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New Trends in Civil Aviation 2014

Under patronage of the Dean of Faculty of Transportation Sciences CTU in Prague

prof. Dr. Ing. Miroslav Svítek

Vyšší Brod - Herbertov

18 - 20 May 2014

Název publikace	**Nové trendy v civilním letectví 2014** **New Trends in Civil Aviation 2014**
Druh publikace	Sborník příspěvků z mezinárodní konference Nové trendy v civilním letectví 2014, obsahují nejnovější výsledky vědecké a výzkumné práce v oblasti civilního letectví, konané v Herbertově ve dnech 18 - 20. Května 2014 Proceedings of the conference New Trends in Civil Aviation 2014 containing recent results of research and development in the field of civil aviation held in Prague 18 - 20 May 2014
Vydalo	AKADEMICKÉ NAKLADATELSTVÍ CERM, s.r.o. Brno
Rok vydání	2014
Vydání	první / first edition
Zpracovala	Fakulta dopravní
Kontaktní adresa	Konviktská 20, 110 00 Praha 1
Telefon	224359184
Vytiskla	Nakladatelství ČVUT - výroba
Adresa tiskárny	Zikova 4, 160 00 Praha 6
Náklad	50 ks/pcs
ISBN	ISBN 978-80-7204-891-5

Publikace neprošla jazykovou ani redakční úpravou.
Publication did no pass editorial treatment.

New Trends in Civil Aviation 2014

Foreword

The fourteenth editions of the International Conference New Trends in Civil Aviation 2014 (Nové trendy v civilním letectví 2014) was held in Vyšší Brod - Herbertov under the patronage of the Dean of the Faculty of Transportation Sciences, Prof. Dr. Ing. Miroslav Svítek, and is organized in close collaboration with partner universities: Brno University of Technology, Faculty of Mechanical Engineering, Institute of Aerospace Engineering and the University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Air Transport. The conference chain follows original International Colloquium established in 1999 by distinguished late colleagues, Prof. Ing. Ludvík Kulčák, CSc. a Prof. Ing. Bohuslav Sedláček, CSc.

The scope of the conference arises from the name itself. It is in compliance with contemporary as well as mid-term strategies of R&D and innovations of aerospace, space and air transportation of European Union in the horizon up to 2020. They cover topics as follows:

Reduction of emissions in air transport
Aircraft propulsion systems and alternative fuels
Aircraft design
Air traffic management
Safety and security aspects of air transportation
Environmental efficiency of aviation

Main purpose of the conference is to give an opportunity to young professionals, Ph.D. students to present results of their research and get together with distinguished and experienced professionals from academia, research, industry and civil aviation institutions as a unique forum for exchange of knowledge and experience.

Presented papers and their professional and scientific level is reviewed by the Scientific Committee of the conference and best presented papers will be offered for publication in reviewed magazines Transactions of Transportation Sciences, Czech Aerospace Proceedings and Acta Polytechnica.

Acknowledgements

Conference organizers thank all sponsors for their support of the conference which contributed significantly to high scientific as well as social level of the conference. Many thanks to partner flying training organizations DSA, F-Air and Flying Academy.

With many thanks to all who participated on the preparation and realization of the conference,
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Development of a Novel Centrifugal Compressor Stage for Aircraft Engines

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***Abstract*—This paper presents the ongoing first steps of development of an innovative centrifugal compressor stage designed for use in turboprop aircraft engines. The so-called tandem impeller blading concept shall be compared to the conventional blading design by means of numerical simulation and optimized to achieve the best possible parameters. In this paper, validation of a conventional stage computational model using experimental data is described.**

Keywords- centrifugal compressor, turboprop engine. impeller, vaned diffuser, secondary flow, CFD

I. Introduction

As the air traffic volume has been growing continuously in the recent years, and, according to the estimates available, will continue to do so in the near future, new challenges for aircraft engine designers appear, especially concerning noise, emissions and fuel consumption. The improvement of these parameters is achieved by designing advanced aircraft engine components using state-of-the-art design techniques, such as CFD, rapid prototyping or advanced experimental methods.

Centrifugal compressors are often used in small-sized turboprop, turboshaft and propfan engines as the last compressor stages. Their use in these types of engines brings several advantages. A centrifugal compressor stage usually achieves a substantially higher pressure ratio compared to an axial stage of the same mass flow rate. This means that a centrifugal compressor covers much less axial space than four or five axial stages of the same pressure ratio. Moreover, small centrifugal compressor stages often achieve a greater isentropic efficiency than axial stages when used as the last stages. This is caused by lower mass flow rates in smaller engines which, together with decreasing the chord length in the last axial compressor stages, lead to lower values of Reynolds number. This means that viscous forces play a more significant role in the flow field, thus reducing the efficiency of such axial stage. Using a centrifugal stage, on the other hand, does not negatively affect the Reynolds number.

