INTERNAL	51	56	57
	EXTERNAL	100	108	118
	TOTAL	**151**	**164**	**175**
	PASSENGERS	68369	70903	99014
	ER	2209	2313	1767

Notes

INTERNAL - Employees of the airport company

EXTERNAL - Employees of the others subjects

i.e. police, suppliers etc.

TOTAL - Total internal and external employees

PASSENGERS - Passengers handled per year

ER, Employee ratio –

TOTAL/PASSENGERS*1000000

With the development of new technologies and business models (especially LCC – Low-cost carriers), the reduction of direct job opportunities for one million checked in passengers is happening. However, this decrease is compensated by the increasing number of passengers, and thus the absolute number of jobs at the airport. Airports therefore remain an important driver of the regional economy development.

Pardubice case

Pardubice Airport is a regional airport with the public international airport status with the external border of the Schengen area. Codename airport is LKPD (ICAO) and PED (IATA).

Pardubice Airport is the largest airport of the East Bohemia region that includes Pardubice and Hradec Kralove region and part of the Central Bohemia Region. Airport ranks among the five major airports of the Czech Republic.

History of Pardubice International Airport dates back to 1994. Until that date it was a military airport used for military purposes exclusively. Before 1989, civilian traffic was not conceivable due to political reasons. Change of the political situation in the country after that date changed the attitude of the Ministry of Defense and allowed the opening of the civilian airport operators not only for domestic airlines but also for foreign carriers.

In order to open the airport for civilian air traffic, East Bohemian Airport (EBA) was founded in 1993. Civilian traffic started after approval of Czech CAA in 1995. In present time, EBA company is owned by City of Pardubice (66%) and Regional Government (34%).

Currently it is the only international airport in the Czech Republic, enabling both military and civilian operations.

The most important part of the airport operation is commercial air transport. The largest and most important segment is made up by the regular and charter flights of Russian airlines from/to Russian destinations (Moscow, St. Petersburg, Yekaterinburg). The second important segment is made up from summer season (June to September) charter flights for Czech travel agencies to seaside destinations (Antalya, Rhodes, Burgas, Podgorica). General aviation (GA) flights, especially those for foreign entities investing in the region, are equally important parts of the airport operation.

In 2012, the airport handled 125 thousand passengers in 2333 aircraft movements. This number was made up from 102,600 passengers on flights to Russian destinations and 19,920 passengers on summer charter flights. The airport handled 185 140 passengers in 2013.

In 2014, the performance of the airport was impacted negatively due to the military-political situation in Ukraine and the impact of EU sanctions against Russia. The airport is capable to handle the passengers by using former military buildings, that were renovated and adapted (2008) for the needs of passengers to check flight times and partly on arrivals. The space and capacity of renovated buildings does not allow further development of the airport. The capacity of the terminal building is max 200 departing passengers per hour, which allows to check in only one type of aircraft B-737 in real time or A320/321 at the same time and only two check-in counters (due to insufficient space to build). This deficiency is critical in cases when there is a need to handle two flights (there is not enough place for all passengers) for operational reasons, or in case of synchronous operation of Schengen and NON Schengen flights when the passengers must be separated. The only solution is the construction of a new terminal. Without the participation of the public sector, this project would be difficult to implement.

***Table 2** – Performance of Pardubice Airport*

YEAR	2009	2010	2011	2012	2013
PAX	49 032	62 302	65 246	125008	184140
MOV	994	1 236	1 826	2 333	2 870
CARGO	344	239	252	603	208

The new terminal can be built with the support of the public sector. The consensus of politicians is important. In the first phase, it is possible to argue by research results of studies mentioned above. If this first step is fulfilled, it is necessary to submit the arguments to politicians that the airport is beneficial for people who do not fly and are not interested in flying. These people are interested in transport services in the region, health or culture.

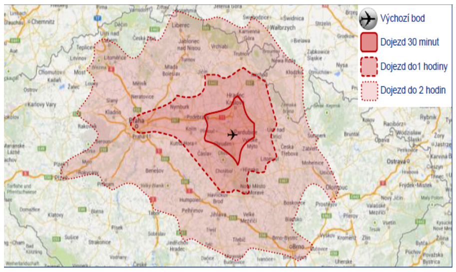

***Figure 1** – Catchment Area of Pardubice Airport*

We provided the field research to find out which are the most pressing problems in the eyes of residents. In the periphery of the region, the most crucial problems are unemployment and depopulation of the region, and young people leaving the region because of job search. The airport must therefore argue that it is able to help with solution of these problems. The investors can help and solve these problems. Usual argument is that Prague airport is situated 110 km from Pardubice, and potential investors or visitors can fly over this city. Experience shows that people who make the decisions need to save time and traffic problems are often the reason for not coming to destination. It is also necessary to explain to common people that if investors come, they will bring work and consequently money into the region. On This is the future for young people on the one hand, on the other hand, the extended use of services such as transport and health with requirements for stabilization and extension of such services.

Another supportive argument for Pardubice Airport directed to another segment of residents is the possibility of holiday departures. Currently the demand exceeds over supply. Airports should be a catalysts in dealing with travel agencies to increase a number of passengers. Pardubice Airport catchment area includes 1.5 million inhabitants. It is therefore the first stage of the goal of doubling the charter passengers number (it is currently just under 30 000 passengers). Realistic scenario in the future could generate 100,000 passengers. In the long term horizon it may be supporting to prepare development of business activities directly related to the airport (repair hangars, cargo terminal).

Conclusion

The airport is beneficial but it must explain its contribution to public benefit. First, it is possible to use previously published studies. It is also useful to use examples of other regional airports and case studies. Then it is possible to find arguments for a particular case. It is important to realize that ordinary people often do not accept these technical arguments. It is therefore necessary to find the problems that are bothering them. It is necessary to argue that thanks to airport it is possible to find solutions to their problems or that the airport can bring money into the region. It is important to note that representatives of the airport owners are not usually experts in air transport. You need to find the right language they will better understand (less technical). Where your partners are politicians, remember that the voters are important to them. Find out what they want to hear. Find the argument that will be clear to ordinary people.

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EUROPEAN EXPERTISE WITHIN A GLOBAL MARKET; ACHIEVING SUCCESS

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Abstract *– Global air traffic has doubled every 15 years and this trend is forecast to continue, confirmed and reported by both the latest Airbus and Boeing market trend analysis. The biggest growth will be in the emerging economies, accounting for 70% of the world's growth within the next 10 years. This provides European companies with major business opportunities, to provide the needed expertise to create a well-structured aerospace sector in new markets. Often the risks of such potential projects are not addressed, the need for change management overlooked in the deployment of technical support. Evidence supports that 70% of programmes fail; the challenges of national, organisational and professional culture are often lacking from the programme design. This paper will address the areas of risk, illustrated with empirical experience gained in major real-world programmes and provide direction for successful change management in the high risk industries in the global market..*

Key words – change management, cultural factors, globalization

INTRODUCTION

Air transport is going through a period of globalisation as emerging economies drive worldwide economic growth and thus the associated increase in demand for air travel (Fig.1) (Airbus, 2014). This drives the development of aviation in new markets, away from the traditional western aviation sector, with major growth expected in the new emerging middle class increasing leisure traffic (Fig.2)

OPPORTUNITIES:

These emerging aviation markets open many opportunities for European aerospace companies in a variety of fields. It has been recognized by the international aviation industry that there will be a shortage of skilled aviation professionals to meet the demand, this concern led to the International Civil Aviation Organisation (ICAO) developing the Next Generation of Aviation Professionals (NGAP) initiative to ensure that enough qualified and competent aviation professionals are available to operate, manage and maintain the future international air transport system (ICAO, 2014).

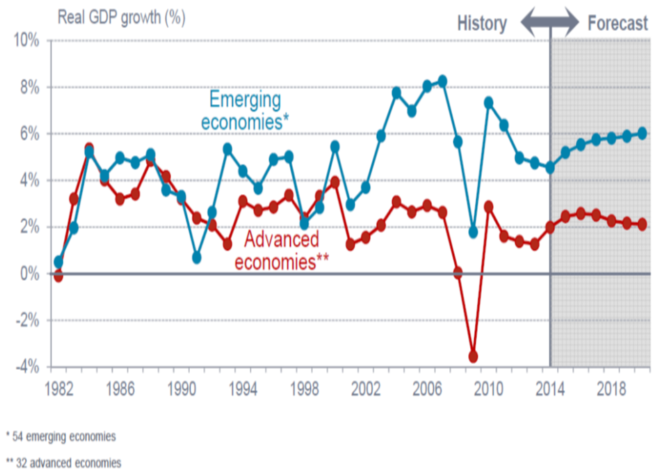

Figure 1 – Comparison of year on year GDP growth (Source: Airbus, 2014)

FLIGHT DECK CREW

Boeing forecast the need for 533,000 new airline pilots for the worldwide airline market over the next 20 years (Boeing, 2014). These new pilots will require an adaptive approach to training, utilisation of new technologies, development of instructors with new skills-sets (i.e. cross-generational and cultures). Both the Asia Pacific and Middle East North Africa (MENA) regions will fuel this demand as airlines within these regions are expanding their fleets and flight schedules to meet the rapid rise in demand. In the past the emerging markets have relied on recruiting western pilots to meet the growth demands, but the growth is such that there will be a need for developing a "local" source of qualified pilots and this in turn requires the development of a suitable training pipeline (ICAO, 2014).

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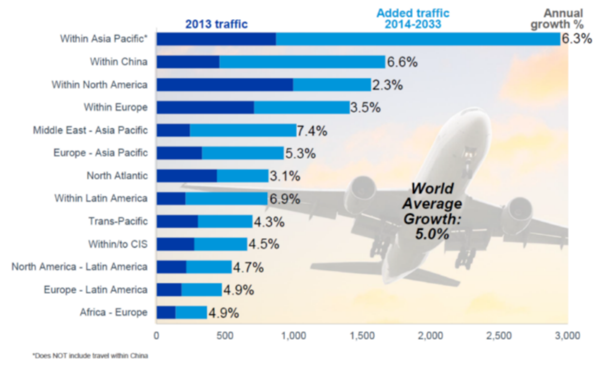

Figure 2: *Air Travel Growth by Market, RPKs billions. (Source: Airbus, 2014*

Technicians

The Boeing Technician Outlook (2014) estimates that 584,000 new maintenance technicians will be needed over the next 20 years (Fig.3) (Boeing, 2014). This creates the opportunity for the established European training establishments to start ventures within the emerging markets, to transfer experience and expertise.

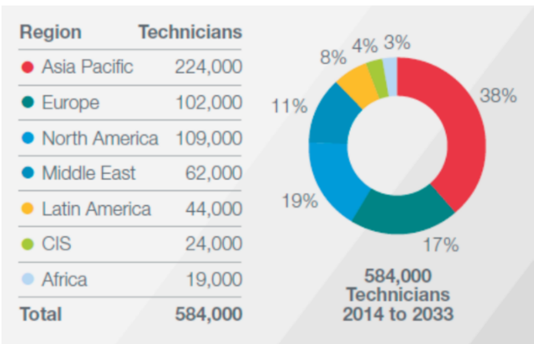

***Figure 3**: New Technicians by Region. (Source: Boeing, 2014)*

Development of New Technology and Capabilities

Whilst aircraft manufacturers continue to drive the development of new technologies within airframe and engine design for increased fuel economy and reduced carbon footprint has led to the creation of new jobs within the complexities of geared turbofans and the use of carbon fibre construction. Airlines are also driving new areas with "information technology (IT) solutions to improve operational efficiency, decrease costs, improve customer service, and increase safety" (Boeing, 2014).

Thus, it can be seen that European companies have the opportunity to lead in meeting the challenges of the globalisation of the aviation market but must understand the risks of moving into a new market, understand the cultural issues that may prevent successful transfer of their current operations into the emerging markets. Too often companies focus on the marketing and winning the contract without identifying the next phase. Any project moving into emerging markets will be involved with change management and organisational change projects have a high failure rate, this is especially true with large scale change efforts achieving a success rate of only 30% (Dent & Powley, 2001) (Kotter, 1995). This paper will address some of the key elements required for success based on empirical experience based on a major project based within the MENA region, Libya

Challenges in the New Markets Culture

To gain a deeper insight into the potential challenges for European companies to diversify out of their current market, there is a need to understand the relevant cultural factors (national, organisational and professional).

National Culture

Herodotus was the first to record the importance of culture as "*the kinship of all Greeks in blood and speech, and the shrines of gods and the sacrifices that we have in common, and the likeness of our way of life*" (Herodotus, 440 B.C.E). Hofstede's seminal work (Hofstede, 1980, as cited in Dastmalchian, et al., 2000), initially identified four dimensions that measured certain values or dimensions of national culture that he defined as "the collective programming of the mind distinguishing the members of one group or category of people from another" (Hofstede, 2014). These four measures (or dimensions) are imprinted on the individual from birth and development within their society and are: individualism versus collectivism; power distance; masculinity versus femininity and uncertainty avoidance. The validity and usefulness of these dimensions has been proven by many other researchers who have either added or adapted to the original dimensions (Grove, 2005). Using the original four dimensions a comparison of Libya with the UK is shown in (Fig.4), three of the four dimensions are relevant and worthy of further discussion (Hofstede, 2014).

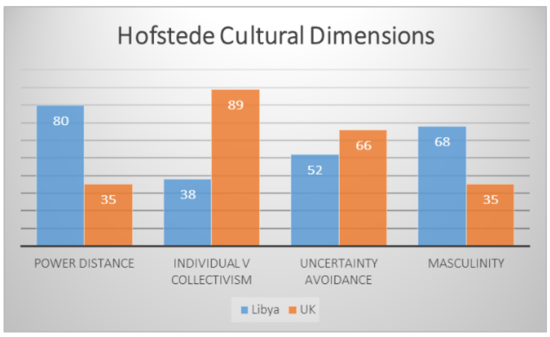

***Figure 4:** Comparison of Libya and the UK (Source: Hofstede, 2014)*

Individualism versus collectivism (IC) represents how individuals are related to groups. Collectivists are integrated into strong, clearly defined groups (e.g. family, religion) with protection guaranteed and loyalty expected in return, in comparison individualist societies have loose bonds. Libya is thus classed as a highly collectivistic society (The Hofstede Centre, 2014); Qadhafi used this to build his rule, the state supplying jobs, even though the majority of post holders were not properly qualified, favoured groups (towns and tribes) flourished and rose to take key positions (Smits, et al., 2013, p. 13).

Power distance (PD), is a measure of how the less powerful members of a society accept that power is distributed unequally, Libya scores highly and this indicates that people expect a hierarchical society, orders are given and no justification needed, further it is accepted that those in authority do not need to obey rules (The Hofstede Centre, 2014).

Uncertainty avoidance (UA), is defined as the "extent to which the members of a culture feel threatened by ambiguous or unknown situations" (Hofstede, 2014), once again Libya exhibits a high UA with a display of rigid codes and a need for rules (but not for them necessarily to be followed), a need for security and resistance to innovation is to be expected.

ORGANISATIONAL CULTURE

Organisational culture is best defined as"

"A pattern of shared basic assumptions learned by a group as it solved its problems of external adaptation and internal integration, which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to those problems." (Schein, 2010)

Schein's definition of organisational culture stems from his research in business organisations, it requires a group to exist who develop and own the culture. Thus, one must first clearly identify what is a group, i.e. a number of people who:

- Experienced challenges together over a significant period of time
- Had the opportunity to work on the challenges and have seen the results of their efforts
- Have taken in new members to their group (Schein, 1984)

Further, National culture influences organisational culture (Lumpé, 2008) ,given that the culture develops over a significant period of time, it should be noted that change will not occur quickly and this time delay will need to be built into the change management programme to ensure that expectations are realistic.

PROFESSIONAL CULTURE

Clearly, culture is based on shared values, beliefs and common experiences of members of groups (National, organisational) and in this case professional culture, i.e. from experience, training, shared knowledge skills and attributes (KSA) defining an occupational group (Helmreich & Merritt, 1998, p. 30). Within the professional culture there are sub cultures i.e. Air Traffic Control, tower versus area control, which although they share the same professional training, differ by their experiences.

ORGANISATIONAL INTERACTION

Three major, functionally related, generic forces can be identified as driving the behaviour of the staff within any organisation, these are culture, structure and processes. Structure is simply the formal organisation and how authority and accountability are distributed, this incorporates communication and co-ordination across the organisation at all levels. Processes are simply the activities that produce the service across the organisation, they cross departments and enable the identification and separation of responsibilities. Finally, culture, the complex collection of beliefs, values, that includes the national and societal cultures (Guldenmund, 2007). These form a dynamic interaction with behaviour as the observable outcome (Fig. 5), that in many ways advances the paradigm 3 approach (Meyerson & Martin, 1987), incorporating the dynamic response to culture and the potential to use structure and processes to create a desired behaviour.

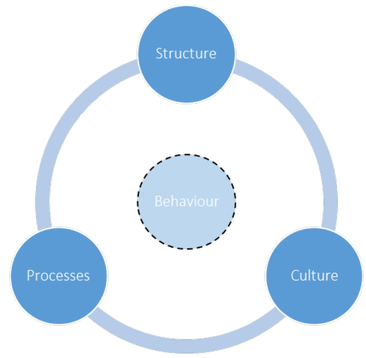

***Figure 5**:The Organisational Interaction (Guldenmund, 2007)*

ORGANISATIONAL LEARNING

A clear understanding of organisational learning is essential for any change management project to succeed. The application of generic western based management theories to other cultures has been rightly questioned and often leads to failure (Hofstede, 1993; Rosenzweig, 1994, as cited in Tsang, 1997). To adapt western models to the need of the organisation requires a clear definition of what organisational learning means and what is the value. Organisational learning has been considered to be the academic study of the learning process of organisations and is often confused with the learning organisation as Tsang (1997) highlighted:

> *"Organizational learning is a concept used to describe certain types of activity that take place in an organization while the learning organization refers to a particular type of organization in and of itself. Nevertheless, there is a simple relationship between the two – a learning organization is one, which is good at organizational learning"*

Further clarification was added by Jones (as cited in Dimovskia, et al., 2008) who described organisational learning as:

> "*a process through which managers try to increase organisational members' capabilities in order to better understand and manage the organisation and its environment to accept decisions that increase organisational performance on a continuous basis*"

Thus the need is for collective learning, a shift in thinking by the organisational members and this can only be achieved through the process of reshaping underlying assumptions (Schein, 2010). Deciding on a suitable process that will expose, influence and change these underlying assumptions and result in sustainable desired behaviour breaking the current domination of the organisation by culture, requires great care (Guldenmund, 2007). Schein concludes with "*learning and change cannot be imposed on people…cultural understanding and cultural learning starts with self-insight*" (Schein, 2010). The double loop learning of Argyris and Schon (as cited in Dimovskia, et al., 2008), identified two levels (loops) of learning, single loop learning is a low level of learning,sufficient to detect and correct errors in the way we operate, whilst double loop learning is necessary for change to the fundmental basis on which we operate.

Governments have also recognised the importance of culture in group behaviour and have employed a range of strategies ranging from incentives, legislation and regulation to gain the required behaviour. Approaches recognised the effect of culture (attitudes, values, aspirations and beliefs) on behaviour is dependent upon the strength of the cultural factors in comparison to the objective and secondly modified by external drivers i.e. incentives, regulation, risk of punishment, choice and alternative causes of action. Finally, change in behaviour is fedback, forming new attitudes, values etc., for this to occur a sustained and long term approach is required (Knott, 2008), this is illustrated below in the cycle of cultural change (Fig.6).

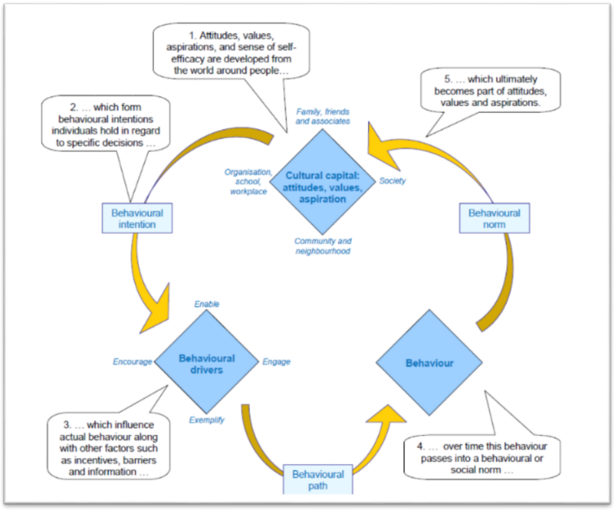

Figure 6: *The Cycle of Change: (Reproduced from Knott, 2008)*

Summary

The challenges for successful implementation of new projects within a diverse cultural arena must not be overlooked. European Companies must build into their project planning, an assessment of the culture (i.e. national, organisational and professional) of their client and then use this information to create a sustainable change programme. Change management is all related to Human Factors (HF) and will require the utilisation of HF experts to create a workable programme for change. The selection of a change model that will be robust and adaptable combining both Theory E and Theory O (Beer & Nohria, 2000), with a long term plan for each specific project that incorporates aspects of Knott's cycle of cultural change and the high level, double loop learning of Argyris and Schon. Leadership development and communication will form a vital core component for change, supporting and re-enforcing good behaviour (Dimovskia, et al., 2008). This requires the combination of a top down bottom up process (Beer & Nohria, 2000), to create a dynamic for change and lead to successful transfer of European solutions to the new markets.

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ECONOMICAL FACTORS FOR TIMETABLE OPTIMIZATION

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***Abstract** – Scheduling can be performed by many ways. One of them is optimization way – mathematical programming. Very important part is mathematical formulation of optimization criterion, if you use mathematical programming. Real criterions are total costs for ensure set of scheduled flights. Aim of paper is mapping all of economic values, which affect t value of the optimization criterion in real situation. In the end of the paper will be specific objective function for mathematical model.*

Key words – timetable, optimization, mathematical programming, economical factors.

I. Introduction

To create timetables must be take into account many external influences, which can change the final form of timetable. Basic affecting factors are economical factors. In Seventies of 20. Century started growing importance of economic factors. It was in time, when in USA act of deregulation of air transport came into force. In Europe was similar situation ten years later. Before changes in Europe were many protected national aviation markets. After it, was created one big aviation market with strong competition. If you want be competitive, you must increase quality of services and combine it with optimization of total costs. Direct costs for service of destinations are part of total costs.

II. Scheduling

The creation of timetable is long-term process. It start minimal one year before. Basis for a new timetable are informations of old timetable. This old timetable is very thoroughly analyse. After analysis are contacted regular customers and customers with large volume of transportation. Final form of timetable is fleshed out on many meetings between customers and airline.

Except old timetable and requirements of regular customers and customers with large volume of transportation has influence many external factors, for example number of frequencies, parameters of airports, capacity constraints of air traffic control, flight duration, time for turn, regular maintenance, backup of airplanes, working time of staff, business priorities, local time in destinations [1].

a) **Number of frequencies –** how many flights will be held during time period (per a day, week,...)
b) **Parameters of airport –** Some parameters could limit scheduling of timetable:
   - Operating time – Limit of operating time can have two reasons. First reason is due to noise limits. It is mainly on airports, which are near big cities. Second reason is because a small number of airplanes. It is mainly on airports near tourist resorts.
   - Capacity constraints – Many airports have capacity constraints, because they are small or they can offer only some services. Constraint of tracks, parking places or entrance tunnel. That is why airlines get slots. It is time period, when airplane must land and take-off. This regulations are using especially in peak time.
   - Availability and quality of service – to this category belong handling, refuling, catering and fly preparation. Airline have contract with service provider for this services. In most cases airline have contract with one fuel supplier (Shell, Total, Lukoil,…) and refuling on airports, where fuel supplier have office. In most cases a catering airline ensures itself. They take catering on his base for both flights. Some of these services could be limited in peak time.

c) **Capacity constraints of air traffic control –** These constraints are mainly in season (summer). In this time is traffic density increased. In this situation airlines get time slots.
d) **Flight duration** – On this time have influence distance, type of airplane, capacity of airways, air traffic control, capacity of airport or some constraints.
e) **Time for turn –** It is minimal time from land to take off of airplane. This time is affected by number of services a quality of services on airports. Very important for this time is type of airplane and flight duration. It can affect for time of refuling, preparation of catering or time for cleaning of cabin. Time for turn can be extended by new organization of cabin.
f) **Regular maintenance –** Regular maintenance is determined by producer of airplane. Intervals between inspections can be changed by airline. This new interval must be shorter than original interval. Some maintenance procedures can be ordered by supervisor authority of country, where is a airplane registered. Airplane is not one unit. Every part of airplane has different conditions for maintenance. About need for maintenance decisions different factors. For example number of flying hours or number cycles.

g) **Backup of airplanes –** It is using in extraordinary situations. For example technical faul or flight delay.

h) **Working time of staff –** It is very restrictive factor. Pilots and stewards have maximum time on duty and minimum time for rest. For maintaining safety all this limits must be observed

i) **Business priorities –** Regular customers and major customers have better conditions for negotiations about timetable. They can get more lucrative times of take-off.

j) **Local time in destinations –** In planning process must be considered about change of time in deferent time zones. Mainly due to operating times in destinations.

III. ECONOMIC FACTORS

***Table 1** – List of abbreviations (units)*

APU	auxiliary power unit
$MTOW$	maximum také-off weight
T_{pr}	time for flight preparation and tasks before take off (h)
T_l	time of flight (h)
T_{po}	time for tasks after landing (h)
T_{st}	time of standing with using APU (h)
T_{na}	time of running the main engines (h)
T_{poj}	is taxiing time on the runway (h)
T_{vz}	take – off time (h)
T_{sto}	climbing time to cruising level (h)
T_{le}	flight duration in cruising level (h)
T_{kl}	descent time (h)
$T_{př}$	landing time (h)
HM_k	hourly wage of captain (CZK)
HM_d	hourly wage of 1st officer (CZK)
HM_{vs}	hourly wage of head steward (CZK)
HM_s	hourly wage of other stewards (CZK)
S_{apust}	consumption of auxiliary pover unit $(l \cdot h^{-1})$
S_{apuna}	consumption of auxiliary power unit to run the main engimes $(l \cdot h^{-1})$
S_{mpo}	consumption of main engine during taxiing $(l \cdot h^{-1})$
S_{mvz}	consumption of main engine during take – off $(l \cdot h^{-1})$
S_{mst}	comsumption of main engine during climbing to cruising level $(l \cdot h^{-1})$
S_{mle}	consumption of main engine during flight in cruising level
S_{mkl}	consumption of main engine during descent to airport $(l \cdot h^{-1})$
$S_{mpř}$	consumption od main engine during landing $(l \cdot h^{-1})$
S_{m1500}	consumption of main engine in FL1500 $(l \cdot h^{-1})$
N_{ud}	cost for accommodating and dieting (CZK)
N_l	costs for pilots (CZK)
N_{pp}	costs for stewards (CZK)
NP_{tax}	costs for taxi fuel (CZK)
NP_{trip}	costs for trip fuel (CZK)
NP_{rez}	costs of reserve fuel (CZK)
NP_{ext}	costs for extra fuel (CZK)
NP_c	total fuel costs (CZK)
$NL_{př}$	costs forlanding fees (CZK)
NL_{par}	costs for parking fees (CZK)
NL_h	costs for noise fees (CZK)
NT_n	costs for en-route charges (CZK)
$NT_{př}$	costs for terminal navigation charges (CZK)
$N_{cest.}$	costs for servuces for passangers (CZK)
$N_{hand.}$	costs for services on ground (CZK)
N_c	total costs (CZK)
P_{ext}	quantity of extra fuel (l)
ZS	basic rate - landing fees (CZK)
JS	unit rate - landing fees (CZK)
JC_k	unit rate in cathegory – noise fees (CZK)
H_{min}	minimum weight in category (t)
M_s	number of other stewards
M_m	number of main engines
S	flight distance over Czech Republic (km)
C	price per one liter of fuel (CZK)
C_n	unit rate per service unit (CZK)

After economic crisis are conditions of air transport better and more stable, but competition is still strong. Airlines looking for a way to reduce a operating costs and preserve quality of services or improve this quality. These requirements are contradictory. Airlines must find a compromise. This paper is focused for analysis of economic factors necessary for flight. Economic factors are from IATA costing model [2]. The following factors are costs for pilots, costs for stewards, costs for fuel, costs for insurance, cost for maintenance, costs for depreciation, cost for rent, landing fees, noise fees, parking fees, route charges, service for passengers, services on the ground.

Costs for pilots

It consists of several parts. Those are net wage, social and health insurance, dieting, and accommodation (they must spend a night in destination). For simplification are net wage, social and health insurance merged together. Dieting and cost for accommodation are merged together, too.

$$N_l = (T_{pr} + T_l + T_{po}) \cdot (HM_k + HM_d) + 2N_{ud}$$

Equation expresses costs for pilots. T_{pr} is time for flight preparation and other tasks before take-off. T_l is time of flight. T_{po} is time for tasks after landing. This time start after landing. Sum of the times is total time, which pilots need for one flight. HM_k and $HM_d$are hourly wage of pilots. In both values are net wage, social and health insurance. N_{ud} is cost for accommodating and dieting, when pilots must spend a night in destination.

Costs for stewards

Minimum number of stewards in airplane is established by the manufacturer. An airlines can their number increase. Calculation of costs for stewards is similar to pilots.

$$N_{pp} = (T_{pr} + T_l + T_{po}) \cdot (HM_{vs} + M_s \cdot HM_s) + M_{pp} \cdot N_{ud}$$

The equation differs by M_{pp}. It is total number of stewarts in airplane. HM_{vs} is hourly wage of head stewart. HM_s is hourly wage of other stewards. M_s is number of other stewards.

Fuel cost

Fuel for one flight has four parts. It is taxi fuel, trip fuel, reserve fuel and extra fuel. Quantity of fuel is affected by many factors. These factors are flight duration and fuel consumption. Other factors are weather conditions, time on airport, rate of climb and descent or flight level. In the equation is considered that the aircraft is refueled before each flight.

$$NP_{tax} = (S_{apust} \cdot T_{st} + S_{apuna} \cdot T_{na} + M_m \cdot S_{mpo} \cdot T_{poj}) \cdot C$$

Costs for taxi fuel are consist of several parts. Parts can changed according on preparation. S_{apust} is consumption of auxiliary pover unit (APU) during standing. Auxiliary power unit runs the air condition, defrost and other airplane systems. Consumption of auxiliary power unit can be influenced by connecting an external source of electricity. T_{st} is time of standing with using APU. S_{apuna} is consumption of auxiliary power unit to run the main engimes. S_{mpo} is consumption of main engine during taxiing. M_m is number of main engines. T_{poj} is taxiing time on the runway. C is price per one liter of fuel. Different types of airplanes can have different equations. The equation may change number of engines, number of engines to taxing or airplanes with system Wheeltug.

$$NP_{trip} = (S_{mvz} \cdot T_{vz} + S_{mst} \cdot T_{sto} + S_{mle} \cdot T_{le} + S_{mkl} \cdot T_{kl} + S_{mpř} \cdot T_{př}) \cdot M_m \cdot C$$

Costs for trip fuel are consist of 5 parts, which copy the flight. S_{mvz} is consumption of main engine during take – off. T_{vz} is take – off time. S_{mst} is consumption of main engine during climbing to cruising level. T_{sto} is climbing time to cruising level. S_{mle} is consumption of main engine during flight in cruising level. T_{le} is flight duration in cruising level. S_{mkl} is consumption of main engine during descent to airport. T_{kl} is descent time. $S_{mpř}$ is consumption od main engine during landing. $T_{př}$ is landing time o airport. Sum of all consumptions by time are multiplied M_m and C. M_m is number of engines and C is price per one liter of fuel. On consumption is affected by weather conditions, flight level, a speed during flight, angle of climb and angle of descent.

$$NP_{rez} = [0{,}05 \cdot (S_{mvz} \cdot T_{vz} + S_{mst} \cdot T_{st} + S_{mle} \cdot T_{le} + S_{mkl} \cdot T_{kl} + S_{mpř} \cdot T_{př}) + S_{m1500} \cdot (30 + 15)] \cdot M_m \cdot C$$

The equation describes costs of reserve fuel. This equation is for situation, when we do not consider alternate airport. Reserve fuel is consists of several parts. It is fuel for unpredictable situations – it is 5% of trip fuel. Next is final reserve fuel – it is fuel for a 30 minutes flight in flight level FL1500 over the airport in destination. And last is additional reserve fuel – it is 15 minutes flight in flight level FL1500 over the airport in destination. .

$$NP_{ext} = P_{ext} \cdot C$$

P_{ext} is quantity of extra fuel. About extra fuel decides the aiplane captain. The fuel takes in the situation, when weather forecast in target destination is bad and pilots expect waiting for landing.

$$NP_c = NP_{tax} + NP_{trip} + NP_{rez} + NP_{ext}$$

Sum of all costs for fuel are total fuel costs.

Costs for landing fees, noise fees and parking fees

Each airports collects some charges for using runways and other areas on airport or environmental charges. Charges for using runways are landing fees and parking fees. Environmental charges are noise fees. The charges are different depending on the size of airplane (weight) and its inclusion in the noise category. Information about charges are on airports websites. The base for equations in this paper is informations from websites of Prague airport [3]. On this websites is charges calculator, too [4].

$$NL_{př} = ZS + [MTOW - (H_{min} - 1)] \cdot JS$$

The above equation is for calculation of landing fees in airport Prague. For calculation are airplanes divided into several groups according to maximum take-off weight (MTOW), where ZS is basic rate. In square brackets is weight coefficient. JS is unit rate. Weight of airplanes is measured in tonnes. Monetary values are in CZK.

Parking fees are dependent on maximum take-off weight, parking time, time of day and location of the parking area. Most airplanes have two hours free parking. After two hours they are charged for each additional minute and each tonne. In final equation are parking fees marked NL_{par}.

Noise limits are especially on airports near cities and populated areas. Noise categories are based on effective perceived noise decibels (EPNdB). Each airplane is assigned to the noise category. In Prague airport are 5 categories (I.-V.). In each category is unit rate per one tonne of maximum take – off weight.

$$NL_h = MTOW \cdot JC_k$$

$MTOW$ is maximum take-off weight in tonnes. JC_k is unit rate in cathegory in CZK.

Costs for en-route charges

These charges are paid for services provided air traffic control on territory of each country – navigation charges and terminal navigation charges.

$$NT_n = \frac{S}{100} \cdot \sqrt{\frac{MTOW}{50}} \cdot C_n$$

Eurocontrol is responsible for collecting of navigation charges in Czech Republic. Erocontrol determines charges for the service unit. This value is about 46,69€ per service unit. This value can change in dependence on the exchange rate (CZK x EUR). Always is charged rate from month before month during which the flight has been performed [5]. Provider of en-route navigation services is Řízení letového provozu (in Czech Republic). S is flight distance over Czech republic. C_n is unit rate per service unit.

$$NT_{př} = 6800 \cdot \left(\frac{MTOW}{50}\right)^{0,7}$$

Terminal navigation charges are paid by all airplanes which weight more than 2 tons. Value is calculate as the product of terminal unit and weight factor. Unit rate of terminal unit is 6800 CZK.