This paper presents a new approach to centrifugal compressor design which will allow certain types of engines to work with an increased efficiency and thus improve their fuel consumption. The tandem-bladed impeller (described below) will be compared to a conventional impeller to prove the advantages of the new concept. In the first stage of development, described in this paper, the computational model of the conventional stage must be compared to the experimental data available. Afterwards, the stage with the tandem-bladed impeller will be modeled.

Figure 1. M602 High pressure compressor impeller [7]

II. Development of the tandem-bladed compressor stage

A. Previous development

The conventional compressor stage concerned was developed for the M602 turboprop engine by Walter Engines (now GE Aviation Czech) and VZLÚ (Aerospace Research and Test Establishment). The compressor of this two-shaft engine consisted of two subsequent centrifugal stages (low-pressure and high-pressure compressor).

The novel high-pressure centrifugal compressor stage will use so-called tandem impeller blading. This means that the impeller blades are transversely divided in two parts after the inducer (see Figs. 3 and 4). The inducer part of the blades is thus made up of an axial blade vane while the exducer part consists of standard radial blading, including splitter blades. The trailing edges of the inducer blades are placed in half the

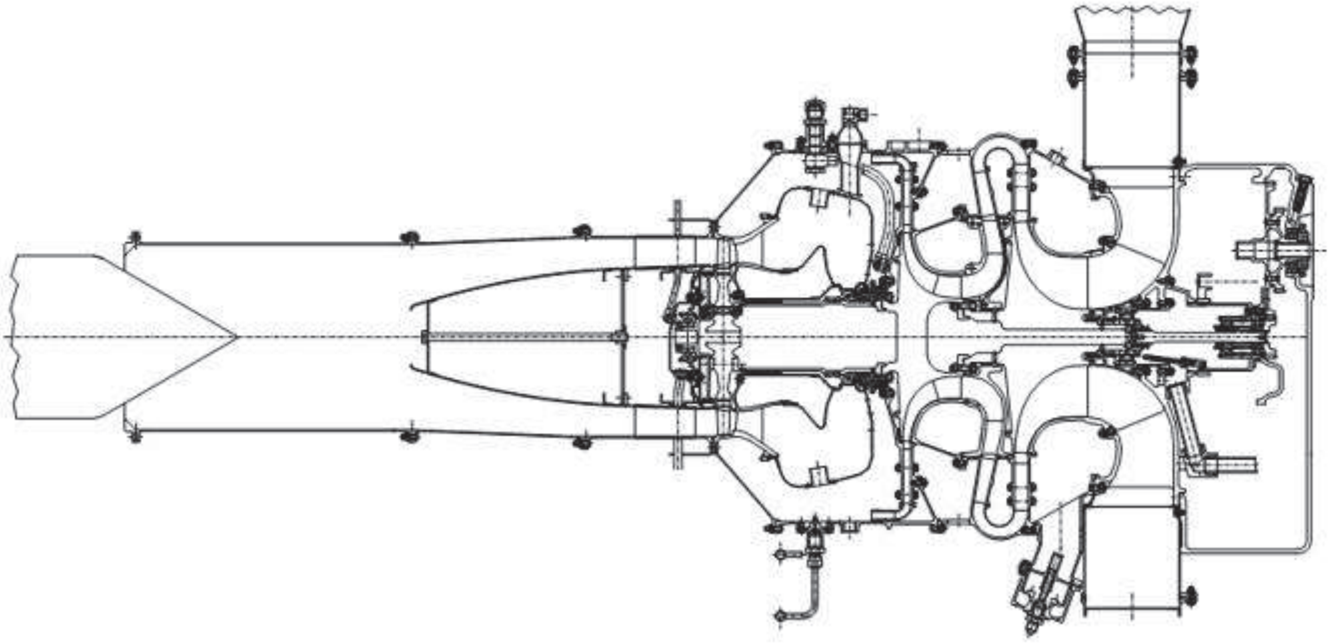

Figure 2. M 602 centrifugal compressor test rig. Left, high pressure stage. Right, low pressure stage [7]

pitch of every second exducer passage. This arrangement positively affects the formation of boundary layers on the impeller blade surfaces. After the inducer parts of the blades, its growth is interrupted and the resulting wake flow is directed into the middle of the downstream exducer channel (Fig. 4). This should result in reducing the size of the wake region at the impeller exit which, in turn, leads to increasing the compressor stage isentropic efficiency. This assumption has already been confirmed by preliminary calculations made in the Institute of Aerospace Engineering, CTU in Prague, which were presented at the ISABE 2005 Conference in München [7].

However, no further steps in improving the tandem-bladed impeller geometry were made. The tandem-bladed impeller was therefore not optimized to achieve the best parameters possible.

The goal of the present research is to find optimal geometries to obtain the highest centrifugal compressor stage isentropic efficiency, highest pressure ratio and the widest mass flow range of stability. A design methodology to achieve such optima shall also be developed.