Costs for services for passengers

Main part of service for passengers are costs for catering. It is important to know who provides catering, if airline itself or if they have contract with catering company. For charter companies are typical, that on short distances they take catering for both flights (to destination and back). Between passenger services also include newspapers and magazines or gifts and souvenirs [2]. It does not calculation with costs for dieting and accommodation for passengers in case of unforeseen situations. In final equation are costs for services for passengers marked N_{cest}.

Costs for services on the ground

It is a service provided by the airlines at airports through handling organization, provided that the airline himself does not handling services. To handling services include offer of mobile mechanized equipment (connecting tunnels, boarding stairs, ground power supply, external air conditioning unit), preflight (analysis of flight paths and weather conditions along the route of flight, aircraft balancing, ensuring aircraft against the movement, extrusion aircraft assistance in starting engines and supervision of individual operations), de-icing, refueling, interior cleaning, loading and unloading baggage and cargo, water and waste system. In final equation are costs for services on the ground marked N_{hand}.

Total costs

Total costs for one flight is sum of all the above costs. In the equation are considered long-term costs in the form of insurance, the cost of planned maintenance, depreciation or rental.

$$N_c = N_l + N_{pp} + NP_c + NL_{př} + NL_{par} + NL_h + NT_n + NT_{př} + N_{cest} + N_{hand}$$

IV. Conclusion

The paper were analysed all economic factors which have a direct impact on the conduct of the flight itself. Some items were consolidated to simplify, for example wage items. The equation is not considered to items that have the character of long-term financing, for example hiring, training pilots, the cost of scheduled maintenance and others. Selected economic factors assembled equation would serve to improvement of the results obtained from the mathematical model for planning turns of airplanes.

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ROLE OF THE ACADEMIA IN AVIATION

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Abstract *–The fast development of aviation industry and its dependence on quality workforce requires alignment between the needs of the industry and the educational systems. Designing a relevant education programme requires taking into account the different customers, which include not only the students, but also the industry needs, or other actors such as parents of the students. The dynamic nature of the industry requires the educational system to integrate soft skills and flexibility. Close cooperation between educational institutions and industry is also essential.*

Key words – aviation education, industry needs, internship.

Motto: *One does not plan and try to make the circumstances fit those plans. One tries to make plans fit the circumstances. I think the difference between success and failure in the high command depends on the ability, or the lack of it, to do just that.*

General George S. Patton

INTRODUCTION

Aviation has always been among the fastest developing but also the most globalised industries. It is also one of the most regulated industries. It a service industry and therefore it is highly labor intensive and dependent on the quality of workforce.

Standards and Recommended Practices for Personnel Licensing were first adopted by the Council on 14 April 1948 pursuant to the provisions of Article 37 of the Convention on International Civil Aviation (Chicago 1944) and designated as Annex 1 to the Convention. They became effective on 15 September 1948 and covered Licensing of flight crew members and of key personnel responsible for air navigation services.

However, regulation with the aim to increase safety and eliminate fatal accidents started much earlier, with the 1926 US Air Commerce Act, but in particular the Civil Aeronautics Act, signed by the president Franklin Roosevelt in 1938. However, those documents describe just a few of the most demanding positions in civil aviation. It is difficult to assess whether flying was more difficult in the past when pilots had to master the aircraft mostly by senses and their skills, or today, when the pilot must understand and handle all complicated systems.

Aviation changed a lot since the beginning of the Jet Age in the 1960 and will be changing faster fueled by technological development. It became the most regulated industry also in the field of training. There are defined specific courses for most of key professions, including pilots, technicians, cabin personnel, firemen and many others - in some airlines even check-in staff or cabin cleaners. From this perspective, it should be easy to meet the training requirements for the different positions by simply designing a course in line with the course specifications. Nevertheless, we should emphasize the difference between training and education. Education is far more complex, usually longer and provided by educational establishments, by universities at the highest levels. Training could be anything from a few-hour course to several months' training provided usually by approved organisations, which may include universities.

WHO ARE OUR "CUSTOMERS"

There are several challenges when designing a training or academic course. We are educating human beings and not programming computers. Not all positions in the civil aviation are described. Everyone has different needs, requires different attitudes, different methods. There are vast cultural differences across the globe. Method which is effective in one country could be inappropriate in another. The new generation is completely different compared with the older generation when the requirements for positions/courses were defined. They have different ways of communicating, finding information and learning. Course requirements were mostly based on the past experience, not future needs.

There are many factors outside and inside the training and education system which influence the market, the economy of operations and the quality of graduates. The other important issue is that we should not (only) train but to educate, to form student attitudes, to create a new personality that will meet future requirements of civil aviation. Those specifications are not included in any syllabus. The question also is for whom should we design the course? Who are our "customers"?

Student – An ideal student should have a good overview of the industry needs and course requirements. He or she should be motivated and dedicated; he/she also knows what are the course requirements and, possibly, have a clear idea of where they wanted to work. But could we expect this from 18 years old student? How many of them are sure what to study and have an idea of future career? An average student is usually different, sometimes trying to pass exams and tests with a minimum effort. However, after a few years of career and changes in personal life their preferences and visions of a dream job can, and will, change. The resources invested in their education may be wasted. For student it would be better to pass a course which guarantees him sufficient flexibility.

Industry - The industry would like to have a graduate prepared for a certain position so that no additional fund investments are necessary. But also if specific course could take 3 years (i.e. ATPL frozen) or even more than 5 years (i.e. technicians) and external conditions can fundamentally change the situation on the labor market (e.g. problematic employment of pilots with MPL during/after the economic crisis). Work placements of some highly specialized position could be problematic and could result in retraining with additional costs. Specific courses are also more suitable for large and stable companies that are able to create training groups with break-even number of trainees.

Parents – Parents are in many countries sponsors or at least "partial sponsors" of their child's education and could influence their decisions. Parents always like to get the "best of the best" for their kids and in case of education they usually consider it as good investment for the future in terms of gaining a better position or earnings. Very specific training or education leading to dedicated job position, even well paid, may be considered as too risky. On the other hand, a good academic education may be, from their perspective, an advantage.

How needs for aviation industry professionals in Europe could be met?

Problem of any educational system is a large "moment of inertia". The longer the course is, the longer the moment of inertia. For a 3 – 5 year course we have to calculate with about one year for the preparation and approval/accreditation of the course. A minimum of six additional months is needed to prepare the admission procedure. This means that the first "product" is "released" 4.5 – 6.5 years after the initial decision to start the course, and at least six more months are needed to receive feedback. This is, in a dynamic industry like aviation, hardly acceptable and it requires the adoption of appropriate measures.

Predicting the future industry need for aviation engineers is difficult. The predictions depend on air traffic evolution and turned out to be inaccurate in the past. Presently, there are no significant shortages identified or foreseen, except a wave of retirements which could be expected in the next 5-10 years horizon[1].

There are no specific technical competences which appear to be missing in the existing curricula. However, the increasing complexity of the systems is reflected in the cockpit, requiring various new competences – in technologies and in human factors aspects - to design human-machine interfaces and automate the tasks while ensuring safety in operations.

A young professional is expected to have good soft and professional skills, including the ability to communicate and work in multidisciplinary and international teams, to have a good systems approach and to take responsibility. In addition, she/he has to be able to learn and adapt to new assignments in an evolving career. Cultural differences will always remain, which is not a major issue, but a degree of harmonisation and agreement on quality standards would facilitate international exchanges like ERASMUS. The exchanges of students across Europe contribute significantly to the development of soft skills like languages, communication, adaptability or ability to work in multicultural teams.

Specific courses or master programmes could be designed to meet the needs for life-long-learning in the industry. In this case very detailed specifications of the needs and costs, as well as a commitment of industry in terms of number of students are necessary to ensure the success of the programmes. Engagement of industry can go even further, with successful examples of the funding of schools or institutes.

In particular students' internships and practical placements could provide universities with good and early feedbacks on their "products" characteristics, but also to give student real picture of aviation business and protect them against excessive expectations or possible disappointment.

If there is a specific industry need for a tailor-made course, the whole course should be paid by the industry.

Conclusion

The air transport industry is facing global competition with airlines from emerging countries. The European aviation market needs well educated, flexible and motivated people. A sectoral approach is needed to attract young people but it must be supported by an industry–academia cooperation to guarantee stability and flexibility for mutual benefits.

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CHANGING AIR TRANSPORT

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Abstract *– Evolution of air transport is significant. There are changes in all sectors of air transport over the time. This article discusses about trends in civil aviation. Paper explores demand and capacity and how to handle with the problems connected to the future growth of air transport. Next part of the article is connected with the changes of various airline business models. At last will paper focus on the other side of the air transport – passengers and cargo.*

Key words – demand, capacity, passengers, cargo, network carrier, lowcost carrier, charter, traveller behavior.

INTRODUCTION

Today air transport is not the same as it was before; it is changing as the market is changing by the time. The demands on airport infrastructure around the world are both growing and changing. This paper explores what problems these changing demands imply for airports, and how they are coping with them. Growth in demand imposes a problem of allocation of scarce capacity in the short run, how well mechanisms such as the slot system are coping with them is explored. Hand in hand with demand and forecasts in air transport go oil prices and also GDP.

Paper will focus on the airlines business models, which are also in the rebuilding process. It uses a panel of 26 air transport experts forecasts of the structure of air transport in the EU in 2015 in respect of network carriers, low cost airlines and at last the passenger behaviour. Based on these forecasts there are prepared scenarios about the future structure and strategy of EU network and low cost airlines and also traveller behaviour.

CAPACITY AND DEMAND CHANGES

Over the last ten years, RPKs have increased by 73% (Figure 1), despite the different crises the World has faced during this period. The resilience of air passenger traffic is one of the most important features of our industry, indicating the importance people place on air travel. Most economic crises have had a very limited direct impact on air travel demand as generally there are a significant number of people who consider travelling as essential, especially for the purpose of visiting friends and relatives (VFR) and for business purposes.

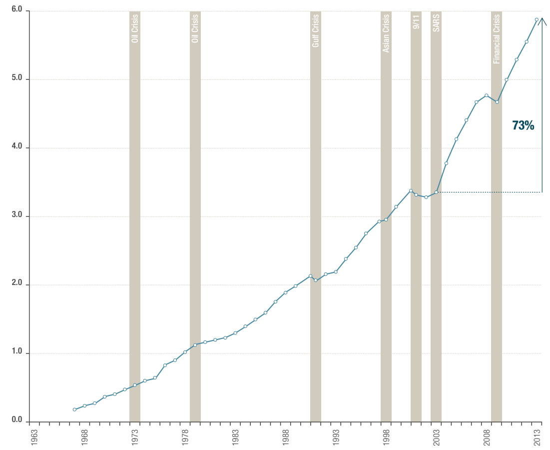

Figure 1 – World annual traffic (RPKs – trillions) (Source: Airbus GMF 2014)

DEMAND

The International Air Transport Association (IATA) released the IATA Airline Industry Forecast 2013-2017 showing that airlines expect to see a 31% increase in passenger numbers between 2012 and 2017. By 2017 total passenger numbers are expected to rise to 3.91 billion—an increase of 930 million passengers over the 2.98 billion carried in 2012.

Also demand forecast of Airbus says that growth will be strong, and traffic will double in the next fifteen years (Figure 2).

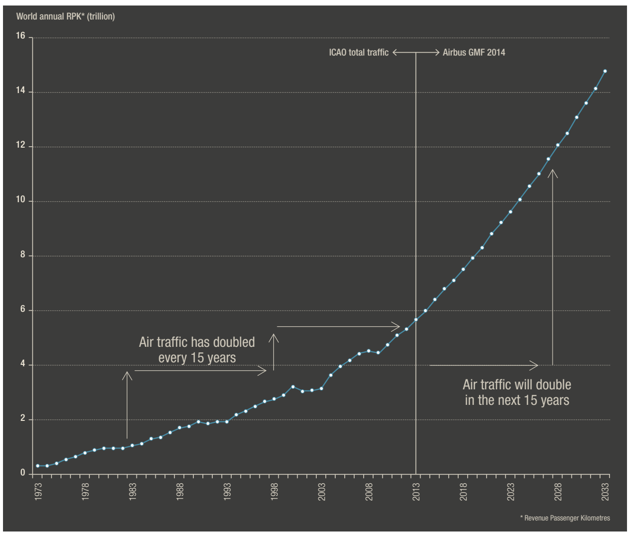

Figure 2 – Airbus passenger traffic demand forecast (RPKs – trillions) (Source: Airbus GMF 2014)

Capacity

Talking about capacity a its problems is still very important, not only because of growing demand but also because of slot coordination problems and airports unreal growth. The paper concentrates on these main themes:

- the short run problem—recovery and the allocation of airport capacity;
- the long run problem—recovery, growth and investment;
- new business models and their impacts on the demand/ capacity balance;
- new aircraft technologies and their impact on the demand/capacity balance;
- improving airport efficiency and reducing cost levels.

In the short run, it is difficult to expand airport capacity, and thus as the recovery in demand develops, there is the problem of ensuring that existing capacity is utilised most efficiently. This leads us to focus in on the capacity allocation devices in place. The two most important of these are: the slot system, in place at most busy airports outside the US; and the structure of airport prices. The slot system has a major advantage along with a significant limitation. The advantage is that it enables demand for the airport to be kept within capacity at an acceptable price in terms of delays. The disadvantage is that available slots are not allocated as efficiently as they could be. As demand grows and runway capacity remains un- changed at an airport, congestion will develop. The great merit of the slot system is that it restricts effective use of busy airports to a level which can be handled with an acceptable level of delay. Delays arise for several reasons, such as poor weather, but delays resulting to airport capacity restrictions can be kept moderate with an effective slot system. The slot system limits the number of flights which are permitted to use the airport at busy times. Where slot systems are not in place, as is the case for most US airports, delays can become very large. The efficacy of the slot system in avoiding delays tends to be taken on trust— empirical studies are not easy to come by. However, there is evidence that the system does make a difference. Some slot prices are very high—for example, slot pairs at London Heathrow have exchanged for £10 m. This is an indication that slots are performing a substantial rationing function— if slots were replaced by delays as the rationing device at Heathrow, the costs of the delays would be very large. Slot systems need not always work well in avoiding delays— authorities have to set slot limits at the right level. There is little evaluation of how well authorities have been in setting slot limits. Overall, however, the evidence is that most slot systems work well in avoiding costly delays. It is likely that slot systems will be able to cope as demand for airport capacity rises. As demand grows, slot limits will be either constant or can increase only slowly, in the absence of substantial capacity increases. Airlines have to adapt to the shortage of slots. They may be able to use off peak slots, they may be able to schedule larger aircraft into slot constrained airports, and they may have some scope to use alternative airports. Delays are kept at moderate levels as demand for airport capacity in- creases—this contrasts with increasing delays in non-slot constrained airports, such as those in the US. Slots become more valuable, and this means that the costs of misalloca- tion of slots become greater. The delay lessening function of slots works effectively but the slot allocation problem becomes a more important one.

If the recovery is sustained, it will add to the need for more airport capacity. Even if it is not, existing capacity bottlenecks will need to be addressed by investment. Adding to airport capacity is notoriously difficult— environmental factors mean that airports are often refused permission for major developments, such as new runways, and adding to capacity on constrained sites can be a very slow and expensive process, as the London Heathrow Terminal 5 illustrates. Decisions about investments in additional capacity are partly made by governments. However, increasingly, with corporatisation or privatisation of airports, decisions are being made by the airports themselves, though influenced by the regulators. The underlying concern is whether the institutional and ownership arrangements under which airports operate will get investment right.

The aviation market has probably adjusted to the impacts of airline strategic alliances, which were the major change of the previous decade. It has yet to adjust to the full implications of the boom in LCCs. LCCs continue to gain market share in the short haul markets, though in some cases they may be approaching their long term share (in the US?). They are now beginning to enter long haul markets—there are LCC flights from Asia to Australia, and the Qantas owned LCC Jetstar is beginning to operate long haul routes (it has Boeing 787 aircraft on order). It has yet to be seen how successful the LCC model is for long haul. The LCCs are having a serious impact on the legacy carriers, which will need to respond carefully (perhaps by operating lower cost services). Here, we are interested mainly on their implications for the use of airport capacity. LCCs target budget conscious travellers, who are prepared to use less convenient airports if this saves them money. Thus, the LCCs have made a point of flying to and from less convenient, but cheaper, secondary airports. To a degree, this has been a case of making a virtue out of necessity, since they would have had difficulty in obtaining adequate slots to operate from busy airports. (If slots were more readily available, albeit at a price, some LCCs which target business travellers might be prepared to pay for them and use busy major airports). LCCs also make extensive use of those major airports which have spare capacity. It is likely that long haul LCCs will also be prepared to use secondary airports.

The introduction of the Airbus A380 will have significant impacts on many larger airports. There will be costs in accommodating it, by widening the runway and by building specialised gates at terminals—in some cases (Melbourne) these costs are modest (less than US $50 m), though in other cases (London Heathrow and Los Angeles) the costs will be considerable (several hundred US $m). One issue concerns who will pay these costs—will it be the airlines which schedule the A380, and gain the advantage of its lower costs, or will the costs be spread over all users of the airport? Once the costs are sunk, the extra costs of handling the A380 need not be any higher than those for any other type of aircraft. To this extent, it would seem efficient to not levy any special charge for it. However, in the long term, it is desirable to set the right signals for airlines to use the A380 only when it is cost efficient to do so, taking into account the costs of airport modifications. If no charge is levied, the airlines will not take these into account, and will use the aircraft to an excessive extent. Another issue concerns whether airports will make careful assessments of the worth of investing to accom- modate the A380—some airports may be unrealistically optimistic about their chances of attracting services using the A380, and having A380 capability may be a prestige issue for some airports and regions. As noted before, in the ownership and regulatory environment that many airports operate in, it is easy for airports to make investments which are not warranted since they are able to simply pass on the costs to the users. Thus there is a risk of excessive investment by airports in preparing for the introduction of the A380.

Airport benchmarking studies are clearly indicating that there are substantial variations amongst airports in their productivity and the level of their charges (ATRS, 2005). While there are difficulties in standardising for different output mixes and achieving comparisons of like with like, it is clear that many airports in Europe and some in Asia are relatively high cost. To some degree this may due to cost factors beyond the control of the airports—for example, the need to operate on a very constrained site. Never- theless, there is likely to be scope for many airports to lower their costs. Cost reduction has not been a priority for many airports. This is true for publicly owned airports, but also so for private regulated airports which are subject to cost plus regulation (as most of them are). The effects of private ownership on costs are also muted since often priva- tisation is only partial. Airports have become more commercial, and they have exploited their non-aviation revenue sources more effectively. Where this is combined with single till regulation it can lead to reductions in charges. This happened in the early years of BAA's privatisation.

AIRLINE BUSINESS MODELS

The major part of the European airline industry was in difficulty before the traumatic events of 11 September 2001. A number of factors had started to impact adversely on the industry's financial fortunes from 2000. A slowing down in key economies, such as those of Germany and Japan, as well as several more in Europe led to a slowing in traffic growth. The collapse of the dot.com boom undermined business confidence which in turn impacted the demand for business travel. At the same time in many long-haul markets overcapacity was becoming a serious problem. This overcapacity and the very rapid growth of low cost operators, especially in intra-European markets, were creating strong downward pressure on average fares and yields. Yet costs were rising. Between October 1998 and October 2000 fuel prices doubled, while labour costs were rising as new wage agreements were negotiated in the aftermath of the very profitable years of 1995–1999.

The events of September 2001 turned a growing crisis into disaster as traffic levels in many key markets collapsed, more especially on the North Atlantic. Sabena and Swissair filed for bankruptcy. Most of Europe's scheduled airlines posted large losses or severely diminished profits for 2001. Only the large LCCs, Ryanair and easyJet, bucked the trend by showing increased profits.

The invasion of Iraq early in 2003, followed by the SARS epidemic in the Far East, hit Middle East and Asian routes. But as traffic growth started to accelerate again in 2004, a new challenge, the rapid rise in fuel prices began to undermine airline profitability once more. Against this turbulent and unstable market environment since 2000 the financial performance of Europe's airlines was varied.

NETWORK CARRIER

The position of the top 10 EU airlines, in relation to their share of available seat kilometres (ASK) and departures within the EU in 2004, is illustrated in Table 1. Clearly, British Airways, Lufthansa and Air France are the principal carriers in the EU market. These three carriers are responsible for over half the ASK and over 40% of weekly flights operated by the EU network airlines. If KLM's operation is added to that its owner, Air France, 61% of ASK and 47% of departures are performed by the top three carriers. The rest of EU airlines offer much smaller shares of capacity.

Table 1 – Largest EU network airlines by ASK share (Source OAG 2014)

Airline	% ASK (2004)	Accumulated %
British Airways	20.4	20.4
Lufthansa	17.8	38.2
Air France	14.9	53.1
KLM	7.6	60.7
Iberia	6.8	67.5
Alitalia	4.9	72.4
Virgin Atlantic	4.0	76.5
SAS	3.8	80.3
Swiss	2.8	83.0
Austrian	2.8	85.8

LOWCOST CARRIER

The low cost airline sector in Europe has grown dramatically since Ryanair first started operating as a LCC in 1991, and easyJet established in 1995. The 9/11 terrorist attacks acted as a catalyst for a dramatic change in the structure of the UK airline industry. While British Airways maintained short-haul business fares and reduced capacity for leisure travellers, easyJet and Ryanair reduced their fares and built capacity. EasyJet in particular took BA's capacity reduction at Gatwick as an invitation to establish a base at London's second airport.

In 2002 and 2004, as the UK market began to become crowded following the arrival of Buzz, bmibaby, MyTra- velLite and Jet2, among others, consolidation occurred as easyJet bought out BA's subsidiary Go and Ryanair purchased KLM's subsidiary Buzz. Continental Europe is following suit with a rapid burst of high market growth, which is expected to be followed by a levelling off and consolidation. Indeed, according to Credit Suisse First Boston, LCCs in 2004 accounted for 20% of European airline passengers, and 43% of the domestic UK market (Travel Weekly, 2004).

LCC passenger traffic is estimated to have been 94.6 million in 2004. Table 2 shows the 10 largest European LCCs in terms of ASK in June 2004. EasyJet and Ryanair are, by some degree, the largest LCCs in Europe but Air Berlin is not far behind in size. Air Berlin still operates a considerable number of charter/leisure flights, which are included in the table.

Table 2 – Largest EU lowcost airlines by ASK share (Source OAG 2014)

	% of ASK	Cumulative % of EU low cost airlines
Ryanair	26	26
EasyJet	24	50
Air Berlin	14	64
Volare Airlines	6	69
bmiBaby	4	74
Germanwings	4	77
Hapag-Lloyd Express	3	81
Virgin Express	3	84
Flybe	3	87
Norwegian Air Shuttle	3	89

Conclusion

Increasing demand and changing patterns of demand pose an adjustment problem for airports. Increasing demand puts pressure on facilities, which cannot be expanded much in the short term. In spite of this, it is possible for most airports, which operate using a slot system, to cope without significant additions to delays. In the short term, terminals will become more congested, especially if it is difficult to provide adequate facilities for security screening. While airports will cope, there may still be an underlying problem concerning the efficiency with which their scarce capacity is allocated between users. In the longer term, the expansion of capacity may not take the most efficient form. Airports are subject to strong environ- mental and political constraints on expansion, and in spite of new ownership and regulatory frameworks which many are operating within, investments in capacity expansion will often not be directed to the most cost effective solutions.

Airports are also facing changes in the patterns of demand they face, from new airline business models, such as LCCs, and from new aircraft types. The latter are not likely to have major impacts on the use of airports. The new business models, however, are making a difference. The increasing use of secondary airports, or major airports with spare capacity, is lessening the pressure arising from demand growth. However, with the proliferation of local airport subsidies, and cross subsidies within major airports and in airport systems, it is likely that a less than ideal allocation of traffic to airports will come about.

The purpose of this study was to assess the elements affecting the market structure and financial viability of European air transport over the next 10–15 years. A Delphi study approach was a suitable method drawing together the views of industry experts to assess veracity of hypotheses about how network carriers, LCCs and airline customers in the forecast time frame. The results of the Delphi experts suggest that business travellers will increas- ingly seek better value for money leading to the end of business class services in short-haul markets and leisure travellers taking advantage of low fares to vacation more frequently both in the EU and further abroad. The airline market is likely to consolidate into a small number of very large network carriers and a similarly small number of very large LCCs. The surviving LCCs will prosper and eventually carry about half of intra-EU traffic. Feeder services into main hub airports will increasingly be operated by lower cost-based franchised partner airlines. There will continue to be an independent role for the small and medium sized European carries, by focusing on point- to-point markets, and feeding traffic to larger network airlines. High-speed rail could also provide feed into hubs where the infrastructure allows that, but elsewhere is likely to compete with short-haul air services. Competition for network carriers will continue to be intense on major long- haul markets. Services to Gulf and beyond will become increasingly vulnerable to competition from Gulf area airlines due to their large expansion in capacity.

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THE OPERATION SUPPRORT SYSTEM OF AIRPORT FACILITIES

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Abstract *– This thesis describes a literature review and of essential issues of the work from the scope of the subject matter carried out. Chosen devices being on an airport surface were replaced Airport Lublin, they divided these devices on account of performed functions as well as briefly they characterised chosen from them. The system of the use of devices were familiarized , a significance of the schedule of the conservation and the time sheet were described for the correct technical operation of devices. Information were presented about the created computer support system CONTROL use of devices among others used were presented software, stages of forming it service, installation and right conclusions were drawn.*

Key words – technical device, system of exploitation, schedule of the conservation.

INTRODUCTION

One of the main difficulties at all airports is how to smoothly manage the supervision of airport equipment operation. This equipment should be maintained in a good condition to ensure its uninterrupted operation at the required level. It performs many important and diverse functions. One of the most important ones is to maintain a runway surface clean regardless of weather conditions, provide a sanitary handling of aircraft, baggage transporting, aircraft de-icing and to ensure fire safety. All of these devices should ensure smooth airport functions and guarantee safe aircraft take-off and landing. The paper presents an information system designed to assist the operation of airport devices as specified in a fixed plan, or TBO (operational capacity). As said in [1], [6], when applying this strategy, durability periods specified in a design of individual items of equipment before they reach the maximum level of wear and tear should be observed. Preventive repair works, overhauls and parts replacement are carried out at fixed intervals. The system continually displays the number of days left to repair a device or replace its parts or fluids. Due to a large number of operating devices at airports, which is burdensome to supervise correct operation, advanced and professional software to support equipment operation operating on similar principles as in this work are available on the market [7], [8].

The described process of creating the CONTROL system should make us aware of the fact that creating this type of computer system is a complex task, show that many factors affect efficient and above all safe operation of airports and show the complexity of operation.

The objective of operation is effective and efficient performance of tasks at minimal operating costs and under safe conditions ensured both for users and the environment, following ecological safety requirements. This objective and conditions require from systems involved in operation while tasks are performed to constantly improve operation and service efficiency, to optimise the impact of machine operation on the environment and to provide the relevant safety level at each stage. Machine operation is assisted by information systems that provide data on the state of the system, usage history and limitations. Systems for diagnosing, analysing and forecasting allow us to assess a device for its operational suitability and support us in taking decisions about its operation in the future [6].

Advances in IT technologies make it possible to design systems to reduce maintenance costs of devices and improve their operational characteristics. Machine operation depends on numerous diverse opportunities of computer usage according to the degree of automation and an operation system.

- A complex and sophisticated design of modern operating systems necessitates the use of achievements in the operation theory, especially that of research systems and processes occurring in them. The following factors are significant to shape a machine operation system in a modern way [9]: complex issues of operation,
- improving efficiency, stand-by and reliability of equipment,
- preserving raw materials, energy and time and maximising performance at minimum costs,
- implementing IT technologies in the management of a machine operation system.

SAMPLE AIRCRAFT EQUIPMENT

The Lublin Airport possess a number of devices that need to comply with the relevant requirements for the airport to function correctly.

The technical services at the Lublin Airport use advanced, specialist equipment to maintain the runway, taxiways and apron clean and in a good state regardless of weather conditions. Snow, mud, ice, water, dust, sand, oil, rubber and other contaminants need to be removed quickly and effectively to prevent their accumulation on the surface [11]. It is important, especially in winter when aircraft operation needs to be uninterrupted regardless of heavy rain or snow.

Running functionally and uninterruptedly, one of these devices is a specialist airport cleaner compact Jetbroom (Fig. 1). This is a multifunctional system dedicated to meet the increasing demands about maintenance of runways, aprons and taxiways in the summer and winter.

***Figure 1** – Airport compact cleaner Jetbroom*

Another device at the airport Lublin is a self-propelled de-icing device. The vehicle can de-ice, protect from icing and clean aircraft on the ground [12]. This device can be used for all types of aircraft, i.e. General Aviation light aircraft, helicopters and the largest aircraft like B747 or A380. Typhoon de-icers can be applied to each of these aircraft [14].

The de-icer in Fig. 2 is dedicated to de-ice aircraft and apply de-icing agents on specified surfaces.

***Figure 2** – A device for de-icing and protecting aircraft against icing*

Another device at the Airport Lublin is Striker fire truck (Fig. 3). Its task is to instantly reach aircraft on the apron after the accident.

The Lublin Airport fire brigade have two fire trucks, i.e. New Striker 1500 (4 × 4) and New Striker 3000 (6 × 6). Both vehicles are manufactured by the American leader in the automotive industry. These vehicles are the latest generation of fire trucks called the New Global Fire Striker [6]. The Lublin Airport as the first in Europe has such vehicles.

***Figure 3** – Striker fire truck*

The device is used by Lotniskowa Straż Pożarna (LSP -Airport Fire Service) which is a specialised unit to perform a number of fire protection tasks at the Lublin Airport. Its main task is to participate in fire and rescue actions in the airport operation area if there is an aircraft accident or the airport facilities and equipment are on fire.

Equipment operation system

The system for equipment operation should include data to safely and reliably handle equipment. Accordingly, we should discuss the issues on the minimum work necessary to guarantee correct operating parameters at the optimum level. Correct operation is based on a maintenance schedule, correct and safe equipment operation and relevant maintenance procedures.

Equipment maintenance needs to follow a timetable provided in a manual. An equipment manufacturer strictly recommends to do timely these activities since operation start to ensure equipment full efficiency. Each device has its own maintenance schedule.

Components and mechanical, electrical and hydraulic systems need regular maintenance. Actually, maintenance is a kind of protection against faults. Disobeying recommendations or frequency of individual maintenance tasks can result in equipment worse performance, its damage and voiding the warranty.

Carried out according to recommendations, overhauls by a driver or operator can be done on a daily or after every use basis and periodic inspections. Periodic inspections and adjustment are major factors behind performance and condition. If performed regularly, overhauls can also increase equipment service life. Types of service tasks and their timing are given as an example in Table 1.

Table 1 – *Basic operation*

No	The Act of	The Frequency			
		A	B	C	D
1	Check whether the vehicle has no visible signs of damage or leakage	X			
2	Check the engine oil level on display in the cabin and supplement	X			
3	Wheel nuts: tightening Control			X	
4	Awaryjne elementy sterujące: Sprawdzenie działania	X			
5	Check the status of all the wires and connections are correctly fitted and undamaged	X			
6	Static test in order to verify the correct operation of all functions and, in particular, locks the door locking, seat belts, lighting and electrical equipment			X	
7	Dynamic function Test. Carry out a short test in order to correct the boot, drive, steering and braking system of the vehicle			X	

Text Symbols:
A: daily before use (only on equipment operation days)
B: daily after use (after equipment usage),
C: once a week (depending on whether equipment was used or not),
D: not applicable

Incorrect maintenance or non-eliminated defects before starting may result in malfunction which may bring risk of serious injury or death to the user. One always needs follow the manual instructions and maintenance schedules. It is not possible, however, to warn against all possible hazards during maintenance procedures and overhauls. The user is the only person to decide on performing a given task [10]. Before maintenance tasks, certain parts should be washed and cleaned, the vehicle should be parked and secured from relocation. If moving parts are overhauled, the temperature should reach 45°C. In addition, you must also comply with recommendations such as engine-off maintenance, installation of supports if a vehicle is on a sloping surface, disconnect the battery, never re-connect pipes under pressure, use safety glasses, keep a safe distance from rotating parts. Actually, authorised services know typical engine features best and have equipment to overhaul and repair engines [2], [4], [12].

Premilinary design of the operation support system

Designing a computer system supporting operation is a very demanding task involving both technical and advanced IT knowledge. Such systems are applied at airports and institutions where supervising correct equipment operation is important. The manner this system is developed means the selection of the simplest solutions, but the complexity of the issues is high.

The main project objectives are:

- ✓ creating a system to assist equipment operation,
- ✓ using available free software,
- ✓ applying possibly the easiest manner of designing and operating,
- ✓ the ability of the system to be used by more than one user simultaneously,
- ✓ expanding the system with additional functions,
- ✓ conclusions and possible modifications to the system until satisfactory results.

The main objective of the system is to facilitate equipment operation. The system continually displays the number of days left to service, overhaul, repair or replace parts or fluids at fixed intervals as specified in a developed maintenance schedule.

This system is likely to reduce the number of sudden failures and therefore the stoppage of equipment under constant stand-by. Also, the system can reduce repair time and costs as a time and scope of future repairs can be known. Accordingly, service can be scheduled and material costs can decrease.

CONTROL is a system to improve the course of airport equipment operation. The system can instantly signal an upcoming overhaul or maintenance deadline and also relevantly highlight a servicing activity specified in manufacturer's requirements. A green light means more than 15 days left to a scheduled activity, an orange one - less than 15 days left and a red one if less than 5 days left.

The CONTROL application is written in the PHP scripting language with a free INTERNET open-access MySQL database. Accordingly, the costs of project development have been minimised. The advantage of this configuration is that it can operate on numerous platforms such as Microsoft Windows, Linux, MacOS and others with web browsers like Mozilla Firefox, Google Chrome, Microsoft Internet Explorer, Opera.

Thanks to the PHP scripting language, this application can be freely and easily expanded/scaled with new modules or functions. This solution enables a quick migration between environments with preserved integral data. These technologies allow us to install the application inside a server or workstation (a local computer). In either case, its operation is identical although if installed in a server, more than one user can simultaneously use it. This is convenient because conditions can be monitored at any time and place only if the computer is connected to the Internet.

The application consists of two main parts, i.e. a list of equipment and a list of maintenance points.