B. Recent development

Until now, a CAD model of the whole compressor stage (which includes the impeller, the vaneless and vaned diffusers, and the outlet channel) was converted to geometric models used by the ANSYS computational package and the first calculations aiming at calibrating the computed compressor performance curve with the experimental one were carried out.

The data obtained by these computations should indicate whether the computational model describes the existing compressor stage accurately enough. Based on this knowledge, the tandem blades will be modeled and optimized.

TABLE I. HP COMPRESSOR DESIGN POINT PARAMETERS

Mass flow [$kg.s^{-1}$]	4.301
Total pressure ratio	2.407
Isentropic eff. [%]	80.5
Total temp. rise [K]	162.0

III. COMPUTATIONAL MODEL SETTINGS

First of all, the design point of the compressor stage was considered (the design point parameters are given in Tab. I).

The boundary conditions in the compressor design point were set according to the recommendations given in [6]. The authors of this paper claim that different boundary conditions should be chosen in the two respective regions of the performance curve (see Fig. 5).

In the left part (near surge condition), the total pressure inlet – mass flow outlet combination should be more accurate since in this nearly horizontal part of the curve, a substantial change of mass flow rate corresponds to a small change of outlet total pressure.

Figure 3. A study of a tandem-bladed impeller [7]

On the other hand, in the right part of the performance curve (near choke condition), a combination of boundary conditions prescribing the mass flow at the compressor inlet and the static pressure at the outlet should be used. This is because, in opposition to the left part of the performance curve, large variations of total pressure ratio correspond to small changes of mass flow rate. Therefore, this combination of boundary conditions was used for the compressor design point lying in the right, near-vertical part of the performance curve.

For describing the properties of air, a semi-ideal gas model was used in which the constant pressure specific heat capacity c_p and the dynamic viscosity μ depend on absolute temperature T. The functions to determine these dependencies were taken from [4].

The constant pressure specific heat capacity c_p is computed according to a linear formula:

$$\frac{c_p}{R} = a_1 + a_2.T \tag{1}$$

in which R = 8 341 J.kg^{-1}, a_1 = 3.27149, and a_2 = 6.85475444×10^{-4}, while the Sutherland model is used for the dynamic viscosity:

$$\frac{\mu}{\mu_0} = \frac{T_{ref} + S}{T + S}\left(\frac{T}{T_{ref}}\right)^n \tag{2}$$

where μ_0 = 1.712×10^{-5}, T_{ref} = 273 K, S = 111 K, and n = 1.5.

Another important issue to be taken into account, when modeling air flow in a centrifugal compressor stage, is the turbulence model. According to recommendations given by the

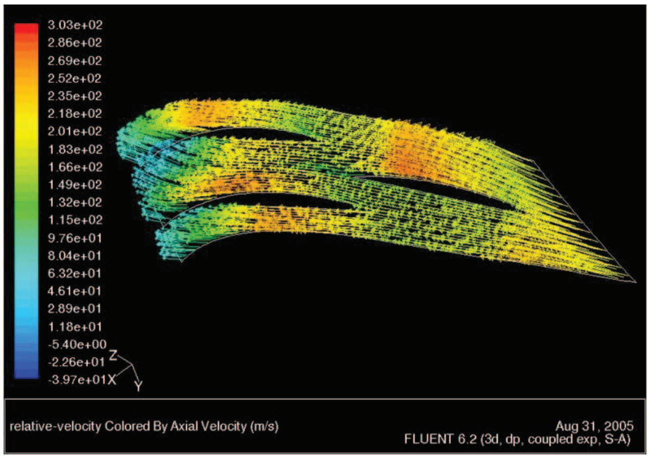

Figure 4. Vectors of relative velocity in a cylindrical layer of the tandem-bladed impeller (a previous calculation) [7]

authors of [1], the RNG k-ε model was chosen which provides a reasonable accuracy without investing an excessive amount of computational time. In [1], the RNG k-ε model was compared to the standard k-ε model and the more sophisticated Reynolds Stress Model (RSM).

The standard k-ε turbulence model is a two-equation model which is based on eddy viscosity concept. In its denomination, k stands for turbulent kinetic energy while ε stands for turbulent eddy dissipation. This model belongs to a group of turbulent viscosity models.

Therefore, the effective viscosity μ_{eff} in the momentum equation is a sum of dynamic and turbulent viscosities (denoted μ and μ_{t}, respectively):

$$\mu_{\mathrm{eff}} = \mu + \mu_{\mathrm{t}} \tag{3}$$

The turbulent viscosity is then computed using the turbulent kinetic energy k and turbulent eddy dissipation ε:

$$\mu_{\mathrm{t}} = C_{\mu} \frac{k^2}{\varepsilon} \tag{4}$$

C_{μ} being a constant (C_{μ} = 0.09 by default).

Since two more unknown quantities are introduced into the system of equations, two additional transport equations need to be solved, one for k, and the other for ε.

The RNG k-ε model uses different values for constants in the transport equation for turbulence eddy dissipation than the standard k-ε model.