The former part is responsible for management (adding, modifying, deleting) and providing a list of devices with their number, name, serial number and year of manufacture.

The latter part is responsible for management (adding, modifying, deleting) and providing a list of maintenance points of a given device with its number, maintenance section, operation, execution date, the mth, the next day, the remaining days / months.

System operation an maintenance

The system is functional, easy to use, update, enter new data, monitor equipment operation. The system is capable of recording and exporting data from the system to a Microsoft Excel file.

The former application part known as "List of devices" (Fig. 4) is capable of adding a maintenance point/section and preview a device, i.e. the data on a device such as its name, serial number and year of manufacture are displayed if the gray button with a magnifying glass pressed.

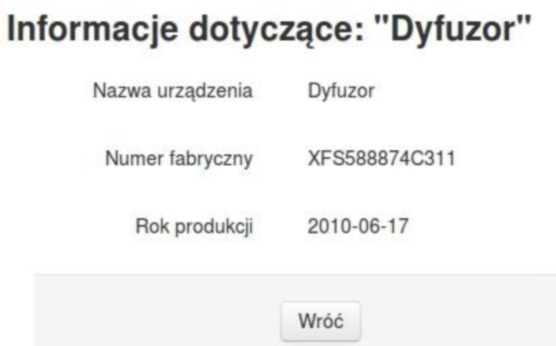

Figure 4 – *Preview of data on a given device*

The system can edit device data. When the green button pressed, data assigned to a given device are displayed to be modified (Fig. 5).

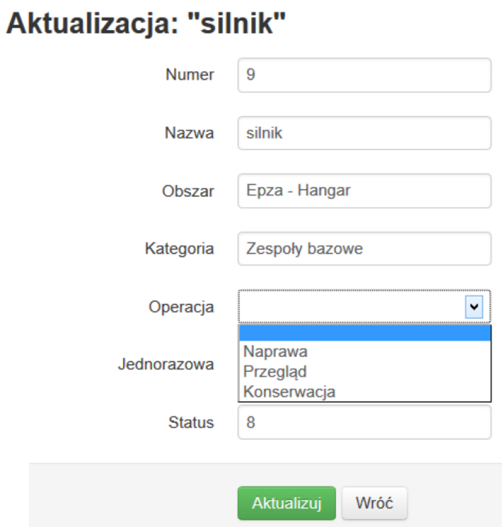

Figure 5 – *Editing data assigned to a given device*

The CONTROL system refers to maintenance points/sections by previewing them, i.e. data "status of the operating device" like its name, maintenance point/section, operation, execution date, In Mth, the next day and the time (left or passed) since RS operation are displayed if the gray button marked with a magnifying glass pressed (Fig. 6).

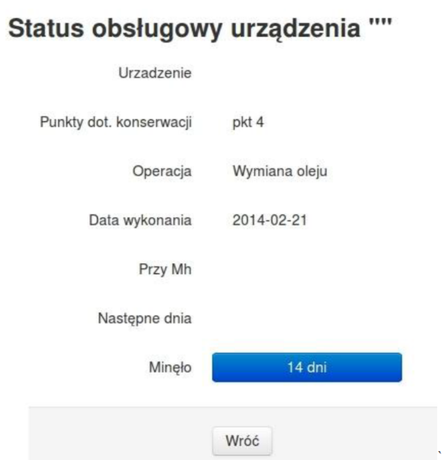

Figure 6 – *Preview of data on a given service task*

Then a maintenance point/section can be edited – data assigned to a given maintenance point/section are displayed to be modified by pressing the green button (Fig. 7). To simplify it, an easy to use datemarker is installed.

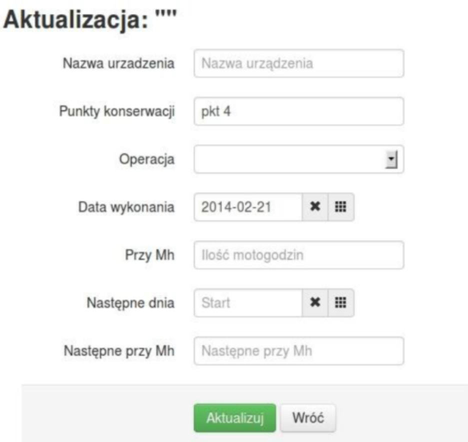

Figure 7 *– Editing data assigned to a given maintenance point/section*

CONCLUSION

The paper presents important issues on the operation of equipment used at the Lublin Airport and describes the CONTROL system to support their operation. Located on the apron, the selected equipment to maintain the runway surface and flying objects clean are listed and described. They include an airport cleaner, aircraft surface de-icer and fire equipment to fire service in the airport area and in a crash. All of the equipment have important functions and are indispensable to airports. Accordingly, its appropriately maintenance and use is important for its smooth emergency operation. The sound use of equipment comes down to saving energy, raw materials and capital [2], [9].

The paper presents the system designed, software applied, servicing and the documentation prepared. The creation of this system is just the beginning. It is planned to programme a number of different options to improve operation at the high level as required by the airport.

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CHARACTERISTIC OF THE AIRSCREW PROPULSION AS A PART OF THE HYBRID POWER SUPPLY SYSTEM STRUCTURE

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Abstract *– The aim of aircraft engines development is the propulsion which is characterize by high power-to-mass ratio. Therefore, the alternative solutions that provide the required power by the low weight propulsion are looked for. The main advantage of these solutions is improvement of environmental and economic properties. This paper presents the studies conducted for the airscrew propulsion with the electric engine as main source of power. For the purposes of studies prepared the test bench enables comparison of the operating parameters from the airscrew propulsion. These parameters were compared for the different propellers and take into account changes in the values of thrust and propulsion power.*

Key words – airscrew propulsion, electric motor, hybrid power supply

INTRODUCTION

In the airplane propeller engines the main receiver of power generated by the engine is the airscrew. The power is converted by the airscrew to the thrust force, which causes the aircraft translation at a specified speed. During the airscrew rotation around the hub axle, on the airscrew blades are generated aerodynamic forces the resultant of which is the thrust force. The value of this force depends on the speed of the blade relative to the air, the surface of the blade and the angle setting in relation to the direction of movement. The engine propelling the airscrew has to overcome the resistance torque, losing thus a part of the generated power. The amount of power wasted depends on the propulsive efficiency of the airscrew, i.e. the efficiency is the ratio of the work executed by the airscrew within 1 second to the work executed by the engine to turn the airscrew (4).

Up to now, the airscrew propulsion has not been replaced due to simplicity in handling and lower cost of purchase of this type of propulsion compared to the more advanced designs of aircraft engines. Its further development involves improvement of the engine and the airscrew. Based on the use of the airscrew-engine assembly, many propulsion systems have been designed and constructed, enabling to obtain larger values of airscrew thrust force. Such engines are, among others, turboshaft engines for airscrew propulsion. The engines are designed in order to increase their power, torque and the engine speed maintaining at the same time the smallest possible size and weight of the propulsion unit.

Nowadays, more and more often are proposed solutions alternative to conventional combustion engines, which apart from providing required thrust force will enable the reduction of harmful exhaust gas emissions and noise. Meeting these criteria is possible due to, among others, use of an electric motor. The alternative propulsion, such as the electric motor, promotes significant improvement in environmental performance. Moreover, in the process of intensive development of electric motors for aviation applications, single-phase commutator motors have been replaced by three-phase brushless DC motors. Modern engines show the improved power-to-weight ratio and higher efficiency.

Another important issue is the dynamic development of the sources of electricity and the devices for its accumulation within the last twenty years. Use of modern cells have enabled, eg. reduction of the time it takes to prepare the propulsion for re-use [2]. Apart from stand-alone use of the electric propulsion in aviation, there are also concepts involving the use of hybrid propulsion systems consisting from the electric motor and combustion engine. Thanks to the use of two sources of energy, it is possible to increase the flying range of the aircraft equipped with an alternative propulsion system (1).

The article presents the tests carried out in order to assess the alternative propulsion system used in aviation. The bench tests of the airscrew propulsion have been carried out and the characteristics were prepared used further to compare the efficiency of the propulsion unit in co-operation with the specified type of the airscrew. These test are a part of the works carried out in order to create the airscrew propulsion with a hybrid power supply.

RESEARCH METHODOLOGY

The tests were performed with the use of propulsion system with three airscrews. During the tests the following parameters were recorded:

- thrust force (F_T),
- shearing force (F_S),
- engine shaft speed (RPM),
- input power (P_{IN}).

Measurements of the shearing force, engine speed and input power were conducted for thrust force ranging from 10 N to 50 N. The data read out during the measurements was used to determine operating characteristics of the airscrew propulsion. On the basis of the obtained results were compared properties of the airscrews cooperating with a particular type of engine installed on the testing bench. Measurement of shearing forces enabled the determination of torque, which, together with the measured engine speed, was used to determine the output power of the engine (P_{OUT}). Components of the test bench (fig. 1) intended for testing the airscrew propulsion were: electric motor with the test bed, the airscrew, the three-phase engine speed controller, the set of batteries with the battery cables, the controller.

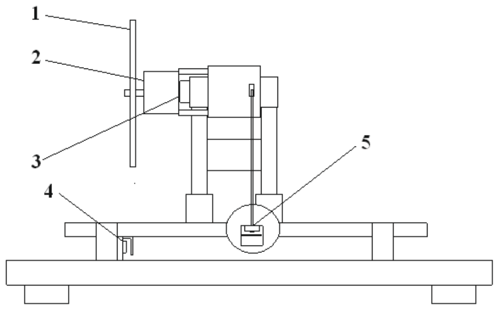

Figure 1 – The test bench : 1 – electric motor, 2 – tested airscrew, 3 – shaft speed sensor, 4 – thrust force sensor, 5 – shearing force sensor

The test bench was equipped with two strain gauges capable of measuring the thrust force and the shearing force. Measurement of the electric motor speed was carried out with a sensor using the optical method. The test bench featuring the universal method of mounting the engines makes it possible to conduct tests of other models of electric motors intended for the model aircraft. The test bench will be further used for testing the designs with the hybrid propulsion system.

In order to visualize the results, the sensors used during the measurements were connected to a Wobit programmable indicators MD150T. These indicators are designed to work with strain gauges for measuring force, enabling the measurements with a resolution of 0,001%.

As the airscrew propulsion was used the three-phase EMP electric DC motor N6354/13 (fig. 2). Engine technical specification is shown in Table 1.

Figure 2 – EMP electric DC motor N6354/13

Table 1 – Technical specifications of the EMP engine N6354/13

Parameter	Value
Power [W]	2500
Engine shaft speed/1V [rpm]	250
No-load current [A]	1.7
Internal resistance [V]	53
Diameter [mm]	63.4
Length [mm]	57
Output shaft diameter [mm]	10
Engine weight [g]	558

To power the electric motor were used two lithium-polymer DesirePower batteries, 35C 4000mAh 18,5V (fig. 3), connected in series.

Figure 3 – View of the lithium-polymer battery used to power the airscrew propulsion

During the tests, the electric motor and shaft speed controller used the same power source. This solution is the most beneficial considering the application of the propulsion assembly on the airplane, as the use of one power source does not increase substantially the entire weight of the power supply. Therefore, an arrangement of the test bench was adopted so as to reflect as much as possible the energy consumption by the device responsible for motor control.

In the tests three types of airscrews were used. The airscrews were different in terms of geometric parameters such as their diameter, the blade profile, number of the blades and the material of which they were made. All airscrews had the same direction of rotation and angle of attack. The optimal diameters of aircrews were selected on the basis of bibliographical analysis and the experiences of the researchers, and the essential parameters were the output power of the electric motor and the maximum speed of the engine shaft. The first airscrew used in the tests was the EMP airscrew, 18x10E. The airscrew was made of a composite material and had two blades with a fixed angle of attack. The second airscrew selected for the tests was the three-blade airscrew EMP, 16x8, which was also made of the composite material. The last tested airscrew was FIALA 19x10 Electro. It differed from the previous airscrews in terms of the material: it was made of wood. The tested airscrews are shown in Table 2.

Table 2 – Types of airscrews used on the test bench

Type of airscrew	EMP 18x10E	EMP 16x8	FIALA 19x10 Electro
View of the test bench			

ANALYSIS OF THE MEASUREMENT RESULTS

The results presented in the article refer to the measured performance parameters of the airscrew propulsion, obtained with the use of three types of airscrews. The conducted measurements and calculations are presented in the form of dependence of the thrust force, shearing force, input power and output power on the electric motor shaft speed, and the efficiency as a torque function (fig. 4 – 8).

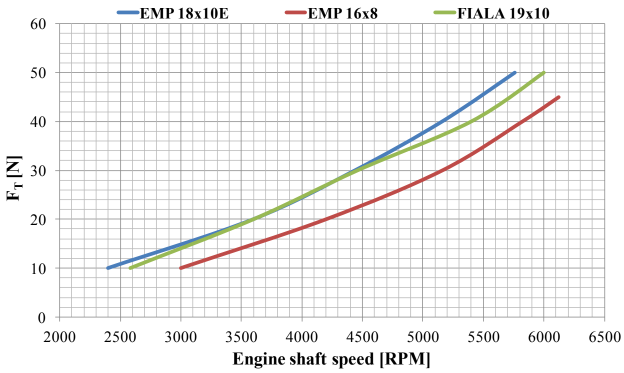

Figure 4 – The thrust force as the engine shaft speed function

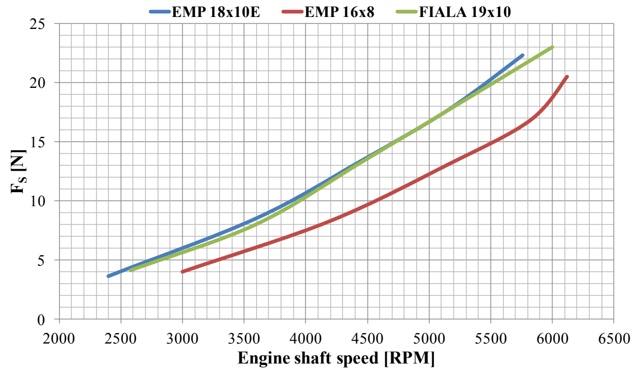

Figure 5 – The shearing force as the engine shaft speed function

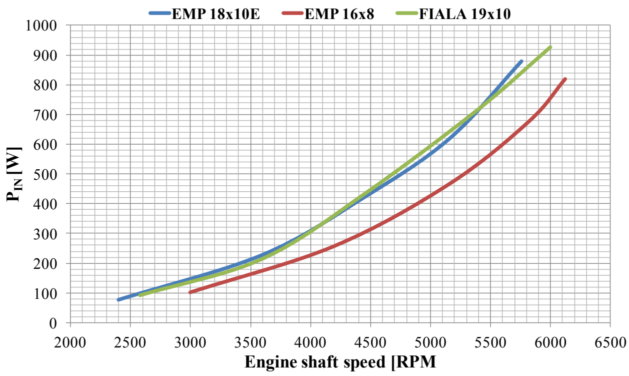

Figure 6 – Input power as the engine shaft speed function

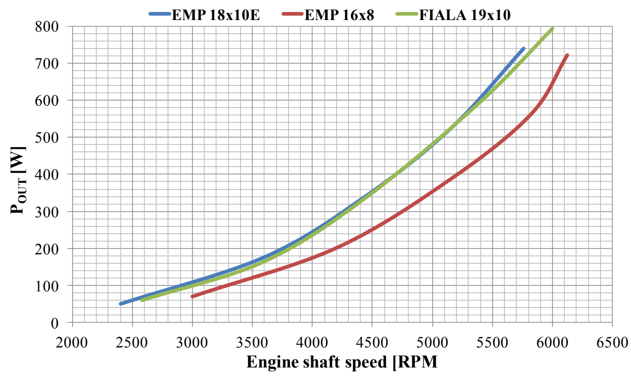

Figure 7 – Output power as the engine shaft speed function

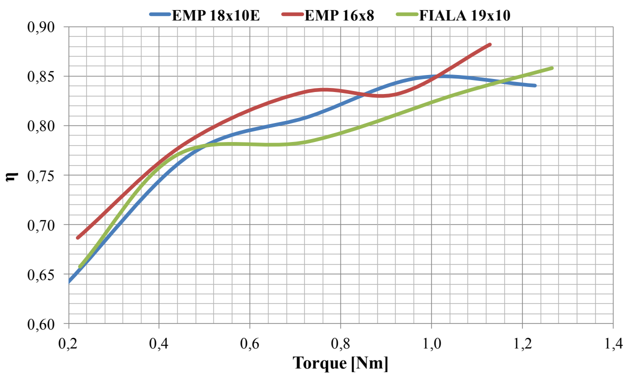

Figure 8 – Efficiency of the propulsion as the torque function

The thrust force is a component of aerodynamic forces generated on the airscrew blades. Obtaining the assumed values of the thrust force required different values of engine shaft speed. The results obtained were influenced by the geometrical properties of airscrews such as their diameter, number of blades and their angle of attack. The EMP 18x10E and FIALA 19x10 airscrews interact with larger aerodynamic drag factor responsible for the resistance torque of the airscrew which is overcome by the engine. The result is reduced need for speed, compared to the three-blade airscrew, in order to achieve the specified value of the thrust force. In addition, during the tests the engine working with the three-blade propeller generated the maximum thrust force of 45 N. The obtained characteristics of the thrust force in relation to speed are characterized by growth close to exponential.

Another of the characteristics shown is the dependence of the shearing force on the engine speed. Conducting tests in stationary conditions makes it possible to obtain higher thrust and shearing forces. The characteristic of the shearing force increases with increasing speed. This force depends also on the power consumed by the engine. The diagram presenting dependence of the shearing force on the speed makes it possible to assess the force with which an airscrew influences the engine housing. The highest value of the shearing force, corresponding to thrust force of the airscrew propulsion equal to 50 N, was received for FIALA 19x10 airscrew. The smallest value of the shearing force at maximum thrust force value was obtained for the electric motor with a three-blade airscrew. The airscrew with a larger diameter exerts greater resistance on the the engine and therefore at the time of the tests the highest values were obtained for two-blade airscrews with a greater diameter in comparison to the three-blade airscrew. What's more, the higher value of the shearing force obtained for wooden airscrew may result from the fact that the wooden airscrew blades have usually thicker profiles, which contributes to getting the maximum lift-to-drag ratio for thick profiles at lower angles of attack compared to the thin profiles.

By analysing the obtained input power values depending on the speed of the motor shaft, the highest energy consumption can be observed for electric motor with EMP 19x10E airscrew, which at the time of the measurements required 925 W to ensure the force of 50 N. The lowest energy consumption for the tested range of engine speeds was obtained for engine with three-blade airscrew. Lower power demand of the electric motor with EMP 16x8 airscrew arises from its geometric properties i.e. the smaller factor of aerodynamic drag for the airscrew blades, which in turn made it impossible to achieve the assumed values of the thrust force for the tested airscrews. The received characteristics of the input power as a function of engine speed indicate the exponential growth.

The presented characteristics of the input and output power as a function of the speed show differences between the electrical power supply of the motor, which is higher than the mechanical power obtained at the engine output. The highest power output was obtained for the FIALA 19x10 airscrew, where also the highest input power was observed. The value of the engine output power, according to the formula, depends on the torque and motor shaft speed.

The FIALA 19x10 Electro airscrew reached the highest output power at the motor shaft speed of 6000 rpm and torque equal to 1.27 Nm. In the case of the three-blade airscrew, setting the higher motor shaft speed of 6120 rpm did not provide higher output power due to the lower torque equal to 1.13 Nm.

As the propulsive efficiency of the airscrew during the engine test in stationary conditions or at a very high flying speed has the value of zero, the propulsive efficiency of the engine was shown in relation to the torque. The obtained values of propulsive efficiency range from 64 to 88%. Lower values of propulsive efficiency were determined for low motor shaft speed settings on the controller. Operation of the engine at such parameters is associated with lower current intensity, below the high efficiency of the engine. The highest efficiency, reaching 88%, was obtained for the electric motor with the three-blade airscrew.

CONCLUSION

The conducted studies considered the issue of selecting the airscrew for use with airscrew propulsion with an electric motor. The article demonstrated the impact of different geometry of the airscrews on the operating parameters of the airscrew propulsion. The conducted tests enabled determination of the characteristics of the selected engine showing the characteristics of its mechanical and electrical power, thrust and shearing forces and the efficiency of the engine. On the basis of the carried out analysis of the results of the tests can be observed the relationship between particular parameters of the airscrews and the achieved values of operating parameters.

Testing the impact of geometry of the airscrews on the operating parameters of the airscrew propulsion some regularities can be observed. The airscrew propulsion equipped with an airscrew with a large diameter obtains the maximum thrust force at a lower speed of the electric motor. The airscrew with such geometric parameters shows a slightly higher demand for power in order to ensure the specific value of thrust force compared to the airscrew with a smaller diameter and with more blades.

Tests of the airscrew propulsion with different types of propellers demonstrate the influence of the airscrew diameter on the obtained value of the thrust force and on the achieved maximum engine speed. Another factor affecting the operating parameters of airscrew propulsion is the number of airscrew blades.

The ability to achieve the maximum thrust force at a lower demand for power is an advantageous solution from the point of view of endurance of the aviation task executed with the use of the airscrew propulsion powered by energy accumulated in the batteries. The use of the electric brushless motor in airscrew propulsion allows to achieve high efficiencies, providing also the ease of control and handling. The unit of this type is characterized by a large engine power to engine weight ratio, and it provides a wide range of engine speeds.

There are many types of aircrews characterised by different geometrical properties, the use of which depends on the purpose and expected performance of the entire airscrew propulsion. On the basis of the obtained results of the tests it can be concluded that, in case of the airscrews intended for aircraft performing flights over longer distances, the multi-blade airscrews can be utilized. Aircraft equipped with the aircrews of this type will achieve a lower cruising speed, despite obtaining the high engine speeds. The two-blade airscrew can be used with all types of aircraft because, after selecting the appropriate airscrew diameter, it is possible to obtain the optimal operating parameters. Such airscrews provide a combination of a large thrust force and a good ratio of the consumed power to the resulting thrust force value.

The tests conducted make it possible to specify the scope of required electric power needed to power the airscrew propulsion. Determination of the scope of power consumed by the electric motor powering the airscrew is one of the stages of the research leading to the construction of a hybrid drive system for the aircraft. On the basis of the conducted measurements, it is possible to formulate the following assumptions:

– the energy delivered to the airscrew propulsion should ensure its operation with the maximum power of 900 W to obtain the thrust force of 50 N,
– the power source should allow the maintenance of a constant electric power of 650 W, assuming that the power needed for flying comprises 70% of the maximum power.

One of the possibilities considered is the use of an internal combustion engine providing energy to the primary source of energy. Another solution assumes the use of fuel cells working with batteries. The use of an alternative source of electric power makes it possible to provide the high energy conversion efficiency and reduction of the negative impact on the environment.

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EXHAUST EMISSIONS MEASUREMENTS FROM A SMALL AIRPLANE

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Abstract *– The paper discusses the possibility of a synthetic approach to the problem of exhaust emissions measurements from piston aviation engines used in small general aviation aircrafts. The realization of this approach is a result of an analysis of the needs of identification and evaluation of the aircraft ecological performance under actual operating conditions. The issues discussed in the paper pertain to piston powertrains that have not yet been included in the aviation emission standards. The paper presents the relation between the emission of the gaseous exhaust components, the parameters determining the operating states of the engine of a small aircraft and also the methodological approach to the undertaken research problem. In the paper authors performs an identification of the values of the operating parameters of piston aviation engines (engine loads, engine speeds under actual operating conditions). The authors include also a description of stationary exhaust emission tests, based on the actual conditions of operation. The exhaust emissions tests of piston aviation engine have been performed in stationary tests. Obtained results could be compared to emission from other piston aviation engines, what can be used as input data to determine exhaust emission standards.*

Key words – exhaust emission, small airplane, aviation engine.

INTRODUCTION

Research into alternative methods for analyzing emissions of hazardous compounds in exhaust gases from aircraft engines began in the 1970s. The first efforts aimed at assessing aircraft's effect on the natural environment were undertaken in the USA by the EPA in 1970. The environmental effect of toxic compounds of exhaust gases emitted by aircraft was analyzed. The said efforts contributed to publication of first standards on the emission of carbon oxide, hydrocarbons and nitrogen oxides by the US Environmental Protection Agency in 1973. Smoke opacity standards were subsequently published in 1976.

Measurements undertaken by the US Environmental Protection Agency and the International Civil Aviation Organization resulted in the emergence of two normative documents. Subsequently, efforts aimed at their alignment were undertaken. Both documents were eventually unified and published in 1981 as a separate annex to the Chicago Convention (annex 16: "Environmental Protection". It consists of the following volumes: volume I – "Aircraft Noise" and volume II – "Aircraft Engine Emissions"). The document contains standards applicable inter alia to stationary tests, measurement methods, measurement equipment and specific emission calculation methodology. In addition, the document contains emission limits for each hazardous compound in exhaust gases separately for different engine types. The original emission limits were subsequently gradually tightened in order to stimulate development of more environmentally friendly aircraft engine systems.

Most static analyses investigating the environmental impact of aircraft, as well as most development efforts carried out as part of various projects concentrate on turbine and turbofan engines used in passenger and cargo aircraft. Thus far no efforts in terms of standardization for general aviation aircraft piston engines have been undertaken.

Studies and analyses carried out as part of this publication address issues related to testing the emissions of hazardous exhaust gas compounds from piston engines used in aircraft and to the methodology of such tests. Therefore, this publication tackles a research problem – how can the emission of hazardous gaseous compounds contained in exhaust gases from aviation piston engines be correlated with operational parameters of such engines in actual conditions [1-9]..

INVESTIGATIONS INTO THE OPERATING PARAMETERS OF AVIATION ENGINES

To understand the operational characteristics of engine parameters for the entire group of airplanes selected for the study, actual engine parameters in flight conditions were for the airplane Cirrus SR22T.

For Cirrus SR22T, fitted with an on-board recorder of flight parameters, an analysis of automatically recorded parameters provided by the airplane's operator was sufficient. Out of all available records, 10 registered flights were randomly selected and subjected to statistical analysis. In this manner, mean in-flight engine parameters were arrived at. Operational parameter values were compared against engine operation parameters from pre-flight tests. The results of those comparisons were then used to build a universal, stationary emission test. A randomly chosen flight from Poznań-Ławica airport to Rzeszów-Jasionka airport (some 500 km away) was selected (Fig. 1). The flight took place in a controlled air space in accordance with the instrumental flight rules (IFRs). Flights of this kind are subject to air traffic control and are separated from one another. From among all recorded in-flight performance parameters of the plane, the following ones were selected in order to demonstrate the engine's operating conditions: engine speed, exhaust gas temperature upstream of the turbocharger, flight altitude, airplane velocity and fuel consumption. Figure 2 presents the selected parameters as a function of time.

Based on the selected parameters' values, one can assess in-flight changes in engine loads, but the absolute values of such loads cannot be directly calculated. Changes in each of the parameter presented as a function of time allow one to identify the airplane's operation phases. The initial part of the record shows the engine's start-up, warming up and taxiing to the runway, followed by the take-off phase.

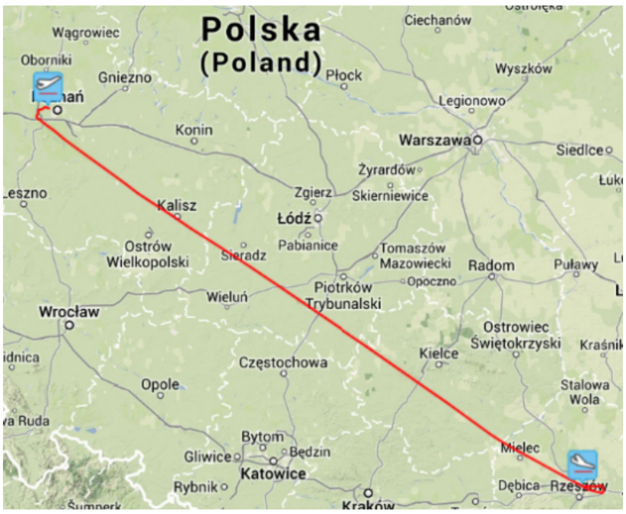

Figure 1 – Trajectory of Cirrus SR22T flying from Poznań-Ławica to Rzeszów-Jasionka

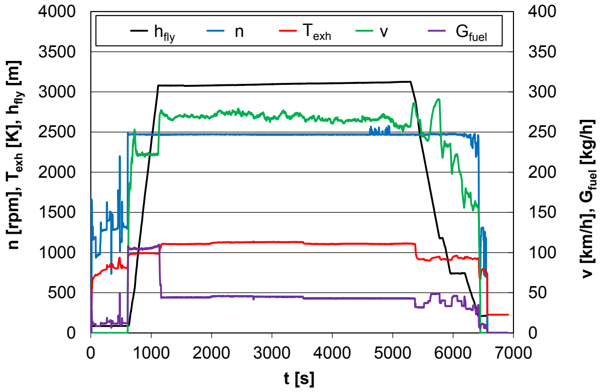

Figure 2 – Selected in-flight parameters of the Continental IO-550-N engine as a function of time during the flight of the Cirrus SR22T

Engine start-up and warm-up is characterized by an unstable engine speed (ranging from 1000 to 1700 rpm), sustained until the beginning of take-off. The temperature of the exhaust gas grows from the start-up into the warming-up phase and then stabilizes at approximately 800 K. The take-off phase is characterized by a growth in the engine speed up to approximately 2500 rpm. This speed remains constant throughout the flight and is determined by the airplane's propulsion system, i.e. a triple-blade variable-pitch airscrew. The exhaust gas temperature grows in line with the engine speed, which denotes a higher engine load. Importantly, in the case of Cirrus SR22T and SR20 planes used as a means of air transportation, the settings of the engine's operational parameters remain unchanged during the ascent, until the preset altitude is reached. The take-off and ascent phase generate maximum engine loads, as demonstrated by maximum fuel consumption during these two phases. The exhaust gas temperature is 1000 K. It is in fact lower than the maximum temperature (approx. 1100 K) observed during steady flight, when engine loads vary from 70 to 80% of the maximum load. The reason behind it is the fact that during the take-off phase the engine operates on a rich mixture, with the excess air coefficient λ amounting to 0.8-0.9. Combustion of such a mixture of air and fuel is characterized by lower process temperature, which determines exhaust gas temperature. In steady flight, despite lower engine loads, the temperature of exhaust gases is higher, which is caused by a change in the excess air coefficient λ, now ranging from 0.9 to 1.0. Thus, the combustion process becomes similar to the combustion of a stoichiometric mixture, being intrinsically high-temperature.

The steady flight phase continues until the airplane begins the approach to land. As the airplane begins to descend, engine loads can be reduced. By changing the airscrew pitch it is possible to reduce the plane's altitude and velocity without changing the engine speed, which remains constant from the take-off and amounts to 2500 rpm. Lower engine load is followed by lower exhaust gas temperature, now amounting to approx. 900 K. During the landing phase, the airplane's velocity goes down, the flaps are extended and the engine speed is adjusted to maintain the required landing parameters. After landing, the plane taxis and cools down the engine that is subsequently switched off. An analysis of the time parameters of the flight in question (including taxiing after landing and cooling down the engine) shows that the entire operation took approximately 6565 seconds. The durations of all constituent phases were as follows: start-up and warming up – 600s, take-off and ascent to 500 m – 150s, ascent above 500 m – 385s, steady flight – 4167s, approaching to landing down to 740 m – 895s, landing – 228s, taxiing and cooling down – 140s. The duration of each phase served as a basis for calculating its relative share in the duration of the entire flight operation. The results are presented in Table 1.

***Table 1** – Duration and relative share of flight operation phases*

Operation phase	Time [s]	Relative share [%]
Start-up and warming up	600	9
Take-off	150	2
Ascent	385	6
Steady flight	4167	63
Approach to land	895	14
Landing	228	3
Taxiing and cooling down	140	2
Total	6565	100

The test flight during which in-service parameters of the Continental IO-550-N engine were measured took 6565 seconds (or approximately 110 minutes). Assuming that the ascent and approach to landing phases are constituent parts of the flight, the aggregated share of actual flight in the total operation time amounts to 83%. The two sample flights discussed above can surely be considered short and it is reasonable to assume that the flight phase may actually be longer and take up to 3 hours, depending on the pilot's and passengers' condition and on the availability of fuel. Therefore, the relative share of the flight phase can grow up to as much as 90%.

Piston aviation engines used for propulsion purposes constitute part of the propulsion system in charge of generating mechanical energy. The energy generated in the engine is then converted to thrust, generated by the airscrew. By properly arranging these two elements to form a propulsion system based on the engine's general characteristics and the airscrew's propulsion characteristics, it is possible to ensure the airplane's propulsion exhibiting the desired performance characteristics.

The key parameters describing the engine's operating conditions include engine speed and engine load, expressed either as the torque or the mean effective pressure. The engine load is closely related to the airscrew characteristics and the ambient conditions, but its value is unimportant from the perspective of operating the plane, which is why the load is not a measured parameter. The approximate value of the engine's power is assessed depending on the values of other parameters. To assess instantaneous engine power one can use for instance its speed, fuel consumption, air consumption, throttle position, exhaust gas temperature compared to one another by means of a suitable algorithm. In addition, values of the engine speed and values of the excess air coefficient are determined by the fuel supply system settings. Both sets of values were compared in order to propose the equation (1), making it possible to assess the relative value of the engine's effective power.

$$\frac{N_e}{N_{emax}} = \frac{T_{exh}}{T_{exh\ max}} \left(\frac{1}{\lambda}\right)^{2.5} \frac{n}{38.6} \quad [\%]$$

$$\frac{N_e}{N_{emax}} = \frac{T_s}{T_{smax}} \cdot \left(\frac{1}{\lambda}\right)^{2,5} \cdot \frac{n}{38,6} \quad (1)$$

where:

$N_e/N_{e\ max}$ – relative effective power [%],

T_{exh} – exhaust gas temperature [K],

$T_{exh\ max}$ – maximum exhaust gas temperature [K],

λ – excess air coefficient [–], values for flight phases: take-off – λ = 0.8; steady flight – λ = 0.95; other operation phases $\lambda \approx 1$,

n – engine speed [rpm].

Using the proposed equation (1) and the measured in-flight exhaust gas temperature values (upstream of the turbine) recorded by the on-board flight recorder during the actual flight phase (Fig. 3), the relative engine power was determined (Fig. 4).

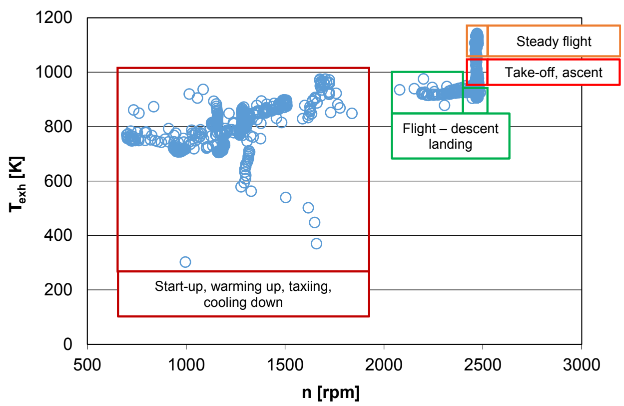

***Figure 3** – Exhaust gas temperatures and their corresponding operation areas*

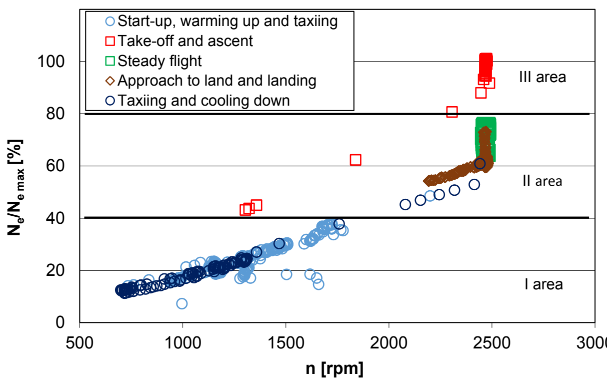

***Figure 4** – Relative effective engine power and their corresponding operation areas*

An analysis of the resultant relative effective power values for different operation ranges of engines powering the Cirrus SR22T (representing newer aircraft) allows one to identify three main ranges of relative effective power. The first range corresponds to engine start-up and warming up, taxiing, landing and engine cooling. Relative engine power values in this range are variable, but do not exceed 60% of the maximum power. Another noticeable operation range corresponds to the steady flight phase, including ascent and descent. For this range, power values vary from 60 to 80% of the engine's maximum power. Finally, the third range corresponds to the take-off phase, whereby the engine works at 90 to 100% of its maximum power.

STATIONARY TEST DESIGN

Verification of exhaust emissions from small aircraft propulsion systems makes it necessary to measure pollution in actual in-flight conditions. For technical reasons, in many general aviation airplanes it is not possible to make such measurements. The key reason is the prohibitively low allowable load and excessively small cargo space, making it impossible to install the measuring equipment. Another difficulty is related to exhaust gas sampling. Therefore, it is necessary to develop a procedure allowing one to measure in-flight performance during a pre-flight test. The pre-flight test is characterized by the fact that it covers all settings of devices affecting engine loads, used in actual operating conditions during the flight.

In order to develop guidelines for a stationary test making it possible to determine engine emissions whose value to some extent corresponds to the actual value, actual in-flight engine loads and their respective durations were determined. On that basis it was assumed that the stationary emissions test would consist of three phases. Phase A – covering engine start-up and warming up, taxiing, landing and engine cooling. Phase B – covering engine operation parameter values recorded during the take-off. Phase C – covering steady flight including ascent and descent, except for ascent right after the take-off.

Based on the determined operation parameters and measured flight durations, the relative times of individual operation phases were calculated in the previous chapter. Relative times of individual operation phases closely depend on the total flight duration; the longer the flight, the lower the share of the first and the second operation states. Flight durations in general aviation usually range between 1 and 3 hours. Therefore, one can assume that the mean operation time of small piston engine aircraft is 1.5 hours (A + B + C = 5400 s), and that assumption was borne in mind when developing the stationary emissions test carried out during a pre-flight trial.

Based on operation points determined in the analysis, operation parameters were identified as relative engine speed and relative power in the test (Fig. 5 and 6). For the distribution of points in the engine operation range for the Cirrus SR22T airplane, the following relative rotational speed and relative power were determined: for point A: n/nmax = 50%, Ne/Ne max = 20%; for point B: n/n_{max} = 100%, $N_e/N_{e\ max}$ = 100% and for point C: n/n_{max} = 100%, $N_e/N_{e\ max}$ = 70%.

The nature of the test is stationary. Therefore, the sequence and durations of all test phases is preset. The phases should be carried out in an alphabetical order (A, B, C), corresponding to the natural sequence of phases in actual aircraft operation. Therefore, the thermal state of the engine will approximately correspond to the actual state. The duration of phase A should be 4 minutes, with 2 minutes for phase B and again 4 minutes for phase C.

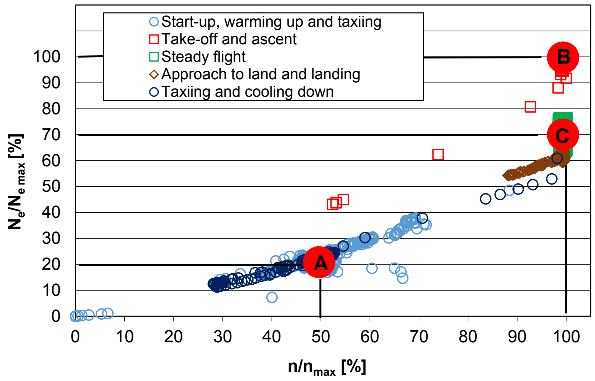

Figure 5 *– Proposed engine operation parameters for individual phases of the emission test for Cirrus SR22T*

Table 2 *– Test points coordinates*

Test phase	Airscrew design		Phase share coefficient
	n/n_{max} [%]	$N_e/N_{e\ max}$ [%]	
A	50	20	0.155
B	100	100	0.045
C	100	70	0.800

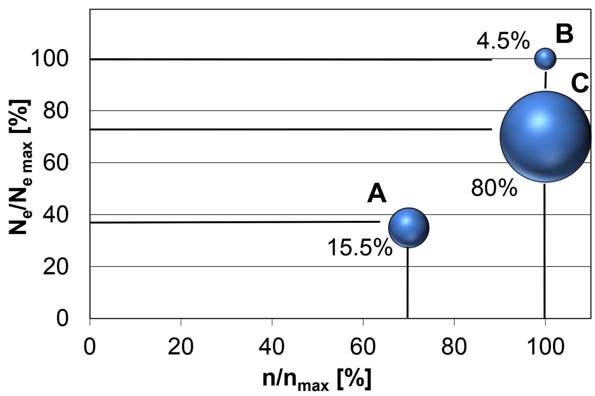

Figure 6 *– Values of engine relative speed and relative power together with phase share coefficients*

The duration of phase B whereby maximum in-flight values corresponding to engine loads during the take-off are tested is preset at 2 minutes because in the case of a longer operation at such parameters the engine may be overheated and damaged as a result. Measurement of concentrations of individual toxic compounds in the exhaust gases should be made after all performance parameters have stabilized. Therefore, it is recommended that emission concentrations should be measured in the last minute of the test phase in question.

TESTING EXHAUST GASES FOR TOXIC COMPOUNDS IN STATIONARY CONDITIONS

The content of toxic compounds in the exhaust gas of small aircraft engines was tested on the ground for the Cirrus SR22T. The content of toxic compounds in the exhaust gas of the engines of the tested airplanes was measured on the ground during a pre-flight test. In a standard aviation operation one can identify several phases: taxiing to the runway, take-off, ascent, steady flight, approach to land, landing and taxiing to the apron. Depending on the flight in question, the relative duration of each phase may vary. The study included a pre-flight test whereby the values of operation parameters matching the proposed test phases were considered. For all operation points characterizing the phases A, B and C, the positions of engine controlling devices and airscrew pitch corresponded to their positions in in-flight conditions.

To measure the concentration of toxic compounds in exhaust gases, Sensors's Semtech DS exhaust gas analyzer was used. The analyzer makes it possible to measure the concentration of carbon monoxide, nitrogen oxides, hydrocarbons and carbon dioxide. Additionally, it is fitted with a flow meter used to measure the exhaust gas flow rate (by mass). An exhaust gas intake probe is an embedded feature of the flow meter. Due to the limitations of the measurement system it is not possible to measure exhaust gases in temperatures beyond 700oC. Therefore, to carry out the test the exhaust pipes were extended to reduce the temperature to acceptable levels (Fig. 7). The exhaust system was extended by 4 meters. As a result, the measurement of toxic compounds concentration took place in a location allowing one to install and secure the measurement probe and the flow meter.

***Figure** 7 – Location of the exhaust gas intake probe during the tests*

Measurement of toxic compounds contained in the exhaust gas from aviation piston engines carried out in stationary conditions typical of pre-flight tests included measurement of carbon monoxide, hydrocarbons, nitrogen oxides and carbon dioxide. The exhaust gas mass flow rate was measured as well. The following engine parameters were analyzed: engine speed and exhaust gas temperature. All parameters were measured as a function of time, at a frequency of 1 Hz. As a result, concentrations of each compound as a function of time were obtained. Based on instantaneous concentrations of each pollutant and the mass flow rate, the instantaneous emission rate for each compound was determined as well. All functions were subsequently divided into sections corresponding to operation phases. Mean values of recorded concentrations were calculated for each phase. Instantaneous emission rates for each phase were aggregated to obtain the total mass of a compound emitted during that phase. Subsequently, bearing in mind the duration of each phase, the average hourly emission of toxic compounds for individual phases was determined. The division of recorded changes in the measured values into operation phases was carried out bearing in mind changes in the operation parameters.

Measurement results were presented in table 3, results of mean hourly emissions of measured toxic compounds in a pre-flight test (Fig. 8).

***Table 3**– Measurement results of toxic compounds emission in a pre-flight test*

Parameter	Operation phase			
	start-up	taxiing	take-off	steady flight
Engine speed [rpm]	–	1600	2700	2700
Duration [s]	82	95	98	81
Mean concentration:				
CO [%]	5.39	8.19	10.20	7.18
HC [ppm]	702	176	1532	610
NO_x [ppm]	172	243	119	65.9
CO_2 [%]	7.01	8.87	7.60	7.12
Mass [g]				
CO	523	1316	2642	338
HC	9.69	9.81	15.8	14.8
NO_x	2.59	5.80	4.58	0.52
CO_2	1070	2241	2995	564
Hourly emission [g/h]				
CO	22943	49876	97070	15004
HC	426	372	579	660
NO_x	114	220	168	23.2
CO_2	46968	84929	110026	25083

Mean hourly emission values in each operation phase depend on the engine's capacity, current condition, design and the capacity-to-power ratio. For reasons presented above, those values are not readily comparable amongst one another. However, the resultant mean hourly emission of each individual compound ascribed to individual operation phases of the engine makes it possible to determine specific emissions. In order to do so it is necessary to take into account the mean engine load in a given operation phase.

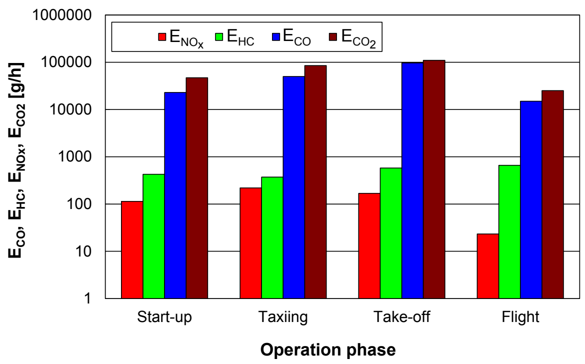

Figure 8 *– Mean hourly emissions of toxic compounds measured in a pre-flight test*

TEST-BASED EMISSION ASSESSMENT

The comparison of emissions from engines of differing designs is possible with the use of values correlated with the engine's power. Therefore, specific emission of each compound expressed in g/kWh is used as the unit of comparison. By reference to the characteristics of the engines used in the selected airplanes, engine power values in each test phase were determined. Subsequently, based on the power value corresponding to the phase in question and the hourly emission value for each compound, specific emission values were calculated (Table 4).

Table 4 *– Mean emission rate and specific emission of toxic compounds from the engine of Cirrus SR22T*

Parameter	Test phase		
	A	B	C
Engine power [kW]	47	233	163
Hourly emission [g/h]			
E_{CO}	36409	97070	15004
E_{HC}	399	579	660
E_{NOx}	167	168	23
E_{CO2}	65949	110026	25083
Specific emission [g/kWh]			
e_{CO}	781	417	92.0
e_{HC}	8.55	2.48	4.05
e_{NOx}	3.58	0.72	0.14
e_{CO2}	1415	472	154

The resultant specific emission values for each test phases were multiplied by the respective phase share coefficients in accordance with the following formula:

$$e_j = \frac{\sum\left(E_{ji} \cdot u_i\right)}{\Sigma\left(N_{e,i} \cdot u_i\right)} \quad \text{[g/kWh]} \tag{2}$$

where:

E_{ji} – hourly emission of the j-th pollutant of the i-th test phase [g/h],

u_i – share coefficient of i-th phase of the test [–],

$N_{e,i}$ – engine power in the i-th phase of the test [kW];

thus obtaining specific emissions in the proposed test (Table 5).

Table 5 *– Specific values of toxic emissions for the selected airplanes in the proposed emission tests*

Specific emission determined in the test [g/kWh]			
Test phase	A	B	C
$N_e/N_{e\ max}$ [%]	20	100	70
Phase share	0.115	0.045	0.800
e_{CO}	141		
e_{HC}	4.10		
e_{NOx}	0.31		
e_{CO2}	221		

CONCLUSION

It needs to be stressed that the emission test in accordance with the proposed procedure can be carried out for the purpose of assessing the emission of pollutants and the technical condition of airplanes. However, to be able to obtain information on operational and environmental performance of aircraft propulsion systems it is necessary to determine the allowed specific emission limits for each pollutant contained in exhaust gas. The Authors' attempt at assessing specific emissions of pollutants in exhaust gas from piston engines used to power small aircraft is aimed at determining the environmental impact of general aviation aircraft. Therefore, it requires an assessment of the actual operating conditions of those engines, as well as measurements of specific emissions in such conditions. To do so, the specificity of their operation must be addressed. On the basis of the Authors' publications, studies and analyses one can conclude that the proposed simplified stationary test for general aviation reflects – to some extent – actual in-flight conditions and can therefore be used in studies involving a larger number of aircraft in order to determine their environmental impact. The said procedures can be accelerated by simplification of procedures (e.g. the use of emission models for aviation piston engines).

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FROM HUMAN ERROR TO COMPLEXITY:

TRANSFERABILITY OF WESTERN BASED APPROACHES

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Abstract *– The study of human error has changed dramatically in the last thirty years, with a move from blaming the 'man' towards a complex interaction between the man, system and organization. Behavioural and cognitive approaches have met engineering, with the creation of various models to explain and identify what went wrong. This in turn has led to more prescriptive safety developments and complexity. With continued globalisation of aviation and other high risk industries, the need to develop a proactive approach has led to further developments and the move towards resilience, as we have entered into Hollnagel's (2014) safety II era. This paper will give an overview of this development, identify potential issues with the current approach, potential problems with direct transfer to the emerging dynamic market economies and highlight the importance of cultural factors.*

Key words – human error, automation, bureaucratization, culture

INTRODUCTION

The concept of human error is well known and with a long history, we are all familiar from our childhood lessons in the classics of with the expression "*to err is human*" a saying attributed to Seneca the younger (4 B.C. to A.D. 65) and also a similar thought by Cicero: "*Cuiusvis errare: insipientis nullius nisi, in errore perseverare*" (Anyone can err, but only the fool persists in his fault) (The Latin Library, 2014). Regularly the expression human error appears in the newspapers and television.

"*How human error can cause a plane crash*" (Haq, 2013).

"*More than 90 percent of road accidents are caused by human error. We, therefore, have to focus on people in our traffic safety programmes*," (Goos, 2011).

"*At least 44,000 people, and perhaps as many as 98,000 people, die in hospitals each year as a result of medical errors that could have been prevented*" (Kohn, et al., 1999).

It is widely acknowledged that human error is responsible for the majority of accidents and incidents worldwide and this led to the process of identifying who was to blame and then how to stop this happening again. One of the earliest approaches was in 1918 by Vernon who developed a single factor model of accident proneness and concluded that accidents are very largely due to carelessness and inattention (Vernon, 1918 as cited in (The Lancet, 1920) i.e. human error.

The traditional approach has been to work on the human to make them more alert and aware through a process of training, supervision, rules regulation and of course, punishment (Hollnagel, 2014), this approach was first proposed by Vernon (The Lancet, 1920) and has been used around the world as a safety improvement exercise. In 1987 in Denmark a campaign to reduce fatal agricultural accidents was instigated by farming journal articles, seminars and road shows, this resulted in a reduction in the number of fatalities by 50% for that year this was followed by a rapid rise in accident the year later, this cycle repeated itself until in 2002 the latest tractor technology was introduced that resulted in a reduction in the fatality rate (Jørgensen, 2008). This approach of "bad things happen to bad people" is referred to as the just world hypothesis (Reason, 2000), but accidents rarely are the result of one single action or event. Rather, errors occur as the consequences of the interaction between the organisation, design of procedures and equipment, with known patterns of human cognitive behaviour (Reason, 2000). So it would seem that error is programmed into human behaviour, but error in itself, is not intrinsically bad, we bring our ability to adapt and be flexible and sometimes we learn by 'trial and error' (Hollnagel, 2014).

The more modern view of human error is that "*human error is systematically connected to features of peoples tools, tasks and operating environment*" (Dekker, 2002). This new view, to identify the interaction between the human and the system, their assessment and actions within the broader environment creates challenges for those seeking to identify the cause of the system failure and often leads back to "*blame the man in the machine*", the challenge is that "*the reconstruction of the mindset begins not with the mind. It begins with the circumstances in which the mind found itself.*" (Dekker, 2013, p. 53). Accepting that humans are by nature fallible and thus one must expect errors, leads to the modern approach of creating protection within the system to trap errors and make a more resilient system (Reason, 2000).

The investigation of human error provides many challenges with multiple approaches available and this opens, for investigators, the risk of "*What-You-Look-For-Is-What-You-Find*' or WYLFIWYF principle" (Lundberg, et al., 2009). For an analysis of human error it would be conventional to start with a definition, but there is no single agreed definition of human error and practitioners have in their definitions, have achieved a "WYLFIWYG" version. Swain and Guttman (1983) as cited in (Whittingham, 2004, p. 3) define this as "an error is an out of tolerance action, where the limits of tolerable performance are defined by the system"; interestingly suggestive that errors can occur that remain with an acceptable tolerance. Hollnagel's viewpoint is that we can all have different understandings of what is human error, it could be a breakdown in the cognitive process of the actual action or in the planning, doing nothing or carrying out the wrong sequence (Hollnagel, 1993). Whilst Reason's (1990) approach to his well-known definition is via a sequential model:

"A generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to some chance agency" (Reason, 2000).

Thus the only way to decide if an error occurs is to compare the outcome against what was initially intended to occur. This post hoc judgment is in itself flawed, e.g. the intended outcome may be achieved but with errors along the way, which were mitigated, allowing the successful outcome; yet human errors did occur and this illustrates the difficulties in identifying human error. Further, all the leading work has been driven from the established western view of safety with little modification for other cultures.

SAFETY COMPLEXITY

Over the years the approach to human error and man's role within safety has evolved and our thinking to how we can prevent or better to reduce the likelihood of error within system has matured. We have come a long way from blaming culture of naming and eliminating that erroneous prone persona, to a more complex approaches that favours "*system thinking*" rather than explaining it in terms of pure human fallibility, which in truth is an intrinsic part of man. The unwritten approach in today's safety driven thinking is "making" a resilient system and with our current knowledge and understanding it would appear a worthy direction.

BUREAUCRATISATION OF SAFETY

Are we becoming too bureaucratic and prescriptive? Are we restraining the great ability of humans, that of adaptability, of "*a creative thinking*" by our over relying tendencies that has crept into safety? Bieder and Bourrier (2013) as cited in (Dekker, 2014) have questioned if the constant development of never-ending proceduralisation in aviation is desirable or avoidable. Has this led to pilots who are incapable of dealing with unexpected events? As operators implement SMS, LOSA and other safety programmes to improve safety, manufacturers also strive to reduce the risks with greater and more advanced automation and thus leads to operators creating more procedures. Further as this drive to create written procedures and the quantification of safety performance (Flight Data Monitoring (FDM)) has led to pilots reducing their risk of showing any error by becoming more reliant on automation (Dekker, 2014)(Fig.1).

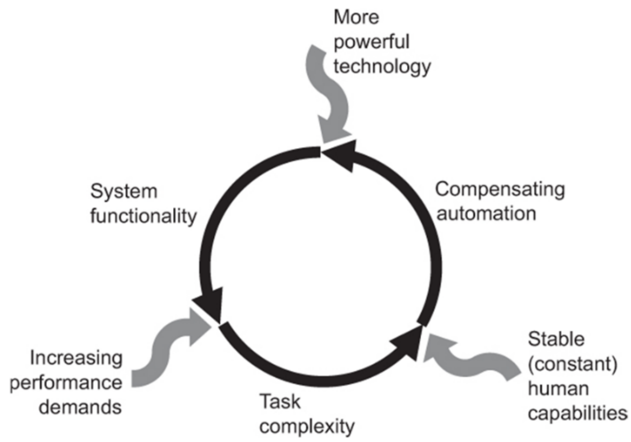

Figure 1-Self-reinforcing cycle of technological innovation (Source: Hollnagel, 2014)

THE AUTOMATION TRAP

The development of automation to compensate for human capabilities has also brought with it an ample amount of prescriptive rules, which we often follow to the letter, depending on our culture. Manufacturers endeavour to design safe and efficient aircraft, produce procedures for pilot and maintenance staff that are safe and effective and constantly provide updates to react to the operational experience. The question that appears to been overlooked is how well does this transfer across cultures? Hofstede's seminal work (Hofstede, 1980, as cited in Dastmalchian, et al., 2000) (Dastmalchian, et al., 2000), initially identified four dimensions that measured certain values or dimensions of national culture that he defined as "*the collective programming of the mind distinguishing the members of one group or category of people from another*" (Hofstede, 2014) (Hofstede, 2014). These initial four measures (or dimensions) are imprinted on the individual from birth and development within their society and are: individualism versus collectivism; power distance; masculinity versus femininity and uncertainty avoidance. The validity and usefulness of these dimensions has been proven by many other researchers who have either added or adapted to the original dimensions (Grove, 2005).

Power distance (PD), is a measure of how the less powerful members of a society accept that power is distributed unequally (Hofstede, 2014). One of the first works on pilot culture that systematically assessed more than fifteen thousand pilots in over twenty countries (Helmreich & Merritt, 1998 as cited in (Helmreich, et al., 2001) revealed major differences in their attitudes about automation, pilots from high PD cultures being "more positive about automation and more likely to use it under all circumstances" (Fig. 2) (Helmreich, et al., 2001).

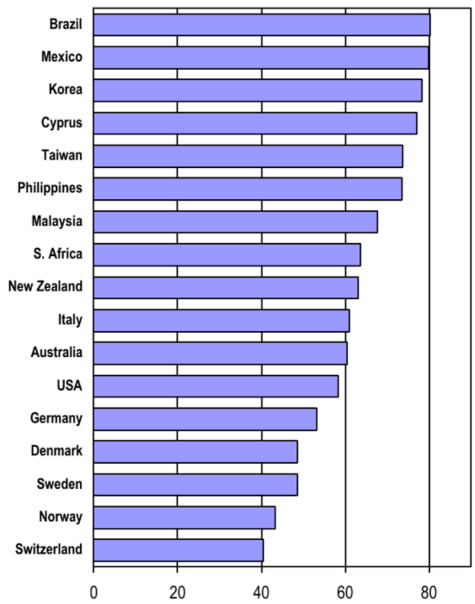

Figure 2 - Automation Preference and Reliance Scale Source (Helmreich, et al., 2001)

This factor may be reflected in the Asiana flight 214 (6 July 2013) crash in San Francisco, with:

"*Over-reliance on automated systems and the complexity of flight systems contributed to the crash of Asiana flight 214 on 6 July 2013*", (National Transportation Safety Board (NTSB).

It should be noted that Asiana Airlines is South Korean and scores high in terms of PD (Fig.2).

In 2012 Airbus reported several in-service occurrences that drove a need to make changes to automation to ensure that aircraft did not take off with less than the required thrust (Airbus Industries, 2012). Despite the current system providing a warning to pilots that:

"ENG THR LEVERS NOT SET"

With the expected pilot action to simply advance the thrust levers from FLEX/MCT to Take-Off Go-Around (TOGA) position (Fig.3), this was not occurring and now the system will automatically give TOGA power after 8 seconds.

Figure 3- Airbus Thrust Levers

These new occurrences may have their origin from the cultural dimension of uncertainty avoidance (UA), that is defined as the "*extent to which the members of a culture feel threatened by ambiguous or unknown situations*" (Hofstede, 2014), i.e. a need for written rules and procedures. The cultural variation across a wide range of pilots can be seen in the following (Fig.3), the higher the score the greater the cultural need for having "written procedures for all situations (Helmreich, et al., 2001).

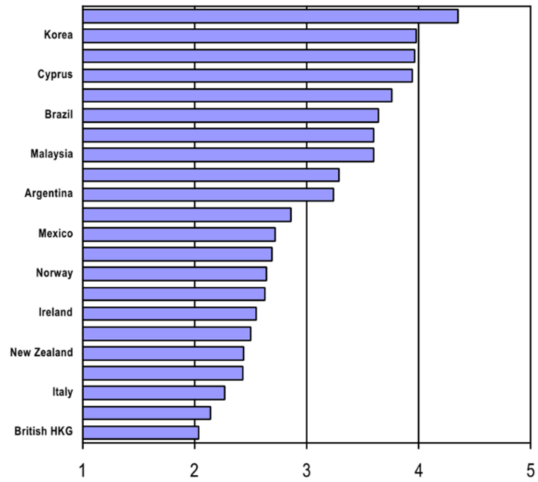

Figure 4 - 'Written procedures are required for all in-flight situations.' (Helmreich, et al., 2001)

Organisational Interaction

Three major functionally related, generic forces can be identified as driving the behaviour of the staff within any organisation, these are culture, structure and processes. Structure is simply the formal organisation and how authority and accountability are distributed, this incorporates communication and co-ordination across the organisation at all levels. Processes are simply the activities that produce the service across the organisation, they cross departments and enable the identification and separation of responsibilities. Finally, culture, the complex collection of beliefs, values, that includes the national and societal cultures (Guldenmund, 2000). These form a dynamic interaction with behaviour as the observable outcome (Fig. 5), that in many ways advances the paradigm 3 approach (Meyerson & Martin, 1987), incorporating the dynamic response to culture and the potential to use structure and processes to create a desired behaviour

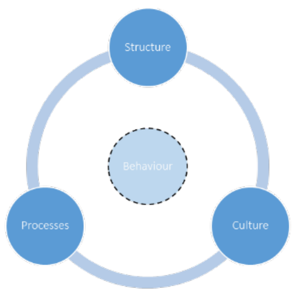

Figure 5- The Organisational interaction (Modified from Guldenmund, 2007)

With a combination of bureaucratic and prescriptive processes, combined with cultural factors, i.e. the need for written procedures for all situations result in the desired behavior?

THE CURRENT PRESCRIPTIVE SAFETY APPROACH

The debate concerning the prescriptive approach often driven by regulation such as SMS has been discussed for some time and in many different areas e.g. its role in organisation learning (Tsang, 1997). Safety schemes have snowballed from the knowledge intensive fields where the aim has its grand objective in relieving the strapped human from ever-increasing complexity, we know our cognitive and physiological limitations and know that while system can get upgrades, we cannot. Man must understand his limitations, as it was subtly phrased by Socrates, "*ipse se nihil scire id unum sciat*" (I know one thing: that I know nothing). This sums our need for constant aids to assist coping with the challenges in this ever-increasing colossus of systems. These aids have developed from simple cards to help us remember steps and procedural orders, to the ultimate step of removing the man out of the system. Training has changed but we have reached a stage where most of our capacities needed to cope with the unexpected are being eroded by the continuous attempts to prepare for the unexpected (Fig.6) (Paries & Hayward, 2014).

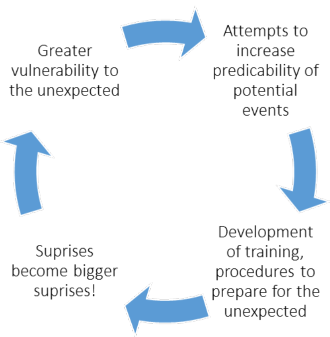

Figure 6- Cycle of Predetermination and Vulnerability (Modified from Paries & Hayward, 2014)

The assumption is not whether it is good or bad to have achieved such a great reliance on prescriptive approaches, there is neither need nor want to eliminated or abolish the prescriptive element entirely, but rather identify what works and what needs to be modified. Further, can we export these outside the "western" world, when one considers even within Europe we can have large cultural differences (e.g. Uncertainty Avoidance) (Hofstede, 2014).

LESSONS FROM AF447 ACCIDENT (1 JUN 2009)

The causal chain of the Air France 2009 accident, paints a picture of an unpredictable manner of pilots performance. We assume competencies and predictability of behaviour on the sides of both the aircraft designers and the crew in command. The accident report findings highlighted that:

"*The combination of the ergonomics of the warning design, the conditions in which airline pilots are trained and exposed to stalls during their professional training and the process of recurrent training does not generate the expected behaviour in any acceptable reliable way*" (Bureau d'Enquêtes et d'Analyses (BEA), 2012).

The causes that were listed by BEA reflect the startling dominance of failures in cognitive perception of the crew from a major European airline, is this indicative of how the cycle of predetermination and vulnerability (Fig.6) is emerging in the industry?

GLOBALISATION AND THE EXPORT OF EUROPEAN EXPERIENCE

Aviation is a global market, the emerging markets, with their strong economic growth, large populations and growing middle- classes, continue to drive the aviation market place, the need for aircraft, airports, pilots and technicians is a demand that is hard to be fulfilled. Overall, China and the Middle East, continue to grow faster than the global average, with double-digit traffic growth and with Asia-Pacific forecast to become of even greater significance in terms of new aircraft deliveries (Airbus, 2014) (Boeing, 2014).

OPPORTUNITIES

A wealth of opportunity exists for European business, IT infrastructure and connectivity prove challenging in developing economies and it is highly likely that a greater number of airlines in these economies will enter the market for IT solutions (Boeing, 2014). Development of at least 70 new airports in China with a further commitment to develop core international hub airports, trunk routes and secondary regional airports. In total, China's Civil Aviation Authority is expected to commit more than $4.25 trillion over the next five years (EC Harris, 2014). This will lead to the need to develop Air Traffic Services, Airport management and ancillary services with a major training need as well as expat staff. The 2014 Boeing Pilot and Technician Outlook projects "*that 533,000 new commercial airline pilots and 584,000 new maintenance technicians will be needed to fly and maintain the world fleet over the next 20 years*" (Boeing, 2014). This will lead to the need to create new training centres to supply the demand located closer to the emerging markets and opens the potential for "Joint Ventures" (JV) between established European companies and those in the emerging markets.

Regulators may also develop into this new challenge, the UK Civil Aviation Authority International (CAAi) has shown how well established and experienced regulators can develop a business model helping developing Authorities to cope with the rapid expansion and remain safe.

SUMMARY

As we have highlighted a shift towards the new global markets will lead the export of European expertise, training, procedures etc. into new cultures. The risks that must be addressed are those of gaining correct transference of this proven expertise. As demonstrated, both Airbus and Boeing have identified the need to adapt to these new markets (Airbus Industries, 2012)(National Transportation Safety Board (NTSB).

As we have discussed many of today's safety strategies are based on a concept of total control and simplification which is an illusion of reality. Complexity demands a shift from anticipation and predetermination, away from central hierarchy and focus on what allows sustained adaptability and success; to break the cycle of predetermination and vulnerability, the move to resilience. This goal of resilience is the "*intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions*" (Hollnagel, 2014).

Thus, if the aviation industry is to remain safe and meet the new demands, there is an urgent need for those companies expanding into new markets, to gain a deeper understanding of the culture of partner organisations. Make use of a suitably experienced and qualified human factor specialists who can provide suitable tools to measure: cultural factors, readiness for organisational change, commitment to change and the resistance to change, as proposed by Blackman et al., (2014) (Blackman, et al., 2014). Further, a great insight into the need for cultural factors training for senior staff, marketing consultants etc., will be needed. By understanding culture, we can adapt training packages to meet the needs of the emerging markets, develop programmes that reduce the likelihood for error and failure by increasing resilience.

Finally, it is proposed that manufacturers should partner with universities and experienced cultural factor consultants to identify new training approaches that mitigate cultural factors, designed to break the cycle of predetermination and vulnerability. This would open the potential for this work to be part funded by the EU and would prove to be a major leap forward for safety and European businesses in the new developing economies.

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AIRPORT SLOTS AND SLOT ALLOCATION: DRIVER FOR MISMATCH BETWEEN AIRLINE NETWORK AND CITY NEEDS?

THE CASE OF ROTTERDAM THE HAGUE AIRPORT

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Abstract – *Aviation increasingly faces capacity challenges exposing inefficiencies and shortcomings of aviation related processes and systems. The European slot allocation system was designed in an era with little to no capacity constraints, now resulting in regulations not fitting in today's developments. The main actors taken traditionally into account when studying the system are the airlines, the coordinator or an airport. The region, of which the airport is part of, is never discussed. This article examines links between the slot allocation system and a region and it stresses whether there is a mismatch between the airport function and the needs of a region. To illustrate the potential mismatch in airline network and regional needs, the case study of Rotterdam The Hague Airport (RTHA) is used. The airport is designated as business airport, but according to Rotterdam is not serving the desired regional business needs in terms of destinations.*

Key words – airport, slot, capacity, mismatch.

INTRODUCTION

In 1993 IATA published worldwide scheduling/slot guidelines [6] on which the EU eventually based their slot allocation regulation. With updates and revisions on both the guidelines and EU regulation the slot allocation system developed into today's standard. However, the aviation industry has changed and the aviation industry increasingly faces capacity challenges with Europe as hot spot due to its mature air transport industry. Most capacity challenges emerge at airports (either terminal, gate or runway capacity) or at flight paths. With increasing demands and scarce capacity, users apply pressure on systems, like the slot allocation system, which results in inefficiencies and shortcomings.

An airport slot is currently defined by IATA as; *the scheduled time of arrival or departure available for allocation by, or as allocated by, a coordinator for an aircraft movement on a specific date at a coordinated airport. An allocated slot will take account of all the scheduling limitations at the airport e.g. runway(s), taxiways, aircraft parking stands, gates, terminal capacity (e.g. check-in and baggage delivery), environmental constraints, surface access etc.* [7]. Given this definition of a slot one can see the importance of such slot for the coordinator, airline and airport. All three stakeholders greatly benefit from the slot allocation system enabling them to run an efficient and structured operation.