As the k-ε turbulence model does not correctly describe the fluid flow in the near-wall region in which viscous forces dominate, a suitable wall function should be chosen to model the near-wall flow field. As a default, a scalable wall function was set.

Based on empirical formulae, wall functions are used for modeling flow field near walls without the need of solving flow in the boundary layer, thus saving computational time.

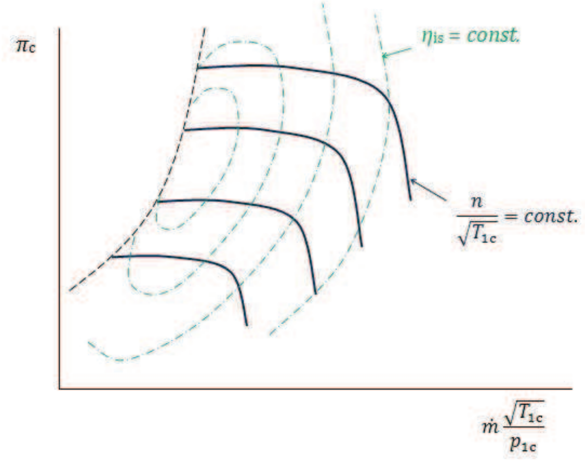

Figure 5. A typical compressor map

The viscous sublayer which is closest to the wall (see Fig. 6) is modeled by the empirical formulae and the nearest computational node is assumed to already lie in the fully-turbulent region of the boundary layer [3].

In addition to the recommendations concerning choice of the most suitable turbulence model, the values of inlet turbulent parameters suitable for modeling flow in small-sized centrifugal compressor stages are provided in [1]. Thus, a turbulence intensity of 5% along with a turbulent length scale of 10 mm was set at the compressor inlet.

Since the flow inside a centrifugal compressor stage is always unsteady and involves both rotating and stationary reference frames, a question of modeling the interface between the impeller and diffuser is of significant importance. A comparison of various approaches to modeling this interface can be found in [8]. In the first computations, the flow was considered to be steady, which, according to [8], can be a reasonable approximation, widely used in practice.

For steady computational models, two types of impeller-diffuser interface models are available in ANSYS CFX: the mixing plane model (named *Stage*) and the *frozen rotor* model.

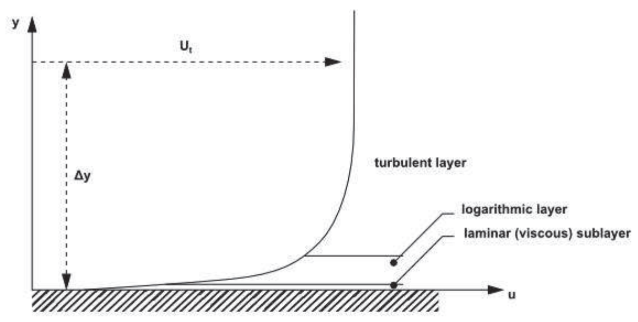

Figure 6. A scheme of near-wall flow layers [2]

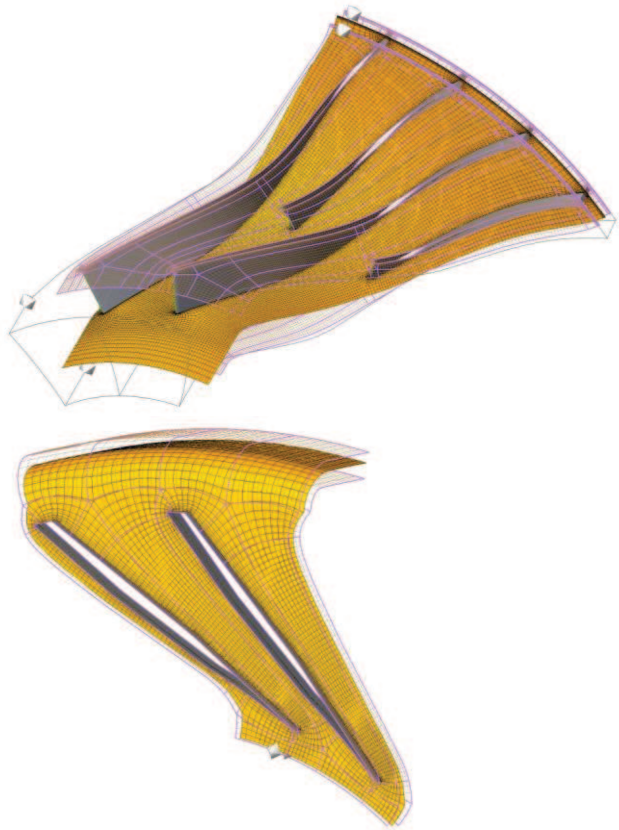

Figure 7. Above, impeller computational mesh. Below, diffuser mesh

As described in [5], the mixing plane model is based on circumferential averaging of flow quantities at the impeller exit, assuming that the losses caused by circumferential mixing are equal to those which arise during a gradual mixing process inside the diffuser. Thus the flow disturbances which develop inside the impeller vanes do not transfer to the downstream diffuser. Although this assumption is incorrect, the mixing plane model is frequently used in turbomachinery development.