Nonetheless, airport slots and its allocation system have ever since been used, discussed, developed and researched. Especially topics such as the *use-it-or-lose-it* rule, *grandfather rights* (Sieg, 2010) and the allocation of new/freed *slot capacity* (Starkie, 1998) are subjected to research. Furthermore the differences between *incumbent airlines* and *new entrants* for allocating slots (Fukui, 2012) and other slot allocation *strategies* (Madas, 2006) are already examined. A large regional airport (1M to less than 5M passengers per year [13]) is often an important asset to a region or city, both gets profit from one another, assuming the regional needs are served by the airline(s). However, one can question if the airline(s) are always aware of the regional needs. Especially if the large regional airport is located in the vicinity of a large community airport (10M and more passengers per year [13]) as is often the case in Europe, regional needs tend to be neglected by airlines as the regional airport used to compete with the large community airport. Mainly due to the scarcity of slots it is worth examining how the current system works and behaves. Scarcity increases the importance of slots and although slots are primarily used to optimise capacity, it can become a leverage and competition tool as well. This possibility also applies to regional airports becoming more a competition tool for airlines than an additional asset to its region and perhaps the large community airport.

SLOT ALLOCATION – THE CASE OF ROTTERDAM THE HAGUE AIRPORT

In 2006 the Rotterdam municipality requested to examine possibilities of improvements in terms of involvement and influencing power of RTHA by the municipality and the (partial) privatization of Schiphol Group (PLC) by the government. Since RTHA is part of Schiphol Group it would also be subjected to this possible privatization. Stated is that RTHA (classified by the EU as a large regional airport [13]) has a significant economic link for the region and that if privatized, the municipality would lose options to take care of interests of companies and citizens. Therefore, the (partial) privatization, partly because it seems a precipitated decision, was undesirable.

In the same year a coalition agreement was signed by the city board that stated to increase RTHA's business destinations in the short-term (2010) with five to ten and in the long-term (2020) with 20 to 25. *Flightglobal* cannot provide destination data dating before 2009. Thus it is unknown how many business-oriented destinations were served at RTHA in 2006 [4]. This complication makes it difficult to determine whether they accomplished the increase in business destinations as agreed to in the coalition agreement. Without knowing the numbers from 2006 one can say the short-term objective is accomplished, although it may have been reached after 2010. As for the long-term objective it is clear this one has not been accomplished yet. As displayed in figure 1, 2010 had a total of eleven business destinations and has now grown to sixteen. This should be about 30 or 35 in 2020 according to the agreement. Both the total number of destinations and the non-business destinations doubled in numbers from 2009 until 2014 while the business destinations only increased with about 78 percent.

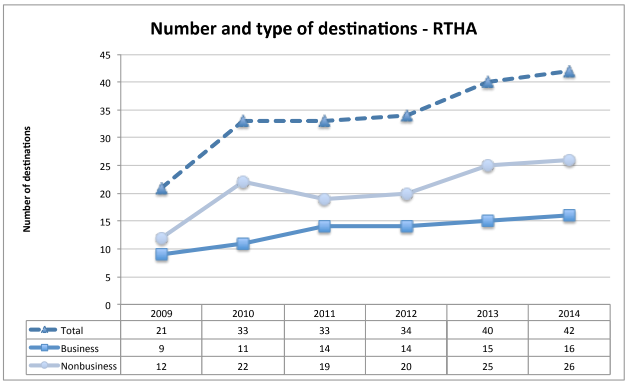

Figure 1 *– Number of destinations from RTHA by type from 2009 until 2014.*

Given the fact that the focus should be more towards business destinations with some additional leisure, governmental or other social necessary flights, one would expect a higher relative increase but as it can be appreciated from figure 2 that is not the case.

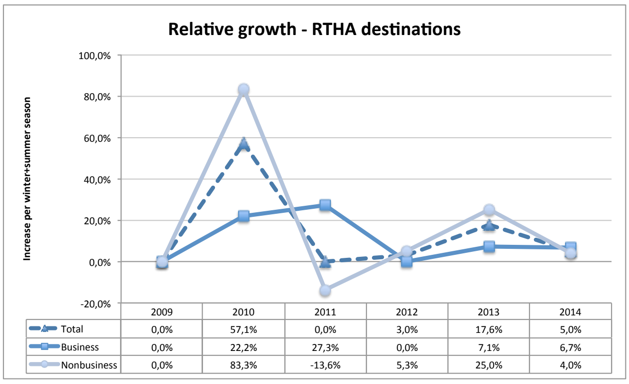

Figure 2 *– Relative growth of RTHA destinations by type from 2009 until 2014.*

Especially from 2009 to 2010 there is a significant increase in non-business destinations relative to the business destinations. This difference has not been gapped since; from 2011 onwards the relative growth remained in favour of the non-business destinations. In 2012-2013 the non-business destinations again gained a significant higher growth in relation to the business destinations as displayed in figure 2. Although developments at the beginning of this year [1] led to more flights from RTHA, again, it was a mix of *British Airways* (BA) flights to and from LCY and more leisure-oriented flights to and from Turkey with *Turkish Airlines*. According to the same news article it appears RTHA has reached its full capacity while last year 19% of its airport slots were not utilized [10]. Nonetheless the news article also states that the airport still wants more business-oriented flights. Clearly there is for some reason a mismatch between the city's needs (desiring more business destinations) and how airlines exploit their network at RTHA. This article stresses to what extent the slot allocation system contributes to this mismatch.

SLOT ALLOCATION – DRIVER FOR MISMATCH?

The ACCESS Consortium report [8] illustrated the role of the stakeholders involved with slot allocation, but also highlighted that there is another 'unofficial' stakeholder: the passenger. As the report stated: *"...they [passengers] are the key actor of the air transportation market. Passengers demand is what airspace users and airports try to satisfy. All business parameters of airspace users (routes operated, schedules, fleet, etc.) and airports (runways, facilities, etc.) are established according to the estimated demand from passengers. Therefore this demand will fully condition the desired slot portfolio of the airspace users."*. The passenger is often situated in a region for either business or private reasons. Thus airspace users fulfil the needs of the region in terms of its *slot portfolio*. However in the case of RTHA a mismatch between the airspace users and the airport in satisfying the passenger demand is apparent as the municipality clearly desires more business-oriented destinations. Also the municipality lacks the power to influence the traffic since it is not allowed to refuse certain traffic or adapt the current slot allocation system by means of a *local rule* due to complicity and legal pitfalls [12]. Furthermore, from a slot allocation point of view, the following inefficiencies described by DotEcon Ltd. contribute to retaining this mismatch [3].

GRANDFATHER RIGHTS

One of the inefficiencies described are the *grandfather rights* airspace users are able to obtain within the slot allocation system. This inefficiency is also related to the lack of clarity regarding to *slot ownership*. Free slots are public entities in possession of the airport coordinator. Allocated slots are still public entities but now in possession of airspace user. If this airspace user operates the slot for at least 80% of the time (80-20 rule), the slot can automatically be obtained for the next equivalent season. At RTHA about 80% of the slots are used by KLM and its subsidiaries or partners. However, AAS is its home base and agreements between Schiphol Group, KLM and the Government state that all mainport related traffic should be kept at AAS. The aforementioned situation results in that all or most of KLM's business-oriented destinations and flights are utilized from AAS. In contrast, other traffic that is considered less important for KLM such as certain leisure traffic of Transavia.com, is preferably situated at Rotterdam, Eindhoven or (in the future) Lelystad. Officially only Eindhoven and Lelystad are appointed as *reliever airports* for AAS. But since KLM owns a significant amount of slots at RTHA, they are also able to *relieve* traffic to RTHA.

Grandfather rights enable KLM to subsequently acquire the slots, possibly hindering competitive airspace users to enter the Dutch market via RTHA. Essentially, they occupy slots that perhaps can be used more efficiently by another airline resulting in higher benefits for the airport as well as for the region. This practice is also known as *babysitting* or *slot hoarding* and the incentive is that, although the slot is perhaps not profitable, it still is more profitable to hold on to the slot rather than loose it and possibly provide the competitors with a slot [11].

ECONOMIC VALUE OF A SLOT

Another problem with the current slot allocation system is that it does not take into account the economic value that an airline can generate with a slot. The coordinator lacks information for determining which airline is able to generate the most (economic) value with a particular slot. In addition, once a slot is allocated it can be used subsequently by an airline due to grandfather rights, the mobility of this slot decreases as well as competition and also the ability to generate more value (babysitting). This inefficiency is basically the fundamental reason why the municipality wants to gain more influence at RTHA. In the municipality's opinion [12], the airport does not fulfil the regional interests as best as possible (see objectives of the coalition agreements regarding business destinations). Therefore the municipality wants to optimize the economic value of slots by making the airport more connected to the regional economy. Measuring the generated economic value for slot (and slot users) is very difficult if not impossible, but according to the destinations the municipality thinks the region will benefit from more business-oriented destinations.

OTHER DRIVERS

Besides the drivers that originate from the slot allocation system, RTHA is also subjected to other drivers that contribute to the mismatch. At first is the fact that Schiphol Group owns AAS as well as RTHA. The downside for RTHA of this situation is that Schiphol Group focuses primarily on developing AAS and RTHA is of secondary interest. Especially when AAS is not utilized at its maximum declared capacity, Schiphol Group might have no intention to look after RTHA more than they do now. AAS is the mainport for Schiphol Group as well as KLM therefore all mainport-related traffic would preferably be served from AAS. This situation results in uncertainty for the municipality of Rotterdam on how KLM will utilize their slots at RTHA. The influence of Schiphol group makes KLM a crucial factor as a driver although it is not part of any decision-making process in RTHA. Furthermore, It is expected that RTHA will become interesting for Schiphol Group and KLM when AAS is operating at their maximum declared capacity, but Lelystad Airport will become a focus point by then since Schiphol Group has decided to use it as a reliever airport (next to Eindhoven airport), which is also approved by the Dutch ministers [5]. Therefore the municipality of Rotterdam faces a challenge if they want to increment the business impact for the development of the region.[2]

Second, for Rotterdam to attract more business traffic, (new) slots at attractive (early morning, late afternoon and early evening) times should be supplied and advertised properly (marketing) towards the desired (business oriented) airlines. On the other hand, the current noise contours and terminal capacity limitations prevent any short-term expansion of new slots. Also, RTHA is geographically encapsulated due to the urbanisation of the region over the years affecting the in- and outbound routes and noise contours [9].

CONCLUSION

The continuous growth in aviation over the last decades and the establishment of a single market in Europe requires more effective capacity utilization at airports as it has been illustrated with the case of Rotterdam The Hague Airport.

In the case of RTHA there is, according to the presented data a clear mismatch between city needs and the airlines' slot portfolio at RTHA. The mismatch is enforced by common drivers from the European slot allocation system such as grandfather rights, economic value and the power of the main stakeholder in the region (Schiphol Group). Furthermore Schiphol Group works as a monopoly of airports in the *Randstad*[2] metropolis and Eindhoven. This monopoly prevents any competition from the other stakeholders that are not currently located at RTHA. In addition, the fact that Rotterdam is encapsulated by urbanisation restricts even more the airport in terms of noise contours. Therefore, the expansion of slots seems difficult in the near future and other solutions should be explored by the region if they want to keep its competitive position in the aviation market. What also should be investigated is the function of RTHA in the case the airport system of The Netherlands is implemented in the mid-term future.

[2] The Randstad is a conurbation in the Netherlands. It consists of the four largest Dutch cities, Amsterdam, Rotterdam, The Hague and Utrecht and their surrounding areas. With a population of 7,100,000 it is one of the largest conurbations in Europe.

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LOW-COST CARRIERS – SWEEPING SUCCESS FURTHER…

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Abstract *– The emergence, expansion and evolution of low-cost carriers over 35 years represent one of the most significant developments in aviation industry. The low-cost airline business model has overwhelmingly been the favoured mode of airline that has caused a fundamental shift in the competitive dynamic of the industry. Fast-paced aviation industry forces the low-cost carriers to change their initial business models. Furthermore, continuing global economic uncertainty in Europe combined with a relatively mature and increasingly saturated market has showed that opportunities for current and new enters in most areas of Europe are limited. Thus, author stresses further opportunities for the expansion of their business to the long-haul low-cost carriers operations. This possibility will be illustrated by Noah's Ark that will cover short and long-haul low-cost operations together. Author also highlights that all actions should be joined with the effort to execute new, effective strategies and subsequently, spreading business over new markets is inevitable to stand out of the crowd in aviation industry.*

Key words – low cost carriers, unit costs, business model, long-haul flight and market share.

INTRODUCTION

Unpredictable and often unstable airline industry is forcing airlines to restructure and subsequently create other flexible strategies to adapt in constantly changing environment. The low-cost carriers appeared in Europe since 1990, when the deregulation process had been spread throughout the European Union. Ryanair and EasyJet followed Southwest business model based on minimising costs as low as possible and revenues based on paying for all ancillary services, such as food on-board, changes of flights.

However, LCCs first arise in England and Ireland in 1995 and they continued spreading its business to the rest of Western Europe, as can be seen in Figure 1. Following mentioned figure, the European LCC's network spread itself more to the tourist areas in the South from 1997. Later, from 2002, their network expanded to Eastern Europe and Scandinavia (Francis et al, 2005).

One of the significant goals of the low-cost airline business model is the strategy to stay profitable and to achieve cost advantages that are related to their competitors. Low cost carriers predominantly operate on short-haul flights, due to the fact that shorter routes offer bigger potential to achieve cost competitiveness over the network carriers. Saturation of the aviation market on short / medium flights forces low-cost carriers to make changes in their business model, and one of the possible ways is to spread business to long-haul operations.

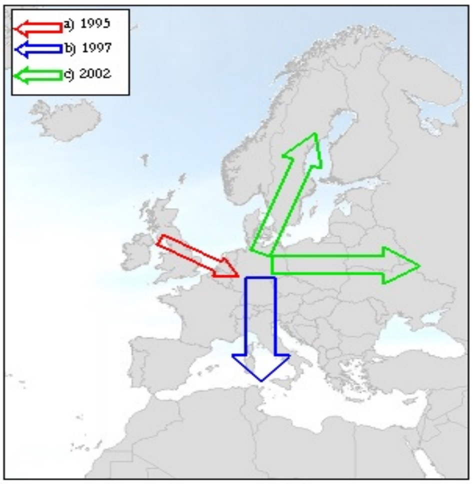

Figure 12 Illustration of the LCCs network (Low-cost carriers in Europe, 2005)

CURRENT POSITION OF THE LCCS IN EUROPE

IATA reported that RPKs have increased about 5.3% **in 2012** where this growth was driven by long-haul, while cargo traffic fell by 1.5%. AEA's RPKs grew by 4.1%, although numbers of carried passenger grew by only 2.2%. ELFAA carried 7.2% more passenger than in 2011.

In 2013, European aviation market shows strong position according to AEA we can see that airlines carried about 0.2% more passengers than in 2012. Moreover, members of the ELFAA reported about 6.7% increasing and also we can see growth of 5.8% in international RPKs as can be seen in *Figure 2 below.*

Figure 2 Comparison of the PAX's growth in RPKs (IATA Statistics)

In addition, in 2013 *Amadeus database* shows that low-cost carriers represents about 19% of total air traffic in Asia, 38% in Europe and over 30% in North America. Despite this, European market is highly saturated due to little opportunities for expansion to new routes, mainly in Western Europe. Ryanair – as the world's busiest international airline according to the WATS 2013 (World Air Transport Statistics) and the opportunities for another expansion are routes over the Europe and across the Atlantic. However, the transatlantic market is highly competitive one with an enormous amount of airlines.

Moreover, Figure 3 illustrates comparison of different period times of selected airlines and their operations. As it can be seen in mentioned figure, every year selected factors rise and also it brings to airlines increasing revenues and profitability.

Airline (Jan-Dec 2009)	**PAX (mil)**	**Average LF (%)**	**Daily flights**
EasyJet	46.1	86	1,050
Jet2.com	3.3	80.3	300
Norwegian	10.8	78	285
Ryanair	65.3	82	1,070
Sky Europe	2.4	73.4	72
Transavia.com	5.2	77	60
Vueling	8.2	72.8	212
Wizz Air	7.8	83.4	146
Airline (Jul 2011-June 2012)	**PAX (mil)**	**Average LF (%)**	**Daily flights**
easyJet	57.4	88.7	1,336
Jet2.com	4.3	85.1	125
Norwegian	16	79	400
Ryanair	77.1	82	1,500
Transavia.com	5.6	78.1	72
Vueling	13.4	77.4	400
Wizz Air	11.6	83.4	243
Airline (Jul 2013-June 2014)	**PAX (mil)**	**Average LF (%)**	**Daily flights**
Easyjet	63.4	90.1	1,190
Jet2.com	5.9	90.7	200
Norwegian	21.5	80	435
Ryanair	82.8	82.8	1,600
Transavia.com	6.7	91	128
Vueling	19.1	78.1	420
Wizz Air	14.5	85.9	302

Figure 3 Comparison of selected airline data [author]

The airline that is highlighted by red colour (Norwegian) will be used for illustration of operational costs due to started long-haul operations since 30 May 2013 – therefore it is relevant to compare related operational costs and research the impact of this operations on economic status of the airline.

LOW-COST LONG-HAUL MODEL AIRLINE BUSINESS MODEL

Long-haul low-cost airline business model is not new attribute that recently started to play important role in current aviation industry. The Association of European Airlines defines a short-medium and long-haul flights. Europe-Middle East and North Africa is medium-haul whilst anything transatlantic is long haul. Long-haul concept of low-cost carriers started in 1977 by Laker Airways – a transatlantic British airline – that operated low-fare scheduled services between London Gatwick Airport and John F. Kennedy Airport and later to Los Angeles and Miami. They provided point-to-point operations with no interline or transfer services. Another feature was represented by high density single class seating and extra costs for any in-flight catering services (Morrel, 2008).

Traditional airlines obtain low seat mile costs and hence offer competitive fares on long-haul services, such as *Virgin Atlantic's* seat mile cost is 43% lower than EasyJet's, although admittedly on a much longer average stage length (Civil Aviation Authority, 2005). Moreover, LCCs on short-haul markets were able to achieve load factors from the 60% to 70% achieved by classical airlines up to around 80%. LFs are already much higher for long-haul carriers, where most of major European airlines exceeding 80% (Francis et al, 2007).

Pros and cons of low- cost application to long-haul flights has been discussed many times. One of advantages is based on the fact that many secondary markets have no existing long-haul service and also provide little competition on point-to-point flights (Bruggen, 2008). Core business of long-haul operations is represented by this basic feature – as distance increases, operating costs rise and unit costs decrease. All of this is linked with increasing fuel costs, maintenance costs, crew cost. Therefore, many airlines solve these costs by offering of higher premium fares, not economy fares, as for initial for short-medium flights. All of this is also linked with decision of the airlines which direction they will lead their business, as it is illustrated in Figure 4 below.

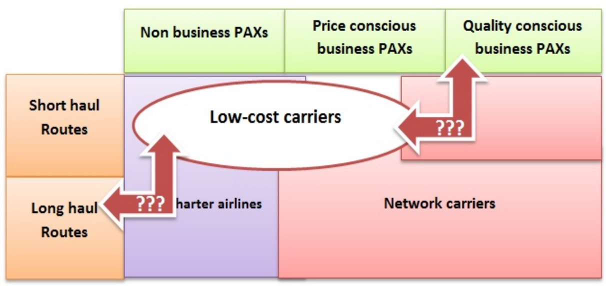

Figure 4 Possible directions of the LCCs [author]

Figure 5 represents enabling and disabling factors related to long-haul operations due to many factors such as, crew requirements, airport facilities and turn times, route density, ETOPS and training differences, etc. Airlines that want to be successful have to realise what they want to achieve and mainly find markets where lower fares than the competition can be profitable.

Enabling factors	Disabling factors
High fares in key markets	Restructured legacies
Availability of quality long-range aircraft	Network alliances / affinity programs
Liberalised route authorities	ETOPS / over flight issues
Customer acceptance of secondary airports	High capital requirement
Regional LCCs building hubs and looking for partners	Labour costs

Figure 5 Factors related to long-haul operations (Wensveen, 2009)

Many carriers have attempted to extend the low-cost model to long-haul flights has attracted many studies, as can be seen in Figure 6. Most of them have failed before starting flight operations and rest of them went bankrupt after three to five years they started their business.

Airline	Year of starting long-haul operations	Status of operations
Laker Airways Sky train	1977	Ceased in 1982
People Express	1983	Ceased in 1987
Zoom Airlines	2002	Ceased in 2008
Oasis Airlines	2006	Ceased in 2008
Jet Star	2006	In service
Air Asia X	2007	In service
Norwegian Long Haul	31 May 2013	In service
Lufthansa Long Haul	Spring 2015	-

Figure 6 Overview of the long-haul carriers [author]

Many studies have been researched about transferability of the LCCs business model to long-haul operations. The overview of selected studies is illustrated in the Figure 7 below.

Author	***Year***	***Purpose***	***Findings***
Francis et al	2007	Cost comparison of traditional LCCs	In large markets LCCs long-haul flights could be possible
Pels	2008	Qualitative assessment of features of LCC BM	In large markets LCCs long-haul flights could be possible
Morrell	2008	Cost advantages of traditional LCCs	Transferability of the LCCs BM doubtful
Wensveen et al	2009	Qualitative assessment of features of airline BM	Low-cost business can survive with innovation process
Douglas	2010	Qualitative assessment of dual strategies of FSNC with their LCC long-haul subsidiary	Viable low-cost business model exists
Morreira et al	2011	Quantitative cost simulation of LCC and FSNC under varying flight distances	Cost advantage of LCC long-haul operations not greater than 10%

Figure 7 Selected studies about transformation of the LCCs to long-haul operations (Daft et al, 2012)

This paragraph deals with comparison of the selected figures that are important for low-cost airline business. Author chooses ***Norwegian*** and key figures, such as number of passengers, load factor and yield for 2012-2014 time periods (Figure 8).

YEAR 2012	**KEY FIGURES**				
	PAX (mil)	*LF (%)*	*CASK (NOK)*	*RASK (NOK)*	*Yield*
Q1	3.65	77	0.50	0.38	0.49
Q2	4.5	76	0.46	0.44	0.57
Q3	5.2	82	0.41	0.48	0.58
Q4	4.35	79	0.45	0.42	0.54
YEAR 2013	**KEY FIGURES**				
	PAX (mil)	*LF (%)*	*CASK (NOK)*	*RASK (NOK)*	*Yield*
Q1	3.9	76	0.47	0.39	0.51
Q2 (May long-haul service)	5.5	77	0.42	0.41	0.53
Q3	6	81.4	0.40	0.41	0.51
Q4	5.2	78.3	0.42	0.35	0.45
YEAR 2014	**KEY FIGURES**				
	PAX (mil)	*LF (%)*	*CASK (NOK)*	*RASK (NOK)*	*Yield*
Q1	4.9	77.3	0.45	0.31	0.40
Q2	6.4	79.8	0.41	0.35	0.44

Figure 8 Overview of selected figures for selected period [author]

As can be seen in Figure 8 above, amount of passengers rise every year due to increased number of connections associated with started long-haul operations. As long-haul operations are more cost-effective in per kilometre point of view, the yield per passenger per kilometre decreased, such as revenue per available seat kilometre. The fact, that these two values changed similarly, points to negligible change in average load factor, which can also be seen in the previous figure. That means that the demand for long-haul flights is similar to demand for short/medium haul low-cost flights.

Moreover, cost gap is also widening for Norwegian in comparison with the biggest competitor – Scandinavian Airlines, as it is illustrated in Figure 9 below.

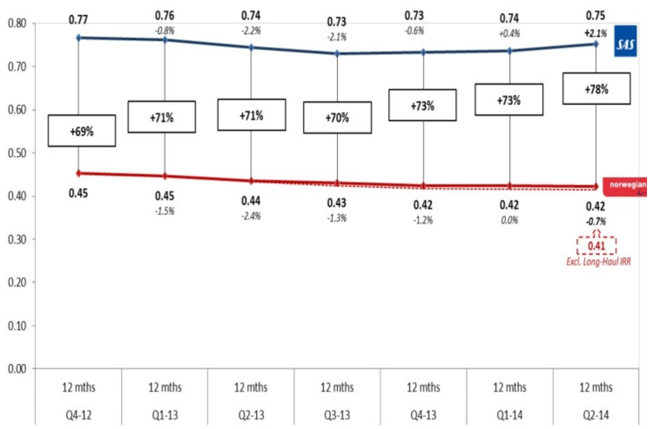

Figure 9 Illustration of cost gap between Norwegian and SAS [Norwegian Report, 2014]

However, unit costs including fuel fall down about 2% in order to weak NOK currency and long-haul wet-lease as can be seen in Figure 10.

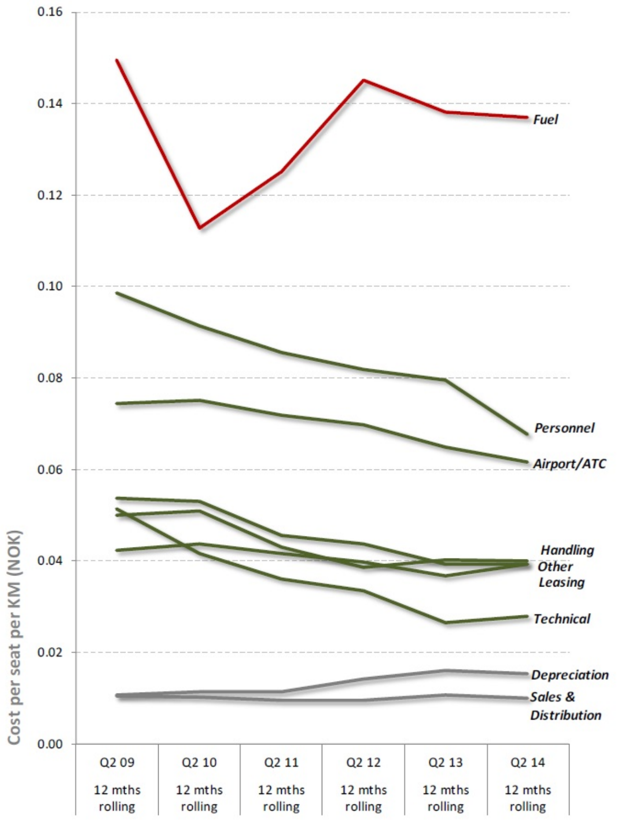

Figure 10 Illustration of unit costs for selected time period [Norwegian Air Shuttle Report, 2014]

NOAH'S ARK APPROACH

Business model can be defined by many ways. The simplest one could sound like any business intends to operate and make money. In airline industry we recognise different business models, such as legacy carriers, low-cost carriers or hybrid carriers. For the purpose of this paper, we will focus on low-cost airline business model. Business strategy of the low-cost airline business model is based on providing services on point to point routes or often using secondary airports. Low-cost carriers have usually markedly lower fares and poor service than network carriers. Therefore, low ticket prices force them to get revenue from all ancillary services, such as food on board, extra baggage, priority boarding, etc.

The question of low-cost airline business model has been researched many times and we can say that just one final approach has been achieved. After deregulation process in 1978 in USA, Southwest airlines set the rule how to be successful – and nowadays, Ryanair and similar pioneers are following that. Nevertheless, the situation has changed since 1967, and mainly passenger's demand and mainly quickly changing environment are determining the need to move forward. European low-cost market is saturated and many airlines went bankrupt or they are in red digits. European is looking for new approach. Professor Doganis suggests new business model called *Noah's Ark* that covers all segments – it means full service (short haul + long haul) and low-cost (short haul + long haul). As an example he gives Singapore Airlines or Air Berlin.

Singapore airlines have a strong presence in the Southeast Asia, East Asia, South Asia and Kangaroo Route markets. Their wholly owned subsidiary *SilkAir* operates regional short –haul flights to secondary cities. *Scoot* operates in the low-cost sector for long-haul flights. *Tigerair* is also a low-cost airline that is Singaporean subsidiary of Tiger Airways Holding and operates services to regional destinations in Southeast Asia, Australia, China and India (Figure 11).

SINGAPORE AIRLINES	*Short-haul flights*	*Long-haul flights*
Network carrier	**Silkair** (Regional)	**Singapore Airlines** (Regional, Medium, Long-haul) + **SIA Cargo and SIA Engineering company**
	• Distinct position on each market segment • Lower risk of cannibalisation	
Low-cost carriers	Regional LCC partner **Tigerair**	**Scoot** (medium and long-haul)

Figure 11 Illustration of Noah's Ark by SIA example [author]

Singapore Airlines is one of the aviation industry's most cost effective operators. Its CASK (costs per available seat kilometre) was just 4.58 cents in 2001-2009 time periods. In comparison with costs for network European airlines it was 8-16 cents, for American airlines 7-8 cents and for Asian airlines 5-7 cents (Wirtz et al, 2010). They also have delivered positive financial returns since its establishment in 1972 and they never had an annual loss.

SIA (Singapore Airlines) combine incompatible strategies of differentiation that is linked with excellent service and continuous innovation followed by cost leadership. SIA's dual strategy is followed by 4 components:

1. Cost-effective excellent services
2. Innovations (both centralized + decentralized manner)
3. Tracking new technology (both leader + follower)
4. Standardization and personalization in all services.

Combination of mentioned components makes a strong leader on aviation market. They achieved a stellar reputation over the past 4 decades in the tempestuously competitive commercial aviation business by providing high-quality services for passengers on one side, and dominating the business-travel segments on other one.

LUFTHANSA'S APPROACH TOWARDS THE LONG-HAUL OPERATIONS

Deutsche Lufthansa is the largest airline in Europe according to the overall passengers carried and its fleet size on one side and in combination with its subsidiaries on other one. The long-haul plan could be a big shift for the company which prides itself to stay a full service airline, but it is interesting to take the challenges that Lufthansa faces to, even the threats are everywhere – Middle East carriers expand themselves aggressively on long-haul flights, LCCs are luring customers in short-haul market and cargo markets stagnates.

Mr. Spohr described Lufthansa's goals based on the structure that consists of *the needs of customers, employees and shareholders* in order to be the benchmark again. All mentioned attributes are also linked with young aircraft fleet, financial stability and market positions (CAPA, 2014). Indeed, interaction between this features needs to be optimized and also balanced with each other to achieve specified goal. Figure 12 and Figure 13 describe the prediction of Lufthansa's Group expansion towards point-to point platform which will also participate in growing leisure market.

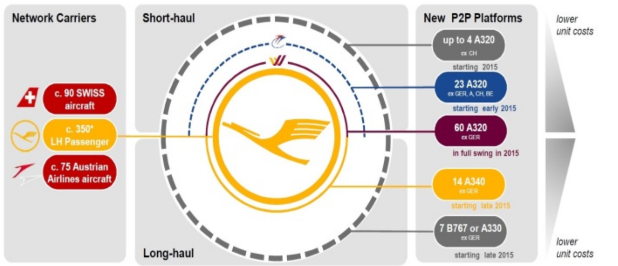

Figure 12 Illustration of Lufthansa's expansion on long-haul market (CAPA, 2014)

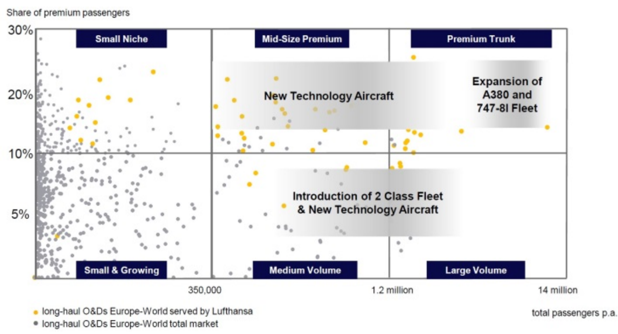

Figure 13 Illustration of the long-haul markets served by Lufthansa (CAPA, 2014)

Lufthansa looks for new concepts for growth. As it is known, private travel is growing faster than business travel and also accounts for a significant share of the market. Therefore, Lufthansa focuses itself on a greater share of private travel. *Wings brands* are core feature that Lufthansa wants to build on. Germanwings will continue its expansion with the transfer of non-hub Lufthansa routes that should be completed by spring 2015. Also, Eurowings' operations to its home countries, such as Austria, Switzerland and Belgium will start in early 2015 firstly with a base in Basel and later in another bases what will be under later consideration.

The future direction of Lufthansa's *Wings family* is presented in Figure 14 below.

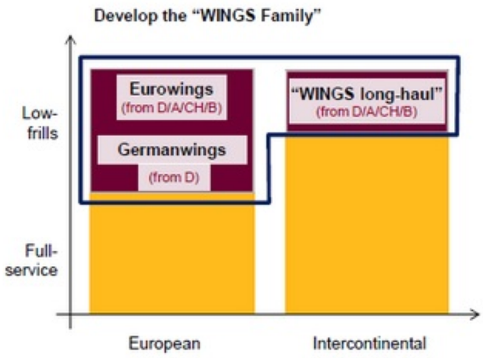

Figure 14 Segmentation of the product on market (CAPA, 2014)

Following Figure 14 above, *Germanwings*' plan is based on the transfer of non-hub Lufthansa's routes (as it is planned by spring 2015) and also expanding fleet to up to 60 aircraft). In the case of *Eurowings ex-Germany* the main goal is based on replacement of aicraft Bombardier CRJs by Airbus A320s. *Eurowings ex-Austria, Switzerland and Belgium* is linked with the first base in Basel and subsequent opening of other bases according to achieving the mentioned goals. *Wings long-haul* operation will be presented under a new brand name and services will be started at the end of 2015 by B767s and A330s aircraft fleet.

Conclusion

Long-haul low-cost operations are interesting and dangerous challenge for low-cost segment. On the other hand, many carries, not even Asian, decided to accept it, but also European do not want to stay one step backwards. Norwegian started long-haul operations in May 2013 and the demand for flying on long-haul flights is similar as it is on short/medium haul flights. Indeed, it is soon to make any statements about success due to relatively short period of time in service. Other attempts from European airline – Lufthansa - will follow Norwegian's example. Also joint operation with Turkish Airlines is possible, but Mr. Spohr also said that Lufthansa is able to start this kind of business alone, as well. However, planned long-haul business aims to create a lower cost base and also leads towards reducing dependency on the hub while avoiding risk to the premium branding of the essential product.

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MEASUREMENT OF EXTERNAL CONDITIONS INFLUENCE ON PILOT PERFORMANCE IN FLIGHT SIMULATION TRAINING DEVICE

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Abstract *– A pilot's performance can be influenced by various external conditions as heat, noise, lack of sleep or rest, vibrations, direct opposite sunlight etc. However, these conditions can also have influence on student pilots in a flight simulation training device (FSTD). In an FSTD, there can be also the impact of instructor's presence in the close vicinity of the trainees. The advantage of an FSTD from research point of view is, that we can change some of these parameters and observe the change in pilot's reactions. We can measure physiological functions as well as amplitude and frequency of pilot errors. In this paper we will provide an overview of measurement methodology proposed in order to define the possibilities to enhance pilot synthetic training thru change of external conditions. A secondary outcome of this research may also be enhancement of current cockpit building technologies in order to diminish the effects of some of these external conditions on pilot performance.*

Key words – training, simulator, pilot performance, FSTD

INTRODUCTION

Student pilot such as veteran pilots are surely influenced by outside environment. This environment influences their physiological functions and subsequently their performance conducting ordinary and abnormal flying tasks. This can be seen from numerous incidents and accidents where the number of tasks given and the number of cognitive signals that a pilot had to process was more than he could actually cope with. However, except the influences that are directly connected to the task at hand, there are also other outside conditions such as heat and cold, noise and even the presence of a flight instructor or examiner. Majority of these influences can be encountered during real flight, but may not be present or simulated in a flight simulation training device.

IMPORTANCE OF EXTERNAL INFLUENCE RESEARCH

As we have already stated, a lot of external conditions influencing pilot workload, physiological or mental state, that can be encountered in a real aircraft, are not simulated in a flight simulation training device.

One example can be cold. An aircraft in normal operating conditions regulates the inside temperature to be more or less stable, or in case of small aircraft the pilot can turn on heating or venting. This comfort, however, must not be taken for granted. The heating system in small aircraft can malfunction, which can negatively influence the temperature comfort especially during severe wintertime. A more pronounced example of severe cold exposition could be rapid decompression of an airliner with pressurized hull, where not only the air pressure decreases rapidly and requires immediate pilot actions, but also the outside cold air will get into the cabin. In the usual flight levels of airliners the temperature can be decreased even under -50°C. This poses a great threat to pilot physiological functions. He will start to shudder, his mucosa will react to the cold, etc. All these effects may have negative impact on pilot's performance and can have an effect of surprise.

When the pilots are training for rapid decompression actions on a flight simulator, they learn to follow promptly the procedures needed for a safe descent to lower altitudes. However, they are not exposed to the effects of cold, reduced pressure and possible noise in case of rapid decompression caused by a structural damage to the hull. The question is, weather this training prepares the pilots sufficiently for everything they will encounter in emergency situation.

There is also an upside-down case, where some condition is not present in the aircraft but is present in the flight simulation training device. We are talking about instructor's presence in close proximity of the student pilots. Sure the flight instructor is present during live training on aircraft, but he will not be present in actual commercial operations of the pilots after their obtaining of pilot's license. The students in a flight simulator may feel some pressure from the instructor closely watching them perform the tasks. On the other hand, they may rely on the instructor's help too much and do not feel as if they were on a flight deck of actual aircraft.

Because of these questions, we would like to test the influence of various conditions on pilots' physiological state and performance. For this purpose we will use several technological means.

Measuring equipment

We can divide the measuring equipment that will be used in our research into two categories. The first category is formed by equipment used for physiological parameters measurement. For these types of measurement we chose to use an arm blood pressure monitor and a non-contact thermometer, as this will influence the pilot's actions the least. As you can see, these measurements will be discrete measurements in specific time intervals or points in time determined by particular pilot's actions or phases of flight.

The second category of measuring equipment is equipment used for assessment of pilot performance. For this purpose we opted for an eye-tracking device. This device will enable us to compare the attention allocation of the pilot under different stress conditions such as low visibility landing and cruise flight, or even with the instructor present or non present in the flight simulation training device cockpit during the same task.

Eye tracking

Our university uses an eye-tracking device for research purposes. This device can be used also in our measurements. It was produced by a company called SMI. The system is contact free and it is possible to use it with included 22" monitor as a plug and play system or with any other monitor after configuration. Some of the features of SMI RED system are stated below:

- Remote, contact-free setup for eye movement studies
- For monitor & TV (from 19", 22" up to 60") and projection (up to 300")
- Free head movement (40cmx20cm at 70cm distance)
- Operating distance: 60cm - 80cm
- High Accuracy: 0.4°
- Spacial Resolution (RMS): 0.03°
- Low Speed Sampling rate of 60Hz and 120Hz
- Variable calibration modes: 2,5,9 points, children module
- Fast & automatic calibration: <3 sec (2 point)
- Works with most glasses and contact lenses (SMI, 2014)

The following two figures show example of possible outputs from the eye-tracking software provided with the eye-tracking system. Figure 1 shows the time of occupation with a particular area displayed as a colour scale, where the red colour represents the most watched areas and blue colour the least watched areas.

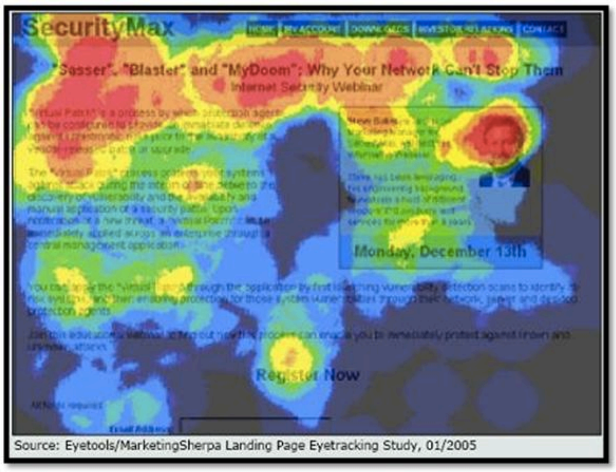

***Figure 1** – Colour scaled eye-tracking output (Thompson, 2009)*

Figure 2, on the other hand, shows us another possible output of the eye-tracking system, which provides not only the time spent at a particular point, but also the information on the sequence of subject's attention. The blue circles represent the points of interest, where the diameter of the circle represents the time spent on this particular point. The lines between the circles represent the sequence.

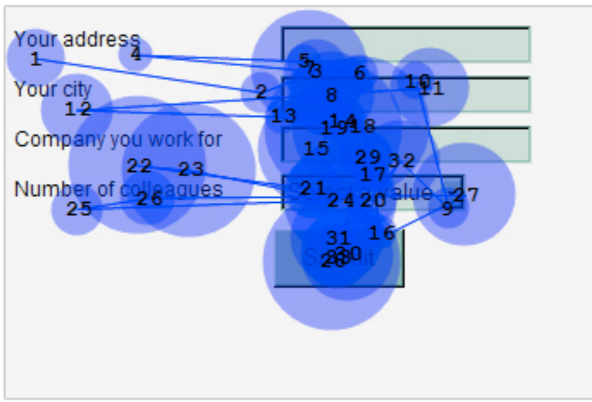

Figure 2 – Sequential eye-tracking output (Wroblewski, 2014)

Particularly this second output of the tracking software may be extremely useful for our research. There is a standardized scanning pattern of flight instruments, where the artificial horizon is the central element of the instrument panel. This pattern can be seen on figure 3. In ideal conditions the pilot will scan the instruments so that after every other instrument he will return to the artificial horizon, as this prevents disorientation in instrument meteorological conditions. However, this ideal state may change and may differ from reality as soon as an outside condition preoccupies the pilot somewhat. The most common cause of scanning pattern deterioration is increased workload of the pilot, when does not have sufficient time parallel to other tasks at hand. This is a well-known fact. However, we would like to add other circumstances to this basic prerequisite, such as for example pilot fatigue, cold/heat, instructor presence or absence close to the flight simulation training device cockpit, noise, conversation among the crew, smoke or fumes in the cabin, warnings and system failures, etc.

Figure 3 *– Instrument scanning pattern (X-plane, 2011)*

Measurement methods

As we have stated above, we will try to measure pilots under stress (increased workload), that are subject to various outside conditions making the stress most probably even more serious. The advantage of the technologies used at our side is the fact that we can conduct simultaneous measurements of pilot performance and pilot physiological state. The disadvantage is a slight invasiveness of the blood pressure and pulse measurement, as an arm blood pressure monitor will be used.

However, the parallel measurement will provide an opportunity to not only research the two aspects (performance and physiology) of the pilot operations, but also to measure the mutual influence of these parameters. This means we will be able to determine the effect of altered physiological parameters (for example because of extreme cold) on the pilot's performance.

The measuring equipment is a rather compact strip in which a camera is installed. This minimalistic layout makes it possible to install this equipment not only onto a display of any kind, but also directly into the flight simulation training device (for example a full flight simulator or flight navigation procedures trainer). The control computer of the system may be installed inside the simulator or outside, but it has to be connected to the eye-tracking camera.

The only problem of this layout is, that for thorough analysis it is good to have the display, on which the camera is installed, connected directly to the control computer. As the display of interest is actually the dashboard of the flight simulation training device cockpit, this may pose a difficulty. The primary flight instruments are usually represented on one LCD display which is overlaid by the dashboard structure panel. This is positive for our purpose. However, this display is fed by one of the visual computers. A possible solution is, to install the required eye-tracking software onto the visual computer, although there may be compatibility problems between the simulation software and eye-tracking software running at the same time as full-screen applications. This will be dependant on the hardware and software of the particular flight simulation training device type used for the measurements.

Another possibility is to set out a fictional field of areas representing the flight instruments used during flight. These areas have to fit inside the size of the instruments LCD display. Then it is possible to calibrate the eye-tracking device to this area and use an LCD display of the same resolution with a graphical representation of the areas of interest represented on screen for better analysis of collected data.

Conclusion

The above-mentioned methods together with pilot error statistics (for example number of altitude changes over 100 ft per time period) and subjective questionnaires will enable us to determine the influence of outside conditions and environment on pilot physiological state and subsequently performance of safety critical tasks. This may lead to improvements in pilot training thru higher level of pilot awareness reached by changes in flight simulation training device flight deck environment.

This paper is supported by the following project: University Science Park of the University of Zilina (ITMS: 26220220184) supported by the Research&Development Operational Program funded by the European Regional Development Fund.

We support research activities in Slovakia. Project is co-financed by EU.

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GNSS JAMMING

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Abstract *– GNSS is important part of today's modern society. Its importance in aviation is significant, because it provides safety in flight and enables implementing improved approaches to airports, where is none ground-based navigational equipment.*

This article addresses the problem of GNSS signal jamming in the vicinity of airports, which could cause the realization of danger. It also provides an overview of GNSS signal jammers, the possibilities of their detection and shows high-risk areas on the example of Leos Janacek Ostrava Airport.

Key words – GNSS, GPS, jamming, high-risk areas.

Introduction

Electromagnetic interference is relatively commonplace in the modern world, where also constantly increases dependence on the signals that are received by mobile devices. From this perspective, any source of electromagnetic interference is big enemy of almost every person in the area of interference location.

However, there is also a second view when interference is used as an appropriate tool for achieving a goal. It can be a meeting of high-ranking individuals, where is appropriate to make communication for potential attackers very difficult. This is a situation where is the use of jammers usually allowed by the competent authority and is therefore in accordance with the law. However, there are situations where the jammer is also used to meet the specific goals of the person, but this goal may not be known to others. In these situations the interference is uncoordinated and unauthorized, which can lead to critical disturbance of signal and also even to hazardous events.

Every signal could be disrupted, but in this article we will focus only on GNSS and mainly on air transport, since the implementation of the approach to land using GNSS signal becoming mostly introduced new approach and approach and landing is statistically the worst in terms of the percentage of accidents during the whole flight.

GNSS Jamming

GNSS signals are only one small subset of utilized spectrum for transmitting and receiving information. With the expansion of the use of personal navigation, due to the cancellation of artificial errors insertion into GPS, ever higher percentage of the population of the Earth depends each day on satellite positioning. And here in certain applications, GNSS is not only the auxiliary information, but the primary source of navigation, which is needed to ensure safety.

GNSS signals that are used for primary navigation primarily include GPS signals L1 (1575.42 MHz) and L2 (1227.62 MHz) and the Safety of Life signal L5 (1176.45 MHz). In case of other satellite constellations (GLONASS, Galileo) there are similar signals on the same or very close frequencies. For augmentation are used mainly the SBAS signals and specifically for conditions of Europe, the European EGNOS system.

Typical GNSS signal jammers are usually referred as GPS jammers that interfere with L1 signal and transmits at the same frequency with higher output power than have the signal from the satellites in the same area. Certain more sophisticated jammers can jam both L1 and L2 signal. In the case of L5 signal, the situation is better, since it is broadcasted with higher output power.

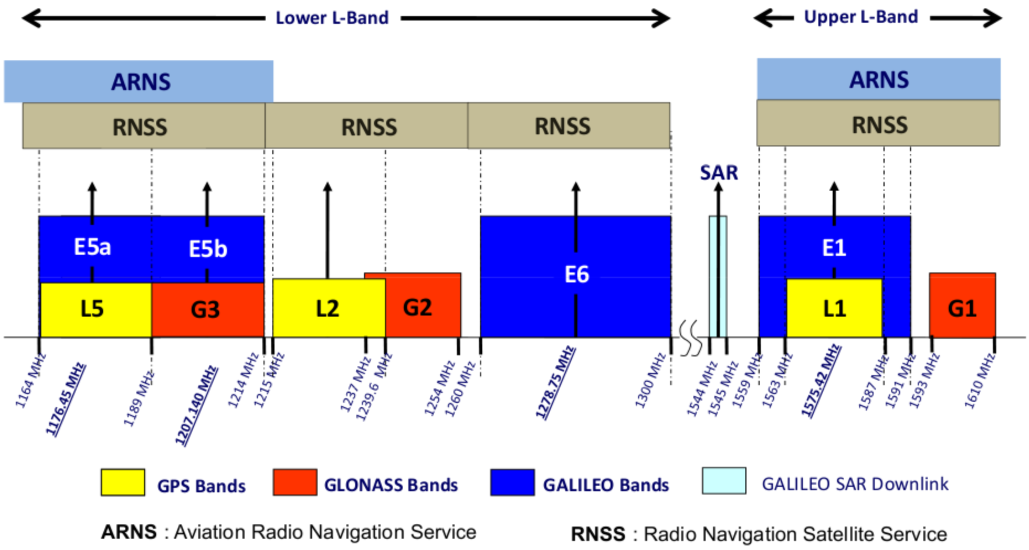

Figure 1 – GPS, Galileo and GLONASS bands [6]

GNSS Jammers

There is a wide offer of GNSS jammers on the market. Several ways of categorization can be used. The first one is based on their size (and the way they are powered). The simplest and usually the cheapest ones use typical 12V or cigarette lighter power outlet available in any car. They offer jamming range of up to 10 meters, although a model claiming range of 30 meters was found. Then there are larger jammers offered with a built-in battery in order to be used without any other power input. They also come with a charging cable which can be used in a car. Their range is usually in the 20 meters area. The availability of a battery comes with a higher price which is about 200 Euros. These two types are the types this article is focused on, because they can be used in a car or by an individual walking around airport and have a reasonable price. But to complete the list of jammers offered on the internet, there are two more types. One of them is still of a decent size, but their weight and especially price of approximately 500 Euros makes them less available to public. The advantage of these jammers is in the variety of frequencies they can jam (for example GSM, 3G and GPS). The range of those jammers, based on the information on the internet, is somewhere between 10-30 meters. The last type is a large device that can also jam other signals than just GPS. They have a size of a backpack and a range of up to 120 meters. But their price is so high (over 10,000 Euros) and it is claimed that only state institutions can buy them than it is very unlikely that a driver might have one in his car or truck.

The other categorization is based on a transmit power of GNSS jammers. It can be said that this power is based on size of device and the larger the device is the larger the power. For the smallest type of jammers the transmit power is in the area of tenths of Watt. The largest one (size of a backpack) has a transmit power of up to 50 Watts. According to Logan Scott, president of a company called LS Consulting, a GPS jammer with one-tenth of a watt of transmit power has a range of 9.4 miles, a one watt jammer, 29.8 miles, and a ten watt jammer, 94.2 miles [1]. This is contradictory to the information given by sellers, where the most powerful device should have range of only 120 meters. But if we based this article on the information given by Mr. Scott, there would be actually no reason to write this article, because even a small jammer could knock-out the signal in a whole region.

The real range for GNSS jammers is in between of the range specified by sellers and the laboratory tested range. In real life could be the range approximated as ten times the range specified by sellers. For our purposes of drawing maps we specified range of one hundred meters for simple GNSS jammers and three hundred meters for more sophisticated ones (still used in cars and trucks)

High-risk Areas

As shown in the previous chapter, the most available jammers have a range of about 100 meters and 300 meters. Therefore it is logical for aviation to focus on the areas around airports where an aircraft is at or below altitude of 300 (100) meters. It means that these areas, more precisely risk areas, are along the extended runway centerline.

Shape of risk areas is given by intersection of the plane of aircraft's glide slope and a set of half-spheres with radius of jammer's range (100 or 300 meters). Because this would require a large number of half-spheres to draw, a simpler way was used. Imagine a sphere around an aircraft that has a radius of the GNSS jammer's range. As the aircraft descends towards airport, the sphere intersects with the ground and edges of the sphere that touch the ground also make edges of risk areas. Important for us is the projection of this shape on the ground, which is part of an ellipse. For basic presentation of risk areas we determined that the ground around Leos Janacek

Ostrava Airport is perfectly flat with elevation of the respective runway end.

These risk areas count with the location of GNSS jammer anywhere around an airport. It is not impossible that someone would be walking around an airport with a jammer, but it is unlikely. Roads that cross these risk areas are much bigger problem, because as mentioned above, the GNSS jammers are very popular amongst drivers. We consider the part of risk areas at such roads as a “high risk areas”, because there is a larger risk of jamming. Following picture shows depiction of risk areas (yellow for jammer’s range of 100 meters and green for range of 300 meters) around Leos Janacek Ostrava Airport with two high risk roads highlighted in red. Although there are more roads intersecting with risk areas, only these two seem to be of higher significance to local road system. The glide path angle is standard 3 degrees.

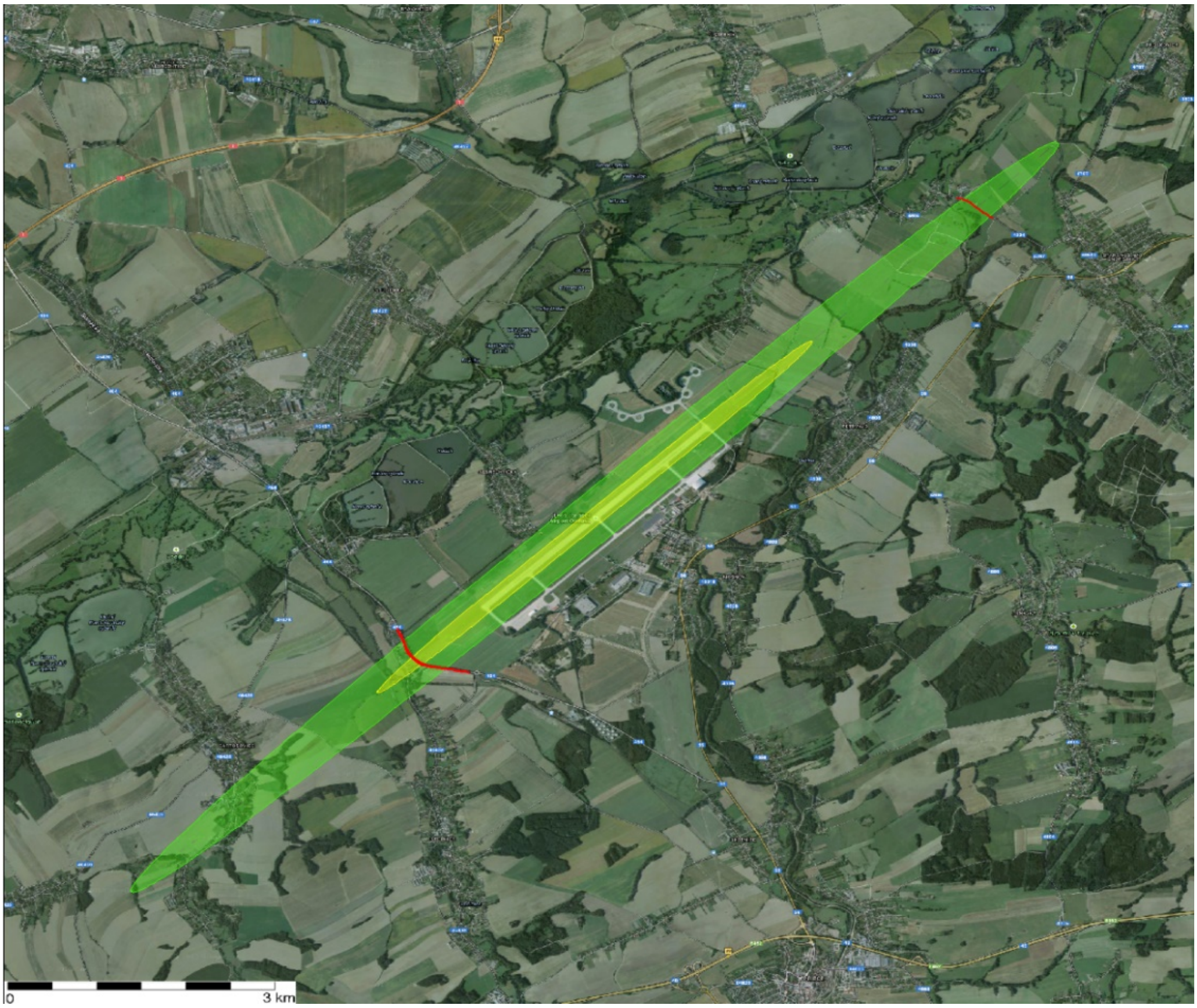

Figure 2 – Risk and high risk areas around Leos Janacek Ostrava Airport (Source: Authors)

Detection

GNSS jamming poses a significant threat to aviation and its future use of GNSS based approaches. It is possible to detect and even locate a GNSS signal jamming nowadays. [2], [3] It might seem like there should not be a problem with ensuring the proper functionality of GNSS around airports then. But it is not true; detecting a jammer is not the same as taking the jammer out. It would require cooperation between the detecting system and local police forces. But this still does not ensure the reliability of GNSS, because another jammer might appear shortly.

Because of this reason, in future with expectation of more air traffic relying mainly on GNSS, it would be wise to place detectors of GNSS jamming around high risk areas, i.e. roads intersecting with risk areas. Primary goal is to detect incoming jamming source before it enters the risk area and to notify airport/aircraft that GNSS could be not reliable at the moment and other navigation system must be used. Secondary goal might be to notify local authorities who might try and find the source of jamming. The most important action is to get the information about jamming to pilots.

Conclusion

Solution of GNSS signal interference can be a major problem in the future, for which must be made preparations. Building more robust satellite navigation systems may improve this situation, but it will be always necessary to reveal GNSS signal jammer on the spot.

Demonstration of high-risk areas for Leos Janacek Ostrava Airport is one of the ways to evaluate potential areas for the most dangerous sources of interference and to consider the use of modern technology to ensure air traffic safety.

Acknowledgements

This paper was supported by the Ministry of the Interior of the Czech Republic, grant No. VG20132015130.

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PROPOSAL OF ECTM PROGRAMME FOR AIRCRAFT PISTON ENGINES

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Abstract *– Engine Condition Trend Monitoring (ECTM) is considered a programme in which pilots and maintenance staff record engine`s parameters during a period of time, analyse them and make a decision about required maintenance activities. ECTM is usually applied for jet engines and its application enables "on condition" maintenance, thus increasing reliability and reducing maintenance costs. On the other hand, "hard-time" maintenance is still used for piston engines. The recommended time between two overhauls (TBO) is 1500 to 1800 hours.*
The paper describes the method and parameters of aircraft piston engine monitoring. The method will be developed for automatic data recording of engine parameters (e.g. RPM, oil temperature, oil pressure, cylinder head temperature, exhaust gas temperature) during flight with the EDM-800 Data Management System, which collects data during flight and displays them in a way useful for pilots and technicians. After collection, the trend of engine parameters will be analysed and interpreted, with the aim to predict engine malfunctions. A proposal of ECTM programme for aircraft piston engines is presented in the form of flow charts and analysis of data figures measured.

Key words – piston engines, maintenance, flight data recording, Engine Condition Trend Monitoring (ECTM).

I. INTRODUCTION

In this paper a method for automatic engine parameter data recording (e.g. RPM, oil temperature, oil pressure, cylinder head temperature, exhaust gas temperature) during flight with EDM-800 Data Management System, which collects data during flight and displays them in a way useful for pilots and technicians, is presented. Data will be collected from numerous flights. After collection, the trend of engine parameters will be analysed and interpreted, with the aim to predict engine malfunctions.

The paper is based on the research published in the previous paper [1] and research in diploma thesis [2].

In the first part of the paper the principles of aircraft and engine maintenance are described, including the role of Engine Condition Trend Monitoring (ECTM). In addition, characteristics of a typical small aircraft and an aircraft piston engine are presented, with special regard to the Zlin 142 aircraft and Avia M 337 AK piston engine. In the main part of the paper, possibilities of measuring engine parameters during flight are explored. In addition, analysis and measurement results are presented. In the end, a proposal of an ECTM programme and the final conclusion are given.

II. THE PRINCIPLES OF THE AIRCRAFT MAINTENANCE

Maintenance is a sum of "actions necessary for retaining or restoring a piece of equipment, machine, or system to the specified operable condition to achieve its maximum useful life" [3]. During the operation of an aircraft possible damage and/or failure of components and systems can occur due to different factors. Because of that it is necessary to implement an aircraft maintenance programme in accordance with all aviation regulations. The first known maintenance regulation was published in the 1950s by the American Federal Aviation Authorities (FAA), which stated that fixed periods for maintenance and overhaul of the aircraft, engine, instruments and equipment have to be defined.

In 1960s, after the idea of preventive maintenance was born, "Maintenance Evaluation and Program Development" (MSG-1) was developed by the Air Transport Association (ATA) Maintenance Steering Group (MSG). The document defined the principle of using a flow chart for the analysis of maintenance programmes and defined the intervals for aircraft components' and systems' maintenance.

Later on, MSG-1 was updated with the MSG-2 document titled "Airline/Manufacturer Maintenance Program

Planning", which introduced process-oriented maintenance using bottom-up approach. In this document three possible processes of aircraft maintenance were presented – Hard Time (HT), On Condition (OC) and Condition Monitoring (CM).

Hard-time (HT) is a preventive process under which a part must be removed from service before its scheduled maintenance period for inspection or repair. It is the oldest type of preventive maintenance, present from the beginning of the aviation industry. Although nowadays considered old and cost-inefficient, HT maintenance is still present as the main type of maintenance for some modern aircraft components like aircraft engine parts (e.g. turbines), extinguishers and survival kits because of the level of safety it provides. Beside its part in the large aircraft maintenance, HT maintenance is still considered the best type of maintenance for small aircraft and piston engines.

On Condition (OC) is a preventive process under which an inspection/functional check is made, determining components' performance and may result in the removal of a component before it fails in service [4]. By introducing simple functional tasks in the aircraft maintenance and analysing functional parameters during and after performance, it is possible to predict the probability of component failure. The component's performance is compared to an appropriate standard and if a given parameter begins to present abnormal values, that can be taken as an indication that component failure is imminent and that corrective action has to be taken.

Unlike HT and OC maintenance, Condition Monitoring (CM) is not a preventive type of maintenance, instead allowing a failure to occur and relying on the data acquired through the component's service life to determine adequate corrective action. It is applied to those components which do not have a direct negative impact on flight safety, making a good base for reliability programmes.

Based on experience and the identified weaknesses of MSG-2, "Operator/Manufacturer Scheduled Maintenance Development" or MSG-3 was developed. MSG-3 introduced a task-oriented, "Top-down Approach" that observes the potential effects of a functional failure and the ability to detect the failure, as well as the costs of failure and maintenance actions. The main idea behind this concept is to recognise the reliability of aircraft systems and components, to avoid unnecessary maintenance tasks and to achieve increased efficiency.

MAINTENANCE OF PISTON-ENGINED AIRCRAFT

Aircraft maintenance can be analysed from different aspects. In its core, maintenance programme can be divided into three parts:

1. Modifications - work on the aircraft performed as part of regular maintenance, published in the form of a Service Bulletin (SB), published by the aircraft manufacturers.
2. Scheduled maintenance - preventive type of maintenance which prevents system degradation and reliability characteristic for a specific aircraft and it can be divided into line maintenance (e.g. defect rectification and troubleshooting) and base maintenance (e.g. 50/100/200 flight hour check).
3. Pre-flight check - serves to verify the general condition of the aircraft and includes a walk around the aircraft and visual inspection of the aircraft. It is performed prior to every flight by the pilot, maintenance personnel or both, depending on the organization policy.
4. Non-scheduled maintenance - a corrective type of maintenance performed due to a malfunction, damage or any kind of failure found during the scheduled maintenance or aircraft operations. The main task is to fix a malfunction/damage of a part of the system or even the whole system if it is required.

MAINTENANCE TECHNIQUES FOR PISTON ENGINES

Since the beginning of aviation, maintenance of the aircraft engine has a special status compared to the maintenance of other systems and components. Regardless the type of aircraft engine (turbine or piston), the main type of maintenance used has always been HT maintenance due to its impact on safety of aircraft operations.

Unlike turbine engines on which, besides HT, some newer and more advanced maintenance techniques are used, piston engine maintenance is still exclusively HT maintenance.

Today, each piston engine comes with a maintenance manual which thoroughly explains everything about the engine, including its maintenance. That maintenance proposal presents the minimum of maintenance work required to ensure safe engine operation. Just like an aircraft, a piston engine has to be inspected after a certain number of flight hours/ cycles/ calendar time. These inspections include a variety of different tasks, depending on the time in service. Some of the inspections performed on a piston engine include pre-flight checks, between-flight checks, after-flight checks, 10h ± 1h inspections, 50h ± 5h inspections and 500h ± 10h inspections.

III. TYPICAL SMALL AIRCRAFT WITH PISTON ENGINE

When talking about the aircraft involved in the everyday, civil aviation operations, small, light aircraft are the most represented group.

Small aircraft can be divided into several groups concerning different characteristics and single engine piston (SEP) aircraft are the most famous ones among them. Although the SEP aircraft are designed for a variety of purposes, they are mainly used for training, sport/leisure flying and private (passenger) flights. Concerning the SEP aircraft used for training purposes, the most produced and used aircraft are Cessna 172 [5], Piper Cherokee (PA-28) and Zlin 42/142/242 [6]. Unlike Cessna and Piper which are present worldwide, Zlin is mostly used in western and central European counties like France, Germany, Czech Republic and Slovakia. Since the Air Transport Department, University of Žilina, where the research was conducted, uses four Zlin 142 powered by Avia's M 337 AK engine for the flight training purposes, it was a logical choice to choose this aircraft and engine as a base for this research.

Zlin 142 is a single-engine, low-wing, cantilever monoplane with fixed main landing gear and nose wheel. It is used for elementary and advanced pilot's training and for training and execution of aerobatic manoeuvres [7].

AIRCRAFT PISTON ENGINE

Engine is a part of the aircraft which provides power and propulsion in engine-powered aircraft. Unlike the turbine engines mostly involved in commercial aviation operations and installed on large aircraft, piston engines are still considered the best solution for the light single-engine and multi-engine aircraft, mainly because of their lower fuel consumption and easy maintenance.

Typical aircraft piston engine can be described as a four stroke engine with four cylinders placed in horizontally opposed configuration. In this paper, a different kind of piston engine will be presented – inverted inline aircraft engine, Avia (Walter) M 337 AK.

M 337 AK

M 337AK is an inverted four stroke, six-cylinder engine with inline configuration, manufactured by Czechoslovak company Avia as a derivate of four-cylinder M 332 engine and supercharged version of M 173 engine [8,9].

Despite its disadvantages over horizontally opposed engines, M 337 AK is still used in several different aircraft like Let Morava L-200, AeroVolga LA-8C, Falconar SAL Mustang and many types of Zlin like Z 34, Z 526 and Z 142, on which observed M 337 AK was installed.

The biggest advantage of this type of engine is that it is considerably easier to build, allows narrower nose section of the aircraft and gives improved access to cylinder heads and manifolds for the ground crew. Despite that, lower power-to-weight ratio (compared to horizontally opposed) led to abandoning of this engine design.

IV. ENGINE CONDITION TREND MONITORING (ECTM)

Engine Condition Trend Monitoring (ECTM) presents a process which follows and analyses trends of changes of certain engine parameters in order to identify and prevent possible engine-part or system malfunction.

ECTM was introduced as an advanced programme for OC maintenance developed and used for Pratt & Whitney PT6 and PW100 turbine engines in accordance with MSG-3 philosophy, soon followed with similar programmes developed by other engine manufacturers. Today, each turbine engine manufacturer has its own version of ECTM programme.

It comes as the regular part of an engine maintenance programme with all the technical requirements of ECTM specified by the engine manufacturer, ensuring reliable and consistent outcomes of the engine usage. ECTM can be started at any engine time. However, it is recommended that trend monitoring should be initiated within 100 hours of new or with newly overhauled inspected engines.

Effective implementation and integration of ECTM into the engine maintenance programme requires the following sub-systems:

- Data acquisition
- Data entry
- Data analysis
- Follow-up actions
- Computer hardware and software

Although regular condition monitoring is performed during flight, ground checks can also be performed but only when needed (due to a high expense of engine run-up (time, fuel and engine cycles) and noise pollution).

To gather relevant data, ECTM relies on consistent and reliable engine performance data like altitude, aircraft speed, outside air temperature (OAT), total air temperature (TAT), engine pressure ratio (EPR), engine rpm (RPM), fuel flow (FF) and exhaust gas temperature (EGT). Hence it is imperative that the required data are acquired at consistent aircraft operating configurations, usually during cruise flight. Data can be acquired in three ways – manual, half-automated and automated, with the following general requirements to ensure reliability and consistency.

The objective of ECTM is to take appropriate corrective action when required based on the acquired trend data and has to be carried out by a person with adequate experience and familiarity with turbine engines that has undergone ECTM training provided by the manufacturer.

AIRCRAFT ENGINE- MONITORING INSTRUMENTS

On almost every cockpit panel of the small aircraft with piston engine, it is possible to find the same engine instruments like fuel flow indicator, exhaust gas temperature indicator, cylinder head temperature display, oil and fuel temperature indicator and oil and temperature fuel pressure.

Although these instruments provide information for the pilot, they are not precise laboratory instrument and they can malfunction and show incorrect value which can lead the pilot to the wrong corrective actions. Also, these kinds of instruments can only partially help the pilot use the engine efficiently without knowing what is really going on inside the engine. For these purposes, special, but still simple enough to be used in the cockpit, instruments were developed.

ADVANCED COCKPIT ENGINE-MONITORING SYSTEM - EDM-800

Unlike the turbine engines which use ECTM on regular basis, implementation and use of ECTM in piston engine maintenance is still considered a new maintenance approach and it started a couple years ago.