In opposition to the mixing plane model, the frozen rotor model does transfer flow disturbances across the impeller-diffuser interface. The drawback of this approach is that it only does so at one instance in time so the unsteady nature of the flow is not captured correctly. In [8], the two above-mentioned stationary models are compared to the unsteady *transient sliding mesh* model, the mixing plane model being more accurate that the frozen rotor. Therefore, the mixing plane model was used in our case.

The 3D mesh (see Fig. 7) was generated in ANSYS TurboGrid. For the reason of saving computational time during the calibration process which involves a lot of computational runs, one impeller channel together with one diffuser channel is modeled. Since 16 impeller vanes and 25 diffuser vanes are used in the compressor stage concerned, one impeller pitch is different from one diffuser pitch. In these cases, ANSYS CFX automatically changes the scale of the downstream (diffuser)

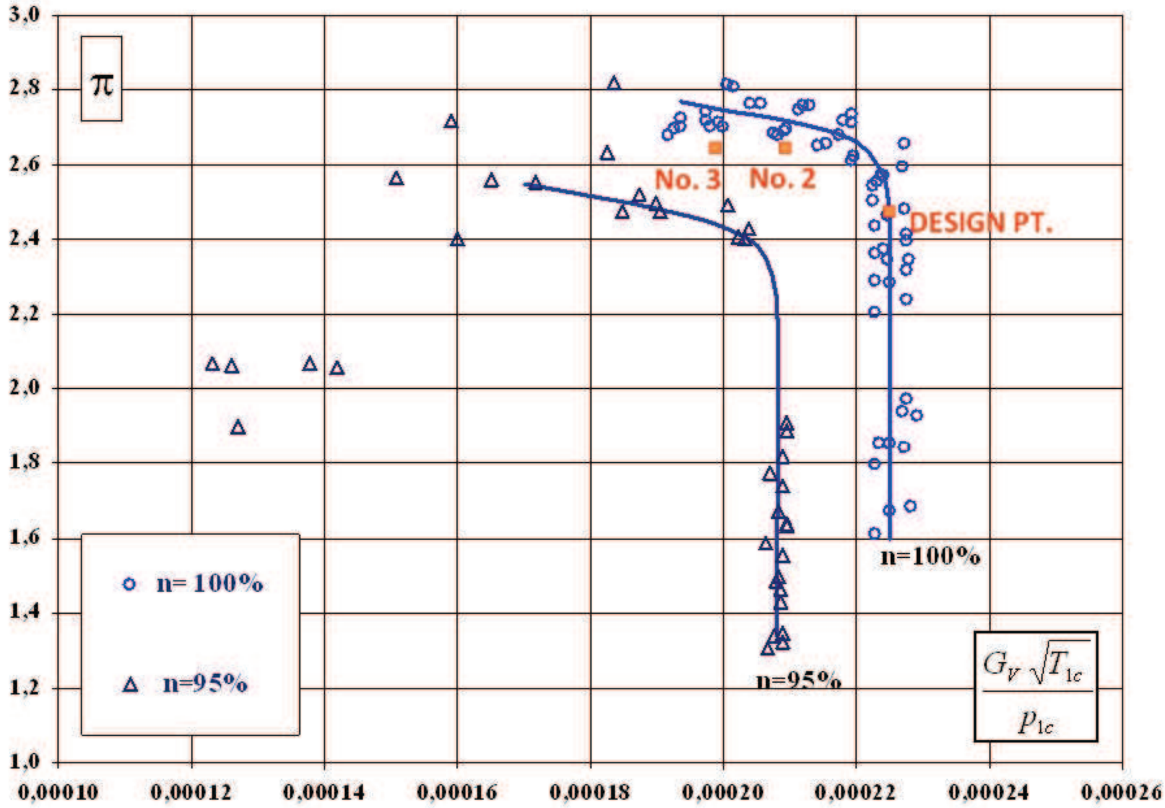

Figure 8. A comparison of the computed points to the measured performance curve

vane. If two impeller vanes together with three diffuser vanes are used, the pitch ratio nearly equals one and the scale change of the diffuser vanes is considerably smaller. On the other hand, the computational time is correspondingly longer and it was tested that modeling 2+3 vanes instead of 1+1 vane does not significantly influence the results obtained.

IV. RESULTS AND DISCUSSION

A. *Stage integral quantities*

Three calculations have been made so far: One in the design point and the other two in the left part of the performance curve. For each of these calculations, the same mesh generated by ANSYS TurboGrid was used.

Due to the fact that the only source of experimental data available at this time from the high-pressure compressor is the measured performance curve, the total temperature rise and isentropic efficiency in points No. 2 and 3 can not be compared to the experimental data.