To make monitoring possible, advanced engine-instruments with automatic recording and suitable software had to be developed.

Several systems for automatic data recording have been developed, all of them having the following components:

- Sensors/probes
- Display and collecting data unit
- Software for data download and processing

For the purpose of this research, instrument EDM-800 owned by Air Transport Department, University of Žilina, was used. The Faculty purchased this system to test all the device options and possibly integrate it in existing maintenance programme.

Figure 1 *- EDM-800 (front and rear)*

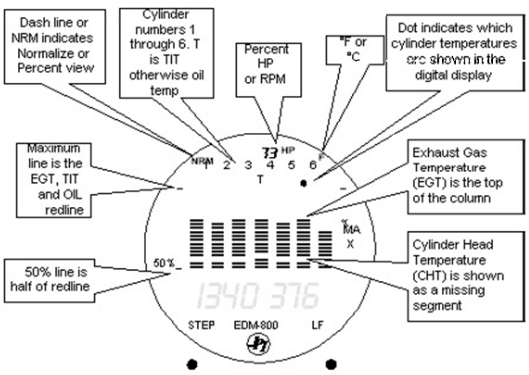

Figure 2 *- EDM-800 display parameters*

The Engine Data Management 800 (EDM-800) is a high-precision piston engine-monitoring system made by JPI Instruments Inc., which offers advanced monitoring options during the flight [10]. Unlike basic engine instruments, EDM-800 is using the latest microprocessor technology and can monitor up to twenty-four critical parameters. (Figure 1 and 2).

To be able to monitor all the critical parameters, EDM-800 gathers information from at least [10]:

- Four exhaust gas temperature (EGT) probes
- Four cylinder head temperature (CHT) probes
- Five different temperature probes for outside air temperature (OAT), turbine inlet temperature (TIT), shock cooling (CLD), induction air temperature (IAT) and oil temperature
- One probe for fuel flow (FF), propeller revolutions (RPM), oil pressure, manifold absolute pressure and voltage
- Special interface connection for connecting any GPS navigation system

Due to its precision and reliability, EDM-800 is approved as a primary temperature instrument for CHT, OIL and TIT. EDM-800 monitors given parameters four times a second, with a linearized thermocouple accuracy of better than 0.1 percent.

There are three standard operating modes of EDM: automatic, manual and LeanFind™. Beside those modes, EDM also offers some additional option which can significantly improve flying operations and engine maintenance (i.e. fuel flow, time remaining, exceedance alarm ect.)

To be able to analyse measured data, appropriate software has to be used. EZTrendz is one of the software available on the internet which can be paired with EDM-800 and which was used in this research.

Like other similar software, EZTrendz offers easy download, archive and plotting of EDM data. Downloaded data are archived on user's computer in .JPI, .DAT or .CSV form and can be plotted anytime.

V. PROPOSAL OF PISTON ENGINE ECTM PROGRAMME

Proposal is based on the known maintenance procedures for the M 337 AK aircraft piston engine and available trend monitoring system EDM-800. All the data and related figures presented in this chapter were gained as a result of measuring process conducted on Zlin 142 by the maintenance staff and pilots at the Air Transport Department, University of Žilina using EDM-800. The purpose of the data presented here is to explain and show all the possibilities which ECTM maintenance programme can offer when applied on piston engine.

To be able to make appropriate ECTM programme for a given engine, different objectives have to be defined and used:

- Suitable instructions/manual issued by the manufacturer
- Monitoring system
- Data monitoring methods
- Software for data analysis
- Observed parameters
- Analysis of measured data
- Trouble-shooting
- Corrective tasks

BENEFITS OF ECTM IMPLEMENTATION

As it has been said before, ECTM is a proven maintenance process in commercial aviation operations. On the other hand, for a long time, ECTM was considered too complicated and cost-inefficient to be used for piston engine maintenance. Recently, after ECTM program has been applied to piston engines, it was proven that it can significantly improve engine life and reliability and reduce maintenance cost. In figures, after the implementation of ECTM in standard piston engine maintenance, TBO has increased up to 10%. If it is known that TBO for piston engine can be between 1500 and 2000 flight hours, additional increase of 150 to 200 flight hours can be of great importance for, e.g., flight training organization with limited number of small aircraft which relies on consistency of piston engines used.

ECTM maintenance does not require special investment or additional training, and the data processing provides significant information of the engine condition and early detection of possible failure.

OBSERVED PARAMETERS

Despite the ability to measure up to twenty-four different parameters, for the purpose of the research and programme proposal only few of them are used and explained.

Cylinder head temperature (CHT) - temperature on the head of a cylinder, measured on at least one of the engine cylinders. It is considered to be one of the best parameters for looking at irregularities in the combustion process, especially when paired with EGT.

Exhaust gas temperature (EGT) - the EGT probe is located in each exhaust pipe. The actual temperature of the exhaust varies with a number of elements such as the power setting, altitude, ambient air temperature, and cylinder compression [11].

Fuel flow (FF) - fuel flow parameter presents the amount of fuel that goes to the engine and it is measured with a small, turbine transducer.

Manifold absolute pressure (MAP) - The MAP is the pressure in the manifold, in principle measured anywhere between the throttle valve and the intake valves. Beside the CHT and EGT, MAP is considered an essential component in the way an internal combustion engine operates**,** and an excellent indicator of many common problems.

Oil temperature (OIL) - In most maintenance programmes it is stated that oil temperature should be checked regularly in order to ensure that the temperature is high enough to cause the accumulated moisture in the oil to boil away during flight.

Fuel used (USD) - With an indication of fuel used, a pilot can monitor the work of the piston engine during flight and report if the unexplainable/suspicious fuel consumption occurs.

VI. DATA ANALYSIS, TROUBLESHOOTING AND RECOVERY ACTIONS

Data presented in this chapter was recorded with the EDM-800 on September 10th 2012, during one of the training flights at the Air Transport Department, University of Žilina. On the top of each figure there is information about the aircraft, number of flight, date and time when the recording was done.

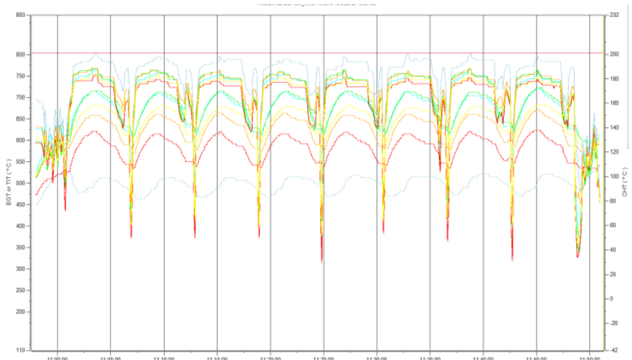

Figure 3 *- Main graph showing change of six EGT (E) and six CHT(C) parameters with time*

In the Figure 3, changes of cylinder head temperature and exhaust gas temperature with time are presented. Temperatures are expressed in "°C" or "°F", with yellow horizontal line representing the maximum temperature allowed.

If compared with other flight data, trend of parameter change can be seen. In this graph it is indicative that the temperature of the 6th cylinder is lower than the temperature of the others. Having that information, maintenance technician can resolve that there is a cylinder related problem and know which corrective action has to be applied.

In the Figure 4, option graph is showing the change of CLD, FF, RPM, MAP and BAT parameters with time. Depending on the parameter, different measurement is applied - RPM is measured in "RPM", MAP in "In/Hg", CLD in "°C or °F" and FF in "LPH".

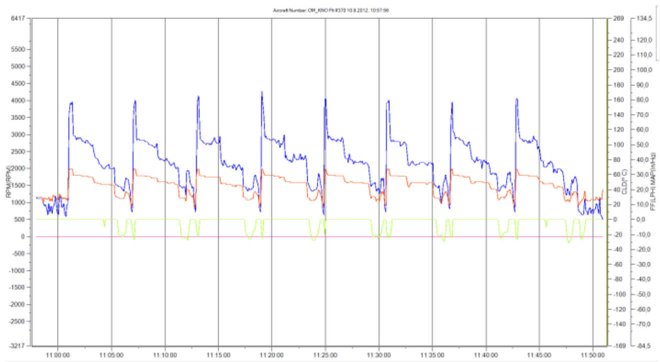

Figure 4 *- Option graph showing change of CLD, FF, RPM, MAP and BAT parameters with time*

To solve that kind of problem, regular hard-time maintenance would require several different inspections before finding a real problem. Using the ECTM, finding the problem is reduced to the shortest time possible, reducing the costs at the same time.

TROUBLESHOOTING AND RECOVERY ACTIONS

Troubleshooting and recovery actions are the core of every maintenance programme. In order to ensure safe and reliable engine work, engine maintenance manual has to contain troubleshooting and proscribed recovery actions. These actions can be applied by maintenance organization as they are or they can be upgraded with additional tasks and/or maintenance programme like ECTM.

For the piston engine M 337 AK, possible engine faults stated in the maintenance manual are:

- Engine won't start
- Uneven running
- Rough engine
- Excessive engine temperature
- Engine back firing
- Failure of engine to develop full power and to attain full RPM when throttle fully opened
- Increased fuel consumption
- None or low pressure indication after engine started
- Ignition system failure

Some problems for which was considered that can be efficiently solved using ECTM approach are presented. Proposed processes are given in the form of flowcharts (Figure 5 and 6) following MSG-3 top-down procedure for easier understanding and possible upgrade [2].

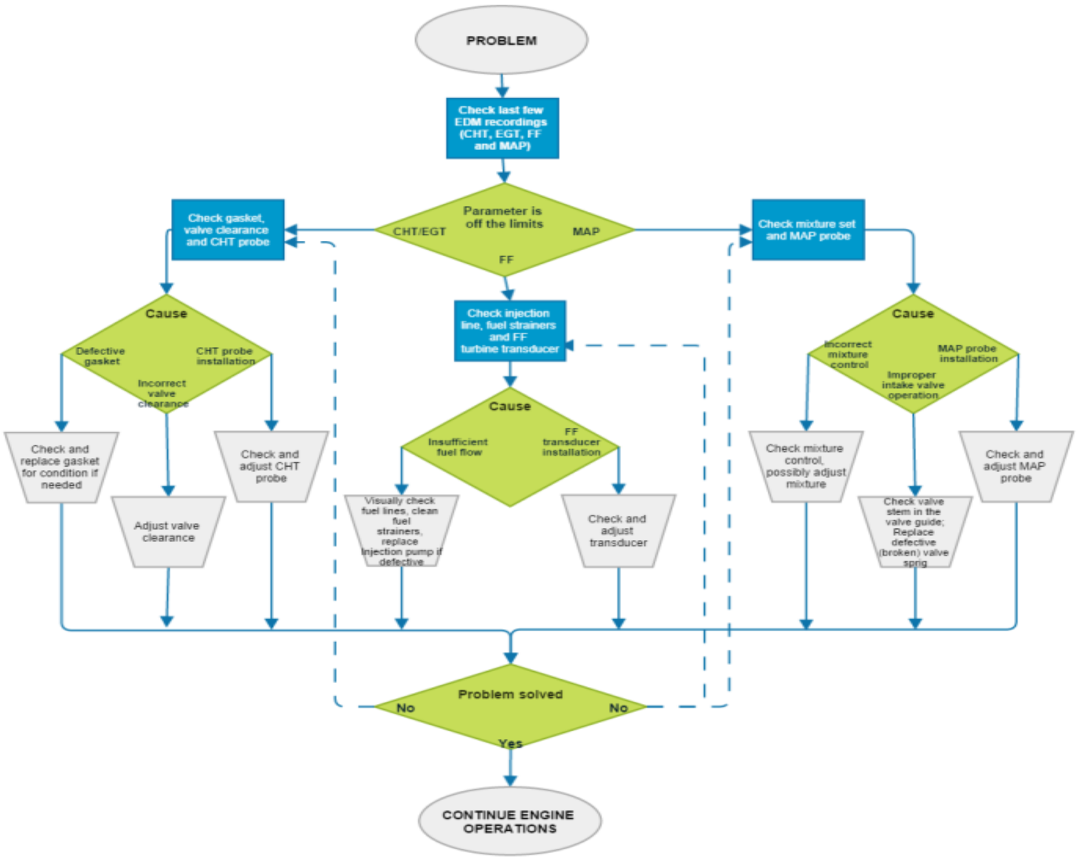

Figure 5 *- Engine back fire troubleshooting and recovery actions*

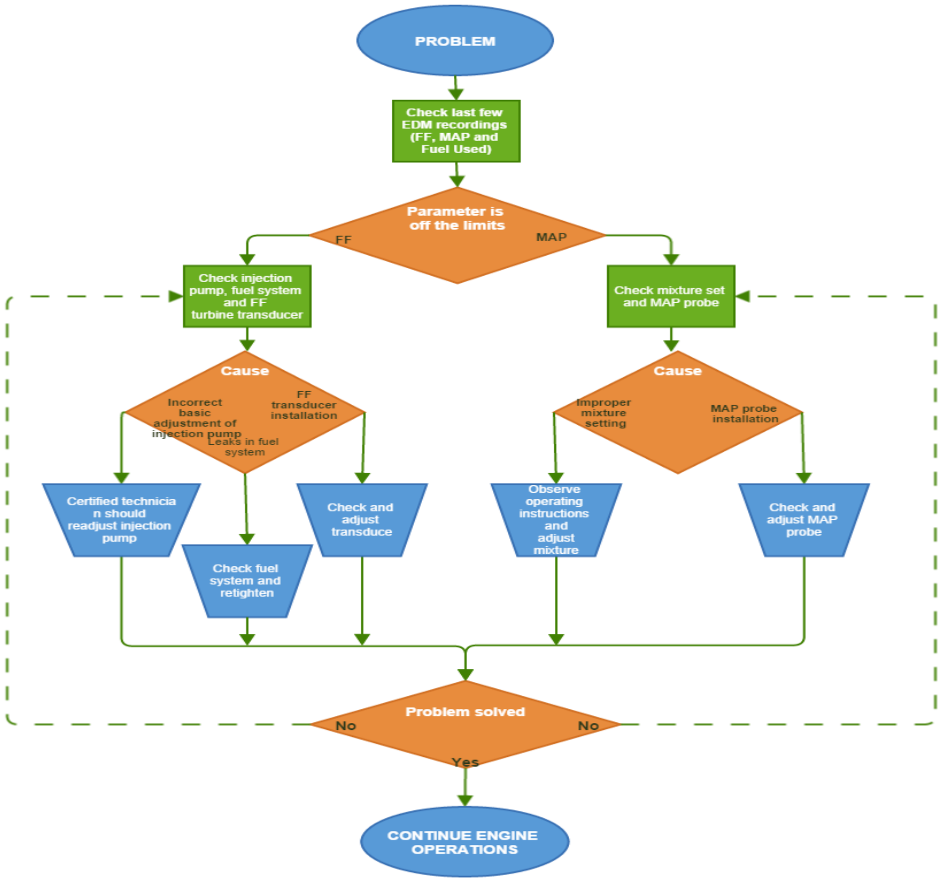

Figure 6 - *Increased fuel consumption troubleshooting and recovery actions*

SYSTEM IMPERFECTION

Like in any existing system, this programme and related trend monitoring system have possible imperfections which can occur during the application. Problems like occasional measuring errors and possible inadequate maintenance methods can be put in the category of system imperfection.

To be able to correct imperfections like these, the system has to be upgraded continually, ensuring the satisfying level of reliability and safety at the same time. Also, it is necessary to ensure an adequate training and good communication between all the participants in the maintenance process – manufacturer, maintenance staff and pilots.

VII. CONCLUSION

Definition of maintenance says that it is a sum of actions necessary for retaining or restoring a piece of equipment, machine, or system to the specified operable condition to achieve its maximum useful life. Looking that way, aircraft can be considered a complex system made from several sub-systems.

Complexity of aircraft maintenance depends on two things – size of aircraft and its purpose. The bigger aircraft it is or its purpose is more important, maintenance of it and its sub-systems is more complex. In order to achieve required safety and maximum useful life, each of these sub-systems has to be maintained in accordance with given instructions and regulations.

Engine condition trend monitoring or ECTM is a process in which trends of changes of certain engine parameters are monitored in order to identify and prevent possible engine-part or system malfunction.

Beside increase of TBO, trend monitoring programme does not require special investment and the data processing provides significant information of the engine condition and early detection of possible failure. One of such methods is the analysis of performance parameters. In its simplest application, this method uses the data obtained by recording the parameters during flight using advanced monitoring system and ordinary maintenance inspection. Measured results can be easily transferred on the personal computer and analysed using an adequate software tool. For the purpose of the research, EDM-800 management system has been taken as an appropriate monitoring system suitable for integration in the small aircraft maintenance and everyday flying procedures.

In this paper a proposal of ECTM programme for aircraft piston engine is presented in the form of flow charts where the monitoring system is combined with hard-time maintenance tasks given in the engine maintenance manual. After conducted data analysis it can be concluded that even a basic type of maintenance like HT can be easily upgraded with right tools and that those upgrades can have a significant influence on engine reliability and operational safety.

This paper is published as one of the scientific outputs of the project: **"Implementation of scientific research knowledge to the Air Transport", ITMS 26220220010".**

Operačný program VÝSKUM a VÝVOJ

Európska únia
Európsky fond regionálneho rozvoja

We support research activities in Slovakia/

Project is co-financed by EU

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BUILDING A STATE LEVEL OF SAFETY INDICATORS (SPI)

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Abstract *– All ICAO Member States are currently implementing safety indicators in aviation. Requirements for their operation are contained in many legal documents, standards and regulations, such as Annex 19 to the Chicago Convention, ICAO Doc. 9859, and Regulation (EC) 376/2014. Safety indicators for EU conditions are based on events data stored in the ECCAIRS database. High-level Safety Objectives that reflect a current need for improvement of the safety of the individual characteristics of the operation of the country can be also considered subject of safety indicators. For the operations with the indicators, the systems such as SDCPS (Safety Data Collection and Processing System) and SDTOS (Safety Oversight Data Targeting System) need further development. The basic principles for determining state-level safety indicators and operating principles of SDCPS and SDTOS are the content of this article.*

Key words – safety indicators, aviation, safety objective, SPI.

INTRODUCTION

International Civil Aviation Organization (ICAO) defines Safety Performance Indicators (SPIs) as parameters characterizing or describing a current level of safety within aviation organization (safety level determination – Acceptable Level of Safety (ALoS)). In addition, SPIs provide safety performance monitoring, which demonstrates efficiency of the Safety Management System (SMS) processes [1].

Management system (led by safety manager) is an organization element responsible for maintaining a required safety level and organization safety performance. This management system as it was previously mentioned is also known as SMS. European legislation considers SMS, its implementation and proper functioning as a must for all concerned organizations. These obligations are brought through different mechanisms such as European aviation safety agency (EASA), EUROCONTROL or ICAO standards.

SPIs and their application represent an important instrument used in state supervision. Thanks to them, a true image of the current safety status can be created and development trends can be followed for individual segments of aviation industry. This enables proper setting and placing of the corrective actions, which play an important role in aviation risk management. SPIs help state in a process of transition from compliance-based oversight to performance-based oversight.

THE PRINCIPLES OF SPIS ON A STATE LEVEL

The measurement of a current safety level and safety performance represents a difficult issue even for organizations such as ICAO, EASA or EUROCONTROL. Defining the indicators structure and their values is the first step that needs to be done in order to make measurements possible. According to these particular values, we will be able to compare the current state and future development trends.

SPIs are processed through a diagnostic system whose outputs provide information suitable for safety supervision. It is of great importance for SPIs to be clearly defined, especially their inner and outer structure. The setting of outer structure is based on those things important for relations between particular indicators. The inner structure on other side defines indicator in the matter of used data resources and feedback logic used in their managing process. The composition of the indicators varies according to effectiveness in the process of system's issues elimination.

The usage of indicators is considered a continuous data collecting process and their following evaluation. Accident, incident and significant event data are collected for the reactive indicators (statistical data). Another group of indicators are preventive indicators. These are monitoring causal links (operational processes elements with higher risks). Another group is the indicators, which are oriented on the creation of the environment suitable for reaching the required level of safety. Those indicators, known as proactive indicators are represented as safety and reporting culture issues as well as relations between management and operational processes.

Systems known as ECCAIRS and SAFA, widely used within EU are essential available data resources. Data from these systems are used during a creation of the optimal system of indicators. At the same time, each state designs own indicators according to the identification of its specific issues.

There are two types of the documents containing all defined indicators, principles of their evaluation and logical functioning of their management system. These two documents are called State Safety Programme and State Safety Plan (SSP and SSp). The next chapter is focused on these documents and it also introduces European Aviation Safety Plan (EASP) developed by EASA and Global Aviation Safety Plan (GASP) developed by ICAO.

SPIs and State Safety Programme

A global approach to the aviation safety on the state level is an issue lately considered by the ICAO as an effective way of regulation of this area. In that matter, a new Annex 19 to Chicago Convention from 1944 brings a requirement that all states must develop an SSP. SSP, as it was defined in ICAO Doc. 9859 is an integrated set of regulations and activities developed in order to improve safety. One of the important parts of the SSP are SPIs. In practical, these include High-level safety objectives supported by relevant safety indicators (SSP Element 1.2) [1]. ICAO Doc. 9859 introduces a requirement that each state must be able to control safety performance of the aviation service providers effectively. Civil Aviation Authority should review targets, alert settings and SPIs given by the service providers (SSP Element 2.2) [1].

Besides the fact, that all Annexes to Chicago Convention are considered as standards, their implementation in all ICAO member state is mandatory. In order to get actively involved in the safety issues area, ICAO developed Global Aviation Safety Plan (GASP). Its main purpose is to point out the specific problems and to offer proper solutions.

European approach is similar to the global one. Naturally, ICAO standards are the basis on which European approach is developed. The main difference compared to the global approach is in its orientation on a specific region, in this case on European environment and all its specifics. A whole process resulted with establishment of the European Aviation Safety Plan (EASP), designed according to similar plans previously developed by member states. This approach is also known as bottom-up approach [2].

If we compare SSP and SSp, the main difference could be found in a different view on issue levels. The SSP is mainly oriented on general risks and general approach to their solution. More specified risks as well as specific activities leading to their mitigations are subjects of SSp. This implies that EASP as document designed according to different Safety Plans is more detailed document, but as well as GASP represent only supporting document whose complete implementation is not mandatory for member states [2].

Reporting System – SPI's Foundation

According to ICAO requirements, each member state is supposed to establish system for mandatory and voluntarily reporting of the incidents, accidents and serious events. The main goal here is a simplification of the safety-related information collecting process [3]. These information are the main instrument necessary for proper functioning of the safety management. The more information available automatically increases the probability of the problem area recognition. That is a reason why majority of the countries support a Just Culture concept, which implies that person reporting his/her error will not be punished, except in the case that error represents a willful violation or negligence. Although the Just Culture is a main aspect we are focusing on, other Safety Culture elements must not be forgotten too. In that matter, Safety Culture as a whole represents an important proactive element of the SMS.

In the case of Czech Republic, a current reporting system is structurally in line with the Annex 13 of the Chicago Convention. In case of incident, accident or specific events authorized body (in Czech Republic body called ÚZPLN) and aviation organization accredited by this body, starts an investigation. All investigation findings are then sent to the system ECCAIRS whose analytical functioning is in line with ADREP taxonomies developed by ICAO.

As it was previously mentioned, some ICAO member states developed mandatory and voluntarily reporting systems. The United Kingdom developed aviation mandatory reporting system called MORS (Mandatory Occurrence Reporting Scheme) [4]. This system is linked to other reporting systems such as CHIRP (Confidential Human Factor Incident Reporting Programme) or UK National Wake Vortex Reporting System [4]. Reporting in Finland is performed through standardized reports (LU3626) [5] [6] verified by Finnish Transport Safety Agency. Incidents or Accidents must be reported to Finnish Safety Investigation Authority as well.

Besides mandatory, some countries developed their own voluntarily reporting system. Through this system, a person can report an event that could have negative impact on safety. Clearly, events reported through this system do not belong to the group of events whose reporting is considered as mandatory. A good example of such a system is SWANS (Swiss Aviation Notification System). The advantage of these systems is possibility of anonymous reporting, enabled in order to increase the number of reports.

Collected data must be properly stored. An objective here is to store all information from reports in a secure way and to make them simultaneously available for further analyzing and sharing with respective subjects. Belgium recognized this issue and set an objective in its Safety Plan to form National Safety Library. Among other things, this library will serve as storage for aviation safety report data [7].

State Level Indicators – Application in Risk Management

A proper functioning of the SMS helps the state in terms of sufficient overview on the current risks and their severity. The process of the SMS proper functioning insurance must be dynamic and constantly checked in order to ensure that state requirements are relevant and suitable according to current situation within respective industry, organization or at the service provider. State is supposed to act as a partner in a risk mitigation process. Information and experiences distribution and sharing within the country and international subject also represents one of the main state objectives.

An important element of any risk management is a setting of the acceptable level of safety. This should be an issue regulated by bilateral agreements between state and respective organization or service provider [8]. The reason for this lays in diversity of the concerned organization and service providers, not only in terms of performed operations but in terms of scope of activities too. Here, we are coming to the point of SPIs application and setting of the specific safety objectives. The main state's role here should be to support and motivate organizations and service providers by requiring a higher than already valid level of safety [9].

International Experiences

In the SSPs and Safety Plans developed by the countries within EU [10], risks identification and the effort for their classification is clearly noticeable. Old French Safety Plan from 2009 defines two groups of risks, the general and specific risks. It also defines its purposes, some of which are stated in the following list. List also contains some of the general and specific risks mentioned in the safety plan [11]:

Purposes of the SSP

a) Safety Culture
b) Safety Performance
c) Information and qualifications
d) Training

General risks:

a) Improve expertise and training in dealing with human factor
b) Make effective safety measures the priority when regulating and monitoring the air transport industry
c) Limit the risks associated with the interfaces between the various systems run by operators
d) Identify the reasons for and react to any deliberate breach of the rules or routine deviation from procedures

Specific risks:

a) Reducing the risks linked to aircraft loading errors and entering data into the Flight Management System (FMS)
b) Reducing the number of runway incursions and limiting the seriousness of any consequences of such an undesirable event
c) Reducing the number of unstabilized approaches and limit the seriousness of any consequences of such an undesirable event
d) Reducing risks linked to icing

The main difference between respective Safety Plans developed by EU countries is noticeable in a way of risk classification. In the United Kingdom, risks are classified according to the aviation industry sector (general, commercial or private aviation). In addition, the plan defines a group of the most significant risks [12]. Finland applied different approach, where risks are classified by severity into 3 main levels [13]. The existence of these different approaches in risks classification is justified by the lack of the common frame applicable in all countries.

According to all mentioned facts, we could say that France already has a general overview of the currently existing risks and that is now passing through the phase of the safety indicators evaluation. These indicators are based on the general and specific risks, where general ones are directed to proactive indicators and specific ones to reactive indicators.

The indicators evaluation is a next step in the process. It should be followed by the effort leading to the safety performance measurement. The next important step is agreement on the acceptable level of safety. Many of EU countries are currently in a process of risks and indicators determination. Finland and Ireland are the ones that made a biggest progress in the area of indicators and safety performance evaluation. Their indicators have been well structured both in terms of their description (to which risks are they relating to, what cases belong there or not) and their data resources.

Application of the SPIs is in a fact a matter of the future and countries experiences. Whole process requires time before we could discuss actual safety performance of the system. In any cases, it is clear that performance measurement and the following setting of the specific objectives is a most probable development scenario in the area of risk management lead by the state.

SPI – New Trends

From 2014, France applied new Safety Plan. Beside commercial aviation, this plan refers to recreational aviation and helicopter operations as well [14]. It represents logical upgrade of the previous plan from 2009. The main difference noticeable between those two is a way of classification and perception of the risks. In this sense, the new plan defines two basic groups of objectives, systemic and operational.

Systemic objectives, whose development was based on the general risks determined in the previous plan, are now applied on the general aviation too.

Operational objectives on the other hand, are not oriented on the specific risks but on different areas as a whole. The following examples are just some of the defined operational objectives in the new French Aviation Safety Plan:

1) Improving the management of approach and landing phases
2) Managing adverse meteorological condition better
3) Reducing the risk of mid-air collision involving commercial aircraft
4) Adopting a global approach to safety on a platform

Other countries often identify completely different risks in their plans, but as a matter of fact, the plans contain many common risks, which are represented in various forms.

Conclusion

The current SPIs design is passing through natural process of transformation. Some countries do not have system for safety indicators evaluation. On other side, there is another group of countries that created particular SPIs for which they are collecting necessary data. This is a phase of initial indicator definition. The third group consists of the countries that passed this phase and are now in a process of their implementation into different functional units. EU Regulation no.376/2014 represents a kind of a support for SPIs determinations. This regulation defines the different problematic areas and links to the existing system ECCAIRS and ICAO ADREP taxonomy.

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AIRPORT CONNECTIVITY, AN ESSENTIAL ELEMENT FOR ECONOMIC PERFORMANCE

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Abstract *– Today's connectedness of the global population has had profound implications for the way in which we generate economic growth. As technology advances and expertise becomes even more specialized and in-depth, less and less products and services can be created by one person, or even one nation or society. Trade, tourism, foreign direct investment and most fundamentally, increased productivity, all tally closely to the connectedness of a people. Every community and society, for ensuring their economy growth need connections for acting in a global knowledge economy.* ***Europe's air connectivity*** *is therefore an* ***essential element of its competitiveness*** *– and an integral element for* ***economic growth*** *and* ***job creation****. Improved connectivity can further enhance an economy's performance by making it easier for firms to invest outside their home country, which is known as foreign direct investment (FDI). Given this, a thorough understanding of an airport's connectivity is equally important for airport management as it is for economic policy makers. Alongside air traffic figures, connectivity will become another essential driver of business performance for airports, as well as a measure of the associated benefits for their communities. In our paper we will analyze the airport connectivity for Europe, Romania and also we present comparative analyses for Central and East European countries. As conclusion, we propose some axes for governmental politics in air transport and also a common airport-airliners strategy..*

Key words – airport connectivity, Central and Eastern Europe, Romania, comparative assessment

WHY AIRPORT CONNECTIVITY IS IMPORTANT?

On the morning of July 25th 1909 boarded on a monoplane designed by engineer Raymond Saulnier, Blériot XI crossed the English Channel during a flight of 38 km in 32 minutes. In 1913, Aurel Vlaicu had the first attempt to cross the Carpathians, but unfortunately this was a failure. It was just the beginning of an era in which we can no longer live without being connected permanently either virtually through the already popular portable telephone, either by the plane that is about to turn into a mean of mass transport. Today, in one day, the English Channel is crossed by approximately 240 aircraft and the Carpathians are flown over by approximately 2,300 aircrafts.

Connecting today's global population has deep implications in the way in which the growth is generated. Just like technological progress, the expertise is also becoming increasingly more specialized and developed, and the products and services can be created less by a person, a nation or a society. Trade, tourism, foreign direct investments and most importantly, increased productivity, they are all closely related to the level of opening or links of a nation. Any community or society needs connections for operating in a globalized knowledge society in order to ensure their economic growth.

The plane transforms economic markets into a global market without borders, thus in 2010 48 million tons of goods were transported, representing 35% of world trade by value. Air transport stimulates the tourism. Over 51% of international tourists travel now by air. Aviation accounts for more openness and new collaborations, both through the possibility of opening new destinations, but also by supporting other sectors as for example the tourism, where 34.5 million jobs in the tourism sector. Air transport is extremely important for the connectivity of the developing countries with important consequences on the labor market. For example, in Africa, it is estimated that 2.5 million people directly employed in tourism are supported by the tourists coming from other continents by air, representing 34% of all tourism jobs in Africa.

Increasingly close relations between countries as well as amplification of their perspective, both individual and country level, lead to a growing number of cross-border journeys. Similarly, the relaxation of restrictions on the movement of goods and people across borders facilitates social development and economic networks that will cause long-term implications for the geographical evolution of air connections. This improved flow of people and goods brings benefits both for the countries of destination and for the origin countries thus encouraging social integration and economic growth.

The greatest economic benefit of increased airport connectivity it's the impact on long-term performance of the economy, usually by increasing overall level of productivity. Higher productivity outside the aviation sector is generated through two main channels: the first consisting on the effects on domestic companies of increased access to foreign markets and increased foreign competition in the domestic market, and the second being the free movement of capital and increased labor mobility between countries.

As is mentioned in ATAG Report 2012, an improved connectivity:

• opens new markets and boosts exports while at the same time, increases the competition and the choice in the home markets based from foreign- based producers, encouraging firms to specialize in areas where they have a comparative advantage;

• Can lead to lower costs and prices charged by companies that have a comparative advantage (such as innovative products and services), beneficiaries of this process are thus domestic consumers;

• Opens domestic markets to foreign competitors, which may also be an important factor for reducing production unit costs, either by forcing local companies to adopt the best international practices in production and management, either by encouraging innovation;

• can benefit domestic customers through competition by reducing the mark-up over cost that firms charge their customers, especially where domestic firms have hitherto enjoyed some shelter from competition.

Improvement connectivity can further enhance even economic performance by easing the investments of companies outside their home country, which is knows foreign direct investment (FDI). These investments necessarily involve staff mobility: for technical know-how for management oversight, service or meetings with clients.

Increased connectivity also allows companies to exploit the speed and reliability of air transport to ship components from remote locations without the need to hold expensive stocks of inventory as a buffer. Less tangible, but equally important, an enhanced connectivity leads to increased passenger traffic and trade. In turn, this can lead to a more favorable environment for foreign companies in developing more links with the outside world, thereby realizing a global environment more business-friendly. In a survey of 625 companies in five countries (ATAG Report, 2012), correspondents considered the lack of good transport links by air as one of the main factors that determine not making an investment.

On average, 18% of companies reported that lack of good transport links by air has affected their investment decisions in the past. Among the investments that have been affected, 59% were made in other places with better air transport services, 18% went on anyway, but with significantly higher costs, while in 23% of cases was not made any investment.

Airport connectivity is largely dependent on the facilities provided by an airport to determine the airlines to use the airport. Therefore investment in airport development are crucial in the development of connectivity. In 2010, airports around the world have allocated around 26 billion for capital expenditures for new infrastructure, building new capacity to meet growing demand, improving existing facilities in order to increase efficiency and building energy efficient terminals.

. WHAT THE MEANING OF "CONNECTIVITY"?

Traditionally, the connectivity is represented by the number of destinations or the number of direct flights offered by an airport. Although valid in itself, this method does not provide insight into indirect connectivity and hub connectivity of an airport. The model connectivity NetScan (ACI, Airport industry connectivity Report, 2014) is based on a more holistic approach and takes into account all three types of connectivity.