As can be seen from Tab. II and Fig. 8, the computation captures the isentropic efficiency and total temperature rise in the design point with an error of 2.23% and 6.1%, respectively. This indicates that the design point isentropic efficiency is underestimated by this model.

TABLE II. RESULTS OF COMPUTATION - INTEGRAL QUANTITIES

	Mass flow [$kg.s^{-1}$]		**Total pressure ratio**	
	CFX	***Exp.***	***CFX***	***Exp.***
Design Pt.	4.301	4.301	2.407	2.407
Point. No. 2	4.000	4.000	2.645	2.715
Point. No. 3	3.800	3.800	2.643	2.750

	Isentropic eff. [%]		**Total temp. rise [K]**	
	CFX	***Exp.***	***CFX***	***Exp.***
Design Pt.	78.7	80.5	171.9	162.0
Point. No. 2	86.6	-	175.4	-
Point. No. 3	85.8	-	177.0	-

In the left part of the performance curve in which the combination of inlet total pressure and outlet mass flow rate was used, the model underestimates the mean value of total pressure ratio by 2.58 % in Point No.2 and by 3.89 % in Point No.3. Even so, the deviation from the lowest measured values is negligible (see Fig. 8).

Since the total pressure values computed are lower than those measured, it can be supposed that the computational model overestimates the total pressure losses occurring inside the compressor stage.

TABLE III. RESULTS OF COMPUTATION - Y+ AVERAGE VALUES

	Impeller	Diffuser
Blade y+ (area ave.)	176.1	335.9
Domain y+ (volume ave.)	144.9	786.0

A conclusion can be made that the computational model must be refined in order to fit the measured performance curve more closely.

The values of y^+ obtained by the solution (see Tab. III) show that especially the vaned diffuser mesh should be refined. The dimensionless distance from the wall y^+ used in this evaluation is computed from the following formula:

$$y^+ = y\frac{u^*}{\nu}; \quad \text{in which } u^* = \sqrt{\frac{\tau_w}{\rho}} \qquad (5\text{ a, b})$$

in which u^* stands for shear velocity, ν for kinematic viscosity, τ_w for wall shear stress, and ρ for air density.

It is the common formula, not the model-specific one which is also used by CFX.

The authors of [1] claim that, when modelling flow inside turbomachines, the values of y^+ higher than 200 should be avoided and that the law-of-the-wall functions best for y^+ between 30 and 60. According to this statement, the impeller mesh can still be considered sufficient while the diffuser mesh is too coarse.

The inaccuracy of the diffuser mesh is also evident from the numbers of cells. As stated above, the mesh was generated in ANSYS TurboGrid using the default settings. One impeller channel was modeled using 250,212 cells, one diffuser channel being made up of just 30,000 cells.

Therefore, the diffuser mesh should be refined in the first step. Afterwards, in order to further refine the computations, a more accurate boundary layer model should be used considering the fact that the flow inside centrifugal compressor stages is dominated by viscous effects and flow separations are to be expected even in the design point. The locations of flow separation should then be predicted more precisely than with the use of the wall function.

B. Flow field inside the impeller

The static and total pressure distribution at the impeller outlet (**Chyba! Nenalezen zdroj odkazů.**) shows typical jet-wake velocity patterns developing in both sets of channels (Main P.S. – Splitter S.S. and Main S.S. – Splitter P.S.) with wake zones close to the shroud and suction sides of both sets of blades. It can be seen that the pressure patterns are different in each set of channels. During further development of this compressor stage, achieving a uniform appearance of pressure patterns in both sets of channels is advisable. This would lead to reducing the mixing losses inside the diffuser.

The sharper difference between the minimum and maximum pressure in the Main Blade P.S. – Splitter S.S. channel is caused by the fact that the tip leakage mass flow is greater on the main blade tip than on the splitter blade tip.

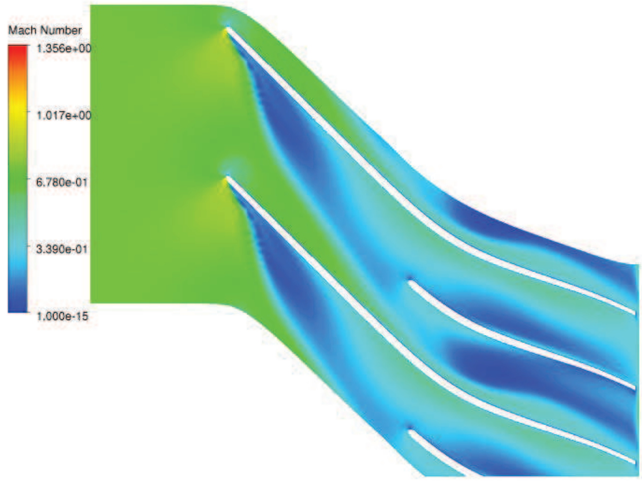

Figure 9. Relative velocity Mach number distribution inside the impeller at 95% span

This, in turn, is caused by a suction side flow separation from the main blade leading edge in the area close to the shroud (see Fig. 9 showing the values of Mach number at 95% impeller blade span). This low energy fluid then migrates across the channel from the suction side of the main blades and meets the pressure sides of the neighbouring main blade and splitter blade at different distances and, thus, with different energies.

V. CONCLUSIONS

In this paper, an initial computational model of a centrifugal compressor stage for aircraft engines was presented.

The results of the computations show that the model underestimates the isentropic efficiency as well as the total pressure ratio of the compressor stage. At the same time, the main phenomena determining the flow inside the impeller have been described and can be handled during the future development of this stage. The main problem the uneven distribution of pressure and velocity fields in the two sets of impeller channels caused by low-momentum fluid migrating across the channels and accumulating near the shroud and the suction sides of both sets of blades.

In the next stage of development which will follow after refining and calibrating the computational model, the tandem impeller blades will be introduced and their impact on flow field inside the stage, and on its total pressure ratio and isentropic efficiency of the stage will be investigated.

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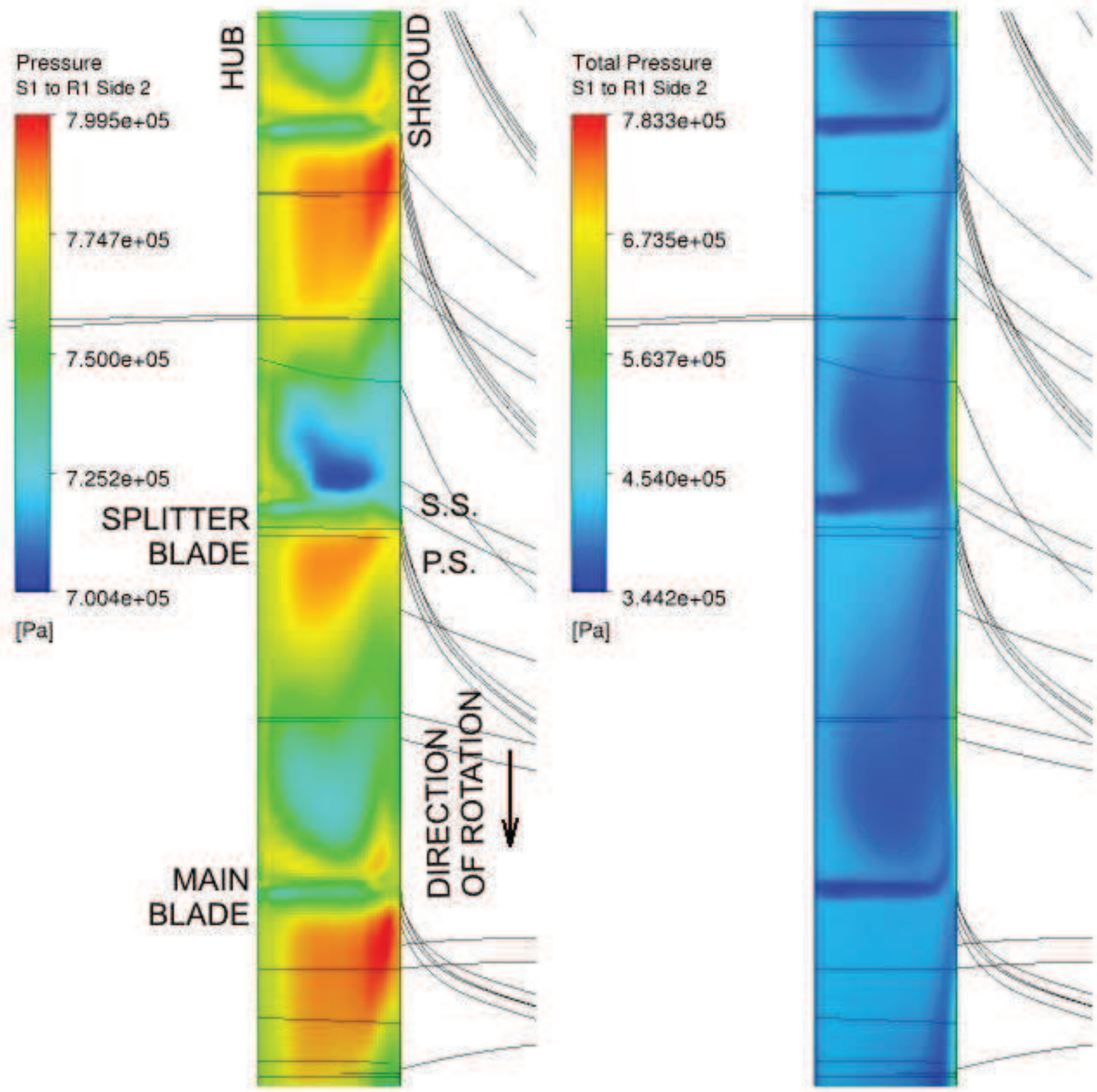

Figure 10. Pressure distributions at impeller exit. Left, static pressure. Right, total pressure.