NetScan model identifies first all direct and indirect connections (one-stop) available for an airport-pair (fig. 1). The model uses as input the passenger flight schedule data on direct flights. The ACI report, data source regarding connectivity used in this work was considered flight schedules for the third week of June. In the model, indirect connections are created by connecting two direct flights, taking into account the minimum and maximum connecting times. Indirect connections are possible on any given airport between: flights of the same airline or flights of airlines, which are members of the same alliance or cooperate by agreement codeshare.

Fig. 1 Air connectivity

Composition of alliances and codeshare considered are those listed for the current year in which the analysis is made.

How indirect connections are less attractive to passengers than direct connections following the addition of circuit transfers times, each connection is weighted for its quality by a factor, on which we call quality connection coefficient. This coefficient can vary between zero and one. For example: a direct non-stop flight operated by a jet aircraft is considered as a flight with a maximum value of quality coefficient which is one. The quality factor of indirect connections will always be lower than one, because at the travel time it's added the transfer time and the circuit time. The same things applies for indirect multi-stop connection or direct connection with a turboprop operated, cases in which passengers face a lower quality flight due to a longer travel time. The connection with too long travel time in relation to the theoretical direct flight time will be assigned a quality factor value 0. As such, these connections are considered unrealistic travel options for the passenger.

Summing the quality adjusted connectivity values offered by an airport on a certain airport-pair gives the total connectivity on the airport-pair. Summing direct and indirect connectivity offered from an airport yields the airport connectivity, which measures the connectivity available to passengers departing from the airport. Adding up hub connectivity (fig. 2) by transfer (hub) airport yields the connectivity offered via the airport, which gives an indication of the performance of an airport as a transfer point.

III. THE CALCUL OF THE QUALITY COEFFICIENT FOR THE INDIVIDUAL CONNECTIONS

The algorithm for determinating the quality coefficient of the individual connections is:

Step 1: The determination of the maximum allowable perceived travel time.

We use :

$t_{x(h)y}^{perceived,max}$= maximum allowable travel time perceived between airports X and Y (1)

The maximum allowable perceived travel time depends upon the non-stop flight time between both airports.

Fig. 2 Hub connectivity

and a factor which increases with the distance between the airports.

We use :

$t_{xy}^{flight,nonstop}$ = the non-stop flight time between airport X and Y (2)

The non-stop flight time is determined according to the geographical coordinates of airports X (origin) and Y (destination) and the flight speed of an average jet aircraft taking into account the time needed for take-off and landing.

With the notations (1) and (2), we obtain:

$$t_{xy}^{perceived,max} = t_{xy}^{non-stop\ flight} + 5*\log\left(t_{xy}^{non-stop\ flight} + 0.5\right) \quad (3)$$

Step 2: The determination of the actual perceived travel time

We use:

$t_{x(h)y}^{perceived,actual}$ = actual travel time perceived between x and y airports

$$t_{x(h)y}^{perceived,actual} = \begin{cases} t_{xy}^{flight,actual}, & \text{for direct flights} \\ (t_{xh}^{flight,actual} + t_{hy}^{flight,actual}) + P_{xy} * t_{h}^{transfer}, & \end{cases} \quad (4)$$

where, P_{xy} is a factor which decreases with the distance between x and y airports.

Step 3: The calculation of the coefficient of connection quality

From the above:

$$\begin{cases} 1, & \text{if } t_{x(h)y}^{perceived,actual} \le t_{xy}^{nonstop\ flight} \\ 1 - \dfrac{t_{x(h)y}^{perceived,actual} - t_{xy}^{nonstop\ flight}}{t_{xy}^{perceived,max} - t_{xy}^{nonstop\ flight}}, & \text{if } t_{xy}^{nonstop\ flight} < t_{x(h)y}^{perceived,actual} < t_{xy}^{perceived,max} \\ 0, & \text{if } t_{x(h)y}^{perceived,actual} \ge t_{xy}^{perceived,max} \end{cases} \quad (5)$$

IV. THE CONNECTIVITY IN EUROPE

Between 2004 and 2014 the connectivity of Europe's airports has increased by +38%, almost a perfect match of the increased number of passengers between 2004 and 2013 (which was +37,4%). This increase of the total connectivity is the result of the +19% increase of the direct connectivity and the increase of +50% of the indirect connectivity.

At the European level there is a close correlation between the level of the airport connectivity of the countries and the welfare of their population. In the figure 3, we can observe the position of the European countries function on the connectivity and the GDP per inhabitant.

Due to the so called network impact, a direct connection from the X airport to the Y airport would also normally generate an increase of the indirect connection number from the X airport to other airports via airport Y. In the past 10 years, the impact on the network was consolidated in Europe within a bigger increase of the direct connectivity of the hub airports VS non hub airports, by the development of the airlines' alliances and the consolidation of other types of cooperation between the airlines. As result, while each direct connection to a hub generated 2,7 onward connections in 2004, this number had increased to 3,4 in 2014.

Between 2004 and 2014 the total connectivity of the non-EU airports increased with 107%, while the growth of the connectivity of the EU airports reached only +27%. This shows the evolution of the traffic in Europe, where the airports outside of EU showed a growth of 125% for the volume of passengers between 2004 – 2013, while on the EU's airports the volume of passengers for the same period of time increase with only +23%.

Between 2004 and 2014, all airport groups showed a growth of their total connectivity. The most notable growth of 46% was shown by the Group IV airports (annual traffic <5 million passengers), while the lowest growth (+34%) was shown by the Group I airports. This shows especially the dynamic development of the low cost airlines, which established new direct connections

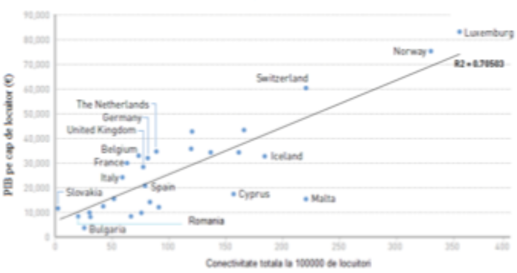


Fig.3 The corelation between the connectivity and the GDP for the European countries (Source: ACI 2014)

from small and regional airports, gaining a 23% growth for the direct connectivity. Another reason of this fact could be the new opportunities which appeared on these airports as a result for the network impact, within the realized connections via bigger airports (+62% indirect connectivity).

There are also less good results, like the decrease of the direct connectivity (7%) from 2008 in the EU, which remain suboptimal to Asia. The most affected was the regional connectivity and the risk of it decreasing more in the future still exists.

The Report Airport industry connectivity (ACI, 2014) reveals that while hubs in EU were more active than small and regional airports in terms of direct connectivity, they still find a significant competition in the hubs situated in Turkey, the Gulf and in a lesser extent, in the ones from Russia.

There is also to be remarked that a growing share of the connectivity of UE with other regions of the world is made through the hubs situated in the Gulf or in Istanbul or Moscow. Concerning the intercontinental connectivity, the UE hubs were overshadowed by the Gulf hubs.

Starting with 2004, the UE hubs lost 10% of their market share concerning the indirect connections outside Europe. They decreased under the level of the hubs in the Gulf – if we speak about the intercontinental connectivity. As an example stands the connections offered by hub airports between world's regions, other than the ones they are located in. In 2004, the level of the intercontinental connectivity offered by the first three Gulf hubs (Dubai, Abu Dhabi and Doha) was well below that the top three European hubs (London-Heathrow, Frankfurt and Paris-Charles de Gaulle): 2,257 versus 7,814. Nowadays, the same top three hubs situated in the Gulf have established a leader position on the market, having twice the level of intercontinental connectivity than the top 3 European hubs: 24,511 v. 12,888. More, only the intercontinental connectivity of the Dubai airport alone (12,820) is equivalent to the international connectivity of London-Heathrow, Frankfurt and Paris-Charles de Gaulle.

The development strategy for the hubs in the Gulf is sustained on every plan. Dubai and Doha airports have radically developed their infrastructure and the airlines Emirates and Qatar spent almost 140 billion euros at Dubai's last saloon in order to purchase aircrafts: Boeing 777 (the new version) and Airbus A380, Emirates having so the most important fleet of Airbus A 380. All these are happening while the area is having an important economic development.

The governments, the airports and the airlines have to know that in the development strategy a traffic growth doesn't necessary mean gaining connectivity. There is to be remarked that if some hubs in Europe will be bypassed, in short time they will stop playing an important role in the global connectivity, things that happens at the moment. These observations should be a starting point in the creation of the governmental and EU institution's strategies.

Warned by these tendencies, the airports in Europe will continue to fight for their own growing connectivity. The development of their network of routes is now part not only of their business, but also of their public warrant. This is not an easy task, because we are having to deal with a mature market in which a big part of the opportunities were already fructified. This is leading to a slower growth of the traffic in the future.

More details regarding the European airports' connectivity are presented in the "Airport Industry Connectivity" Report, published by the Airport Council International – Europe.

Table 1 The situation of the airport connectivity in Romania, 2014

Country	Region	Airport connectivity		
		Total	Direct	Indirect
Romania	Africa	141		141
	Asia - Pacific	367		367
	Europa	2497	951	1545
	Latin America	194		194
	Middle East	59	15	44
	North America	656		656
Total		3914	966	2947

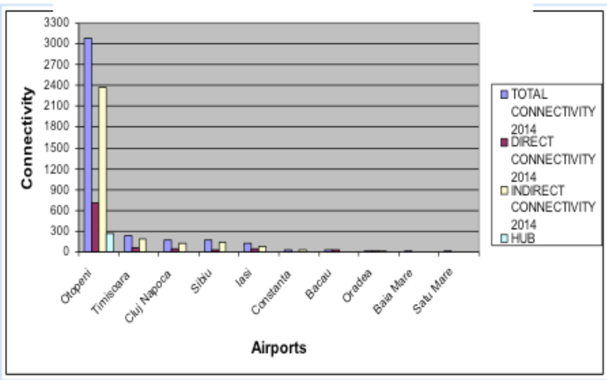
V. Airport connectivity in Romania

In Romania, in 2014, the total airport connectivity is 3914: the direct connectivity's value is 966, while the indirect connectivity is 2947 (ACI, Report on airport connectivity, 2014). From 2004 to 2014, Romania's annual rate of growth for the total connectivity was 6% (direct: 4%, indirect: 7%, hub: 6%). These increases are correlated with the growth of the number of passengers (Table 3 and 6 and Figure 6) and with the evolution of the GDP in Romania (Figure 6). In Table 1 we can observe in detail Romania's connectivity with different regions of the globe. It is easy to note that Romania has a direct connectivity based on short and medium currier flights, the growth of the direct connectivity being represented in an important proportion by the national airline, TAROM, and by the low cost airlines.

When talking about the connectivity by individual airports, between 2004 – 2014, 7 of Romania's airports (Otopeni, Cluj, Iaşi. Sibiu, Bacău, **B**aia Mare and Satu Mare) have recorded a growth for the total connectivity; 2 of them have recorded a decrease and 6 of them (Otopeni, Iaşi, Sibiu, Bacău, Baia Mare and Satu Mare) have recorded an increased direct connectivity. Having a higher value for the total connectivity, 3083, Otopeni Airport is situated on the 42th place in Europe's top of airports, followed by Timisoara Airport , situated on the 190th place with a total connectivity of 240, Sibiu and Cluj Airports which have the same value for the total connectivity, 175 and which are situated on the 206th and 207th places. Table 2 shows the total, direct and indirect connectivity for each airport in Romania. The graphical illustration can be seen in Figure 4.

Otopeni Airport recorded an important growth for the total connectivity, 82%, growth which is resulted after summarizing the direct connectivity's growth by 90% and the indirect connectivity's growth with 80%. Hub connectivity records in the same period, a growth by 133%. Increased airport connectivity correlates with the allure of economic development at national and regional level (Table 4) and with significant investments made in the airport. However, the increasing connectivity is below the growth of passenger traffic by 157% between 2005-2013 (Table 3, Fig. 6).

Fig. 4 Airport connectivity in Romania, 2014



The most spectacular growth of the total connectivity is remarked on Iasi airport, by 475%, which means 125 as an absolute value. However, the level of connectivity places Iasi Airport on the 236th position within the EU's airports (Table 2).

Even if Timişoara Airport is situated on the 2nd place among Romania's airports regarding the total connectivity, during 2004 – 2014, it shows a decrease by -4% for the total connectivity and by -62% for the direct connectivity, it still shows an important growth when speaking about indirect connectivity (Table 2). More than this, after an important growth for the passenger's number during 2005 -2013, the airport shows a sudden drop of the passenger number since 2012 and especially since 2013 and also o a decrease of the hub connectivity by -100%. An explanation for this could be the development strategy for some connections with hub airports which meant the growth for indirect connectivity.

Country	Region	Airport connectivity		
		Total	Direct	Indirect
Romania	Africa	141		141
	Asia - Pacific	367		367
	Europa	2497	951	1545
	Latin America	194		194
	Middle East	59	15	44
	North America	656		656
Total		3914	966	2947

These variations could be explained also by the decision taken by the company CarpatAir of not using anymore the „hub-and-spoke" model, which was implemented by the Company on this airport.

The spectacular growths of the indirect connectivity for some airports in Romania, in majority of the cases, represent the effect of the network impact presented in the 4th paragraph.

It is interesting to remark that in 2014, 5 airports: Otopeni, Cluj, Timişoara, Sibiu and Iaşi are responsible for the connectivity of the airport industry of Romania, as it can be seen in figure 5. Meanwhile, the absolute value of the traffic of these airports (9.857.234) represents 91,7% of the passenger traffic for Romania's airports.

Table 2 Individual connectivity for Romanian Airports *(source: ACI Report regarding the connectivity of the airport industry, 2014)*

Airport	Connectivity							
	Absolute 2014				Growth during 2004 - 2014			
	Total (for the airport)	Direct	Indirect	Hub	Total (for the airport)	Direct	Indirect	Hub
Otopeni	3083	712	2371	269	82%	90%	80%	133%
Timişoara	240	57	183	0	- 4%	- 62%	80%	-100%
Cluj	175	53	122	0	56%	-19%	158%	-
Sibiu	175	34	141	0	704%	80%	4800%	-
Iaşi	125	43	82	0	475%	296%	656%	-
Constanţa	36	5	31	0	-	-	-	-
Bacău	33	33	0	0	24%	112%	- 100%	-
Oradea	20	12	8	0	- 24%	- 49%	242%	
Baia Mare	10	5	5	0	177%	142%	224%	
Satu Mare	8	6	2	0	61%	45%	132%	
Suceava	n.c.	n.c	n.c	n.c	-	-		
Tulcea	n.c.	n.c	n.c	n.c	-	-		
Băneasa	n.c.	n.c	n.c	n.c	-			
Craiova	n.c.	n.c	n.c	n.c	-			
Arad	n.c.	n.c	n.c	n.c	-			
Târgu Mureş	n.c.	n.c	n.c	n.c	-			

As for the air passenger traffic (Table 3), with 9.674.226 passengers who have used the Romanian airports in 2012, Romania stands on the 17th position in the EU, being overrun by countries like Czech Republic (more than 17 million passengers). The next positions are held by smaller countries with less citizens: Hungary, Cyprus (which holds the European record for the highest number of passengers for 1000 inhabitants), Bulgaria, Latvia, Malta, Slovakia, Lithuania, Estonia, Luxemburg and Slovenia (Eurostat, 2014).

When speaking about indicators for the volume of transported passengers per 1.000 inhabitants, in 2011 Romania has 483 passengers/1.000 inhabitants, which represents approximately the fifth part of the EU average, 2.206 passengers /1000 inhabitants.

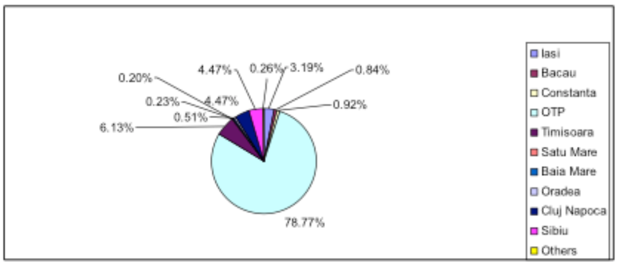


Fig. 5 The share of the total connectivity of all airports in the total connectivity of Romania

The biggest Romanian airports, the main entrance gate of the country, "Henri Coandă" - Otopeni Airport was situated in 2011 on the 35th place regarding the number of movements, thanks to the 99.500 landings and take offs (European Commission, 2013). It was also situated on the 46th place thanks to the number of passengers who used this airport (Eurostat, 2013). In any case, the traffic of passengers on Otopeni is growing. For example, july 2014, according to ACI Communiqué, Airport Otopeni brought a growth of 9.8% comparing the same period of 2013, the value for the overage growth on European level being 4.6%. As on the European level, in Romania there is a correlation between the GDP's level for each region with the level of the airport connectivity. The exception is Otopeni Airport, which is a national interest and its link is not that strong with the regional GDP. Other airports situated in Romania are considered as being "regional" and they are situated in the 4th group, according to the ACI classification.

Table 3 The evolution of the passenger traffic in Romania 2005 – 2013 (source: Eurostat 2014)

Airport	Passenger trafic								
	2005	2006	2007	2008	2009	2010	2011	2012	2013
OTP	2972799	3497938	4937683	5063555	4480765	4802510	5049443	7120024	7643467
Avram Iancu Cluj	202556	244366	390521	752181	834400	1028907	1004927	954400	1035438
Timişoara	611705	750934	836574	890704	973873	1130453	1202925	1039109	757096
Târgu Mureş	12571	47274	159700	70173	84062	74856	257303	300427	363389
Bacău	36261	40601	112854	116492	195772	240735	336961	393352	307488
Iaşi	41959	71378	120000	146000	148538	164000	184225	173248	231933
Sibiu	48896	63629	105654	141012	154160	198751	176908	176503	189300
Constanţa	110900	71236	42331	60477	68690	74587	73713	94641	73301
Arad			26284	130000	100000	21978	1124	14844	39901
Craiova				12988	15130	23629	-	29626	40291
Oradea				38843	39051	40404	46230	40494	39440
Suceava	7734	12766	20728	23398	32561	34437	27208	25143	20054
Baia Mare				22307	23818	19020	22462	17523	16798
Satu Mare				7298	11101	18859	23469	19.289	16192
Băneasa	385000	700000	1000000	1768000	2005694	2118150	2400000	n.c	n.c
Tulcea								780	

In the last few years in Romania were made important investments in order to develop the infrastructure on Otopeni, Cluj, Iași and Craiova airports – Oradea being developed now. With the new changes and improvements, these airports have now the capacity of participating in the regional and national economic growth. Generally, as shown in Table 3 and in the graphic from Figure 6, Romanian airports have grown and Romania reports growths when talking about passenger traffic and the level of connectivity.

It is mandatory to highlight that the development of the airport infrastructure is a necessary condition in order to generate an economic growth, but this is not enough. It is also needed an optimal utilization of the air transport, and the economic companies have to use it with the purpose of enhancing the foreign trade and the cooperation relations. Also, for the capitalization of the airport, it is very important to follow and finish them according to initial projects, because, in one airport's case, not finishing the work leads to lack or poor utilization, the results being below the planned ones. The partial use makes impossible to assure the safety conditions required for some specific procedures, fact which leads to the non return on investment. Of course, the objectives of growing the air traffic and the improvement of the safety for airport operations won't be accomplished either.

Tabelul 4 The corelation between GDP, number of airports and connectivity when talking about the level of regional development in Romania (source: INS, 2014)

Regions	Number of airports	GDP per region (bil. euro) 2013	GDP per capita (euro) 2013	Total connecti-vity 2014	Total connectivity for 100000 inhabitants	Passenger traffic per region (2013)
Bucharest -Ilfov	2 (OTP, BBU)	35.39	15 783	3083	138	7643467
West	2 (TSR, ARW-nc)	14.46	7 382	240	12	796997
Nord - West	4 (CLJ, OMR, BAY, SUJ)	15.09	7289	212	8	1107868
Center	2 (SBZ, TGM-nc)	16.43	8612	175	7	552689
Nord-East	3 (IAS,BCM, SCV)	15.30	5528	158	4	559475
South - East	2 (CND, TCE-nc)	14.96	6974	36	1.3	75188
South - Muntenia	0	17.90	7033	0	0	
Sud-Vest-Oltenia	1 (CRA-nc)	11.84	6743	n.c	n.c.	
Romania	**16**	**142.245**	**7100**	**54 938**	**3914**	**10775975**

VI. Romania compared with the Central and East European countries

Within the EU, in 2014, Romania is situated on the 22nd place when speaking about the total connectivity, being surpassed by countries from Central and Eastern Europe – Poland and Czech Republic (Table 5, Fig. 7). The highest value of the annual medium rhythm of growth of the total and direct connectivity during 2004 – 2014, between Central and East EU countries, was recorded by Bulgaria, with 8% and 7% followed by Romania with 6% and respectively 4%. We can also underline that Poland is remarked with a high level of hub connectivity, 2230, 10 times more than the one of Romania, which is 270. More than this, in Romania there are 16 airports, while Poland has 14.

Continuing this analysis, it is to be remarked that Poland and Czech Republic are situated in a better position when talking about direct connectivity with other continents than Europe, whose value are 59 for Poland and 26 for Czech Republic, comparing 15 for Romania. We can also observe a sustained growth rhythm for the indirect and hub connectivity of Serbia and Moldavia.

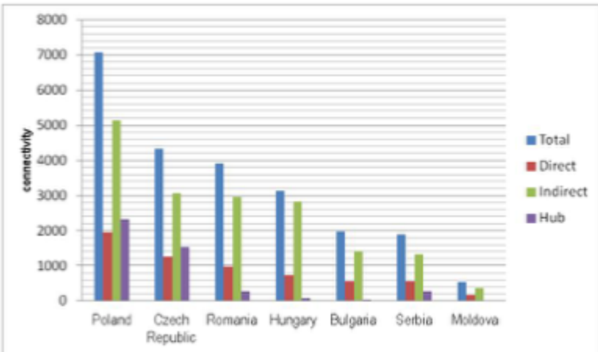


Fig. 7 The connectivity in Eastern and Central Europe

The highest passenger traffic was registered in Poland, followed by Czech Republic and Romania. From the figures number 8 and 9, we can observe how the important growth of the Poland's GDP is in concordance with the highest traffic level from all the compared countries. The evolution of the traffic follows the GDP's evolution of each country. Poland is an exception. Although Poland didn't register a drop of the GDP's value in 2009 and 2010, the passenger traffic is still affected by the worldwide crisis.

Table 5 The airport connectivity for Eastern and Central Europe Countries

Country	Connectivity							
	Absolute in 2014				Average annual growth 2004 – 2014			
	Total	Direct	Indirect	Hub	Total	Direct	Indirect	Hub
Poland	7075	1945	5129	2320	5%	4 %	5 %	5 %
Czech Republic	4328	1260	3068	1543	3 %	1 %	4 %	-3 %
Romania	3914	966	2947	270	6%	4 %	7%	6%
Hungary	3121	734	2387	72	1 %	-2 %	2%	-21%
Bulgaria	1969	555	1414	38	8 %	7 %	8%	8 %
Serbia	1887	555	1332	274	9%	5%	11%	18%
Moldova	538	166	372	14	9%	5%	11%	17%

By correlating the values of the airport connectivity (Table 5), the passenger traffic (table 6, figure 8), the evolution of the GDP (fig 9) and the number of airports from the analyzed countries, we can observe that the essential element which generates the traffic's growth and the connectivity is the growth of the GPD, meaning the economic growth, not the number of airports. It is very important to generate economic growth and sustain it within a correct strategy concerning the development of the air transport and infrastructure needed for the airports with a real growth potential for the traffic and the connectivity.

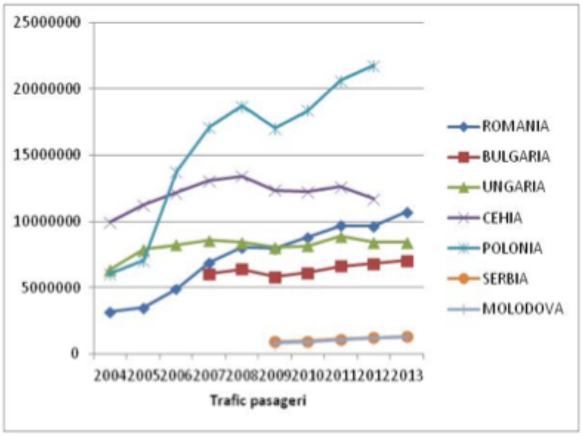


Fig. 8 The evolution for the passenger's traffic in Eastern and Central European countries during 2004 – 2013

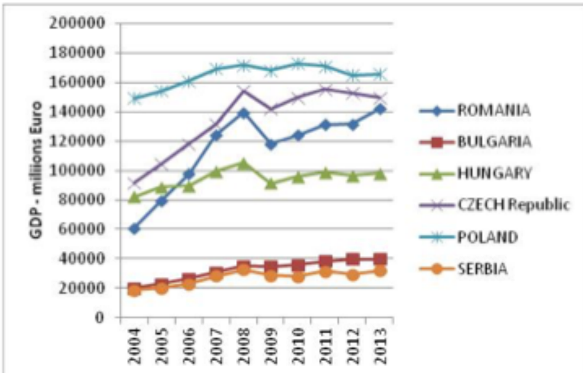


Fig. 9 The GDP's evolution in Eastern and Central Europe

VII Conclusion

1. Both airport infrastructure and airport connectivity are favored and favor the economic growth.
2. The European Union and the national governments should have the same objective: using the aviation in order to sustain economic growth.
3. Airports are in a continuous competition and it is necessary to find solutions as fast as possible in order to align the economic regulations with the air transport market dynamics.
4. It is necessary to have economic regulations in order to stimulate the cooperation between airports and air companies, because only this can
5. lead to a better connectivity through new routes and higher frequencies.
6. It is necessary to concentrate the development airport investments, which have to be according the economic potential of the region, the foreign investor's interest in the region and the existing infrastructure of the airports and the possibilities of creating an efficient intermodal transport.
7. Romania's big airports have to organize their traffic and maybe open new routes which within the network impact can grow their role in the indirect connectivity in the region

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Table 6. Passenger's traffic for some Eastern and Central European Countries during 2004 – 2013 (source: Eurostat)

Country	Number of public airports	Passenger traffic									
		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Romania	16	3192620	3493783	4900134	6908599	8031267	7984057	8848949	9687456	9674226	10745403
Bulgaria	5				6071210	6417873	5838685	6168346	6651562	6819024	7078294
Hungary	5	6380372	7918083	8245920	8580261	8429082	8081067	8174510	8884837	8429843	8459015
Czech Republic	6	9950314	11265764	12171235	13098141	13429149	12367467	12242386	12650532	11742352	
Poland	14	6091886	7080325	13737539	17120015	18727132	17046474	18382517	20634903	21791428	
Serbia	4						926618	985075	1149102	1240709	1320926
Moldavia	2						808096	937030	1046086	1220506	1321236

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The publication of an article in the peer-reviewed journal "INTERNATIONAL CONFERENCE ON AIR TRANSPORT" (INAIR) contributes to growth of knowledge in the field of air transportation. We encourage the best practices and standards of publication ethics and take all possible measures against publication malpractices. It is important to agree upon standards of proper ethical behavior for all parties involved in the act of publishing: authors, editors, peer reviewers and the publisher. EDIS, publishing house of the University of Zilina and the Air Transport Department of the Faculty of Operation and Economics of Transport and Communications, University of Zilina, as publishers of the journal INAIR, take their duties of guardianship over all stages of publishing extremely seriously and we recognize our ethical and other responsibilities.

Duties of authors

(These guidelines are based on existing Elsevier policies and COPE‟s Best Practice Guidelines for Journal Editors.)

Reporting standards

Authors of papers should present an accurate account of the work performed as well as an objective discussion of its significance. Underlying data should be represented accurately in the paper. A paper should contain sufficient detail and references to permit others to replicate the work. Fraudulent or knowingly inaccurate statements constitute unethical behavior and are unacceptable. Review and professional publication articles should also be accurate and objective, and editorial „opinion‟ works should be clearly identified as such.

Data access and retention

Authors may be asked to provide the raw data in connection with a paper for editorial review, and should be prepared to provide public access to such data (consistent with the ALPSP-STM Statement on Data and Databases), if practicable, and should in any event be prepared to retain such data for a reasonable time after publication.

Originality and plagiarism

The authors should ensure that they have written entirely original works, and if the authors have used the work and/or words of others, that this has been appropriately cited or quoted. Plagiarism takes many forms, from „passing off‟ another‟s paper as the author‟s own paper, to copying or paraphrasing substantial parts of another‟s paper (without attribution), to claiming results from research conducted by others. Plagiarism in all its forms constitutes unethical publishing behavior and is unacceptable.

Multiple, redundant or concurrent publication

An author should not in general publish manuscripts describing essentially the same research in more than one journal or primary publication. Submitting the same manuscript to more than one journal concurrently constitutes unethical publishing behavior and is unacceptable. In general, an author should not submit for consideration in another journal a previously published paper. Publication of some kinds of articles (e.g. clinical guidelines, translations) in more than one journal is sometimes justifiable, provided certain conditions are met. The authors and editors of the journals concerned must agree to the secondary publication, which must reflect the same data and interpretation of the primary document. The primary reference must be cited in the secondary publication.

Acknowledgement of sources

Proper acknowledgment of the work of others must always be given. Authors should cite publications that have been influential in determining the nature of the reported work. Information obtained privately, as in conversation, correspondence, or discussion with third parties, must not be used or reported without explicit, written permission from the source. Information obtained in the course of confidential services, such as refereeing manuscripts or grant applications, must not be used without the explicit written permission of the author of the work involved in these services.

Authorship of the paper

Authorship should be limited to those who have made a significant contribution to the conception, design, execution, or interpretation of the reported study. All those who have made significant contributions should be listed as co-authors. Where there are others who have participated in certain substantive aspects of the research project, they should be acknowledged or listed as contributors. The corresponding author should ensure that all appropriate co-authors and no inappropriate co-authors are included on the paper, and that all co-authors have seen and approved the final version of the paper and have agreed to its submission for publication.

Hazards and human or animal subjects

If the work involves chemicals, procedures or equipment that have any unusual hazards inherent in their use, the author must clearly identify these in the manuscript. If the work involves the use of animal or human subjects, the author should ensure that the manuscript contains a statement that all procedures were performed in compliance with relevant laws and institutional guidelines and that the appropriate institutional committee(s) has approved them. Authors should include a statement in the manuscript that informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed.

Disclosure and conflicts of interest

All authors should disclose in their manuscript any financial or other substantive conflict of interest that might be construed to influence the results or interpretation of their manuscript. All sources of financial support for the project should be disclosed. Examples of potential conflicts of interest which should be disclosed include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Potential conflicts of interest should be disclosed at the earliest stage possible.

Fundamental errors in published works

When an author discovers a significant error or inaccuracy in his/her own published work, it is the author´s obligation to promptly notify the journal editor or publisher and cooperate with the editor to retract or correct the paper. If the editor or the publisher learns from a third party that a published work contains a significant error, it is the obligation of the author to promptly retract or correct the paper or provide evidence to the editor of the correctness of the original paper.

Duties of editors

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Publication decisions

The editor of a peer-reviewed journal INAIR is responsible for deciding which of the articles submitted to the journal should be published, often working in conjunction with the relevant society (for society-owned or sponsored journals). The validation of the work in question and its importance to researchers and readers must always drive such decisions. The editor may be guided by the policies of the journal's editorial board and constrained by such legal requirements as shall then be in force regarding libel, copyright infringement and plagiarism. The editor may confer with other editors or reviewers (or society officers) in making this decision.

Fair play

An editor should evaluate manuscripts for their intellectual content without regard to race, gender, sexual orientation, religious belief, ethnic origin, citizenship, or political philosophy of the authors.

Confidentiality

The editor and any editorial staff must not disclose any information about a submitted manuscript to anyone other than the corresponding author, reviewers, potential reviewers, other editorial advisers, and the publisher, as appropriate.

Disclosure and conflicts of interest

Unpublished materials disclosed in a submitted manuscript must not be used in an editor's own research without the express written consent of the author. Privileged information or ideas obtained through peer review must be kept confidential and not used for personal advantage. Editors should recuse themselves (i.e. should ask a co-editor, associate editor or other member of the editorial board instead to review and consider) from considering manuscripts in which they have conflicts of interest resulting from competitive, collaborative, or other relationships or connections with any of the authors, companies, or (possibly) institutions connected to the papers. Editors should require all contributors to disclose relevant competing interests and publish corrections if competing interests are revealed after publication. If needed, other appropriate action should be taken, such as the publication of a retraction or expression of concern.

Involvement and cooperation in investigations

An editor should take reasonably responsive measures when ethical complaints have been presented concerning a submitted manuscript or published paper, in conjunction with the publisher (or society). Such measures will generally include contacting the author of the manuscript or paper and giving due consideration of the respective complaint or claims made, but may also include further communications to the relevant institutions and research bodies, and if the complaint is upheld, the publication of a correction, retraction, expression of concern, or other note, as may be relevant. Every reported act of unethical publishing behavior must be looked into, even if it is discovered years after publication.

Duties of reviewers

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Contribution to editorial decisions

Peer review assists the editor of INAIR in making editorial decisions and through the editorial communications with the author may also assist the author in improving the paper. Peer review is an essential component of formal scholarly communication, and lies at the heart of the scientific method. INAIR shares the view of many that all scholars who wish to contribute to publications have an obligation to do a fair share of reviewing.

Promptness

Any selected referee who feels unqualified to review the research reported in a manuscript or knows that its prompt review will be impossible should notify the editor and excuse himself from the review process.

Confidentiality

Any manuscripts received for review must be treated as confidential documents. They must not be shown to or discussed with others except as authorized by the editor.

Standards of objectivity

Reviews should be conducted objectively. Personal criticism of the author is inappropriate. Referees should express their views clearly with supporting arguments.

Acknowledgement of sources

Reviewers should identify relevant published work that has not been cited by the authors. Any statement that an observation, derivation, or argument had been previously reported should be accompanied by the relevant citation. A reviewer should also call to the editor's attention any substantial similarity or overlap between the manuscript under consideration and any other published paper of which they have personal knowledge.

Disclosure and conflict of interest

Unpublished materials disclosed in a submitted manuscript must not be used in a reviewer´s own research without the express written consent of the author. Privileged information or ideas obtained through peer review must be kept confidential and not used for personal advantage. Reviewers should not consider manuscripts in which they have conflicts of interest resulting from competitive, collaborative, or other relationships or connections with any of the authors, companies, or institutions connected to the papers.

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INAIR 2014

International Conference on Air Transport

Printed by EDIS-Žilina University publishers, November 2014

Edited by Martin Hromádka

First edition

Circulation 100 copies

ISBN 978-80-554-0944-3

ISSN 2454-0471