Electric taxiing

Keynote lecture

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***Abstract*: Electric taxiing is progressive method for lowering costs and environmental impacts of ground operations. Despite the fact that no manufacturer had certification for such device today, there are more than 1000 orders placed. That shows the facts that air operators are interested in this technologies. Main goal of this article is to provide sceptical point of view to put in contrast with very optimistic marketing statements of involved companies.**

Keywords – taxiing, wheeltug, taxibot, EGTS

I. 3 DIFFERENT APPROACHES:

There 3 main players in area of electric taxiing. Company Wheeltug, EGTS system from Honeywell-Safran and IAI´s Taxibot machine. Every single system has own specialities and little bit different approach to the problematic.

II. WHEELTUG

Nearest to certification is probably the company Wheeltug. Wheeltug solution is based on usage of electric engine, powered by APU, mounted on front wheel of aircraft. Using front wheel brings several advantages – system allows manoeuvring and making of special manoeuvres near the gate.

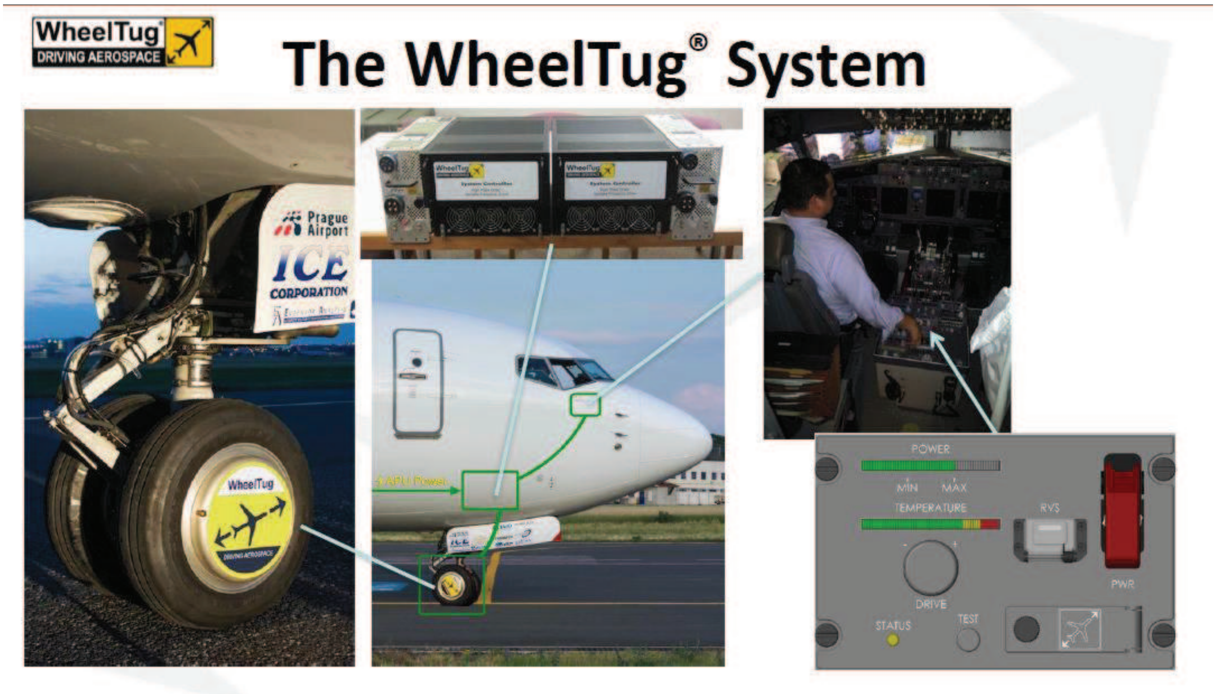

Figure 1 Wheeltug system overview [1]

System is controlled by pilot from cockpit with an additional control panel. Advantage of wheeltug is low mass, which decrease additional fuel burn during flight, the use of front wheel allows steep manoeuvres and business model of the Wheeltug Company may be very interesting for air operators. The business model is based on fact that the device is provided to air operator for free, assembly maintenance and training is provided by the Wheeltug Company also for free. The only payment which air operator has to make is part of savings which results from electric taxiing usage. It seems interesting g but there may be the biggest disadvantage of whole system.

a. Disadvantages of Wheeltug

The problem is that Wheeltug Company presumes that the savings are, except from direct savings, such as lowering fuel consumption during taxi, FOD savings etc., also made from time savings. Wheeltug states that because that aircraft is capable of steeper and more precise manoeuvring, it is possible to park parallel to gate and use two bridges to load and unload passenger. And according their presentation they awaits saving of more than 15 minutes every turn, as shown in the figure 2.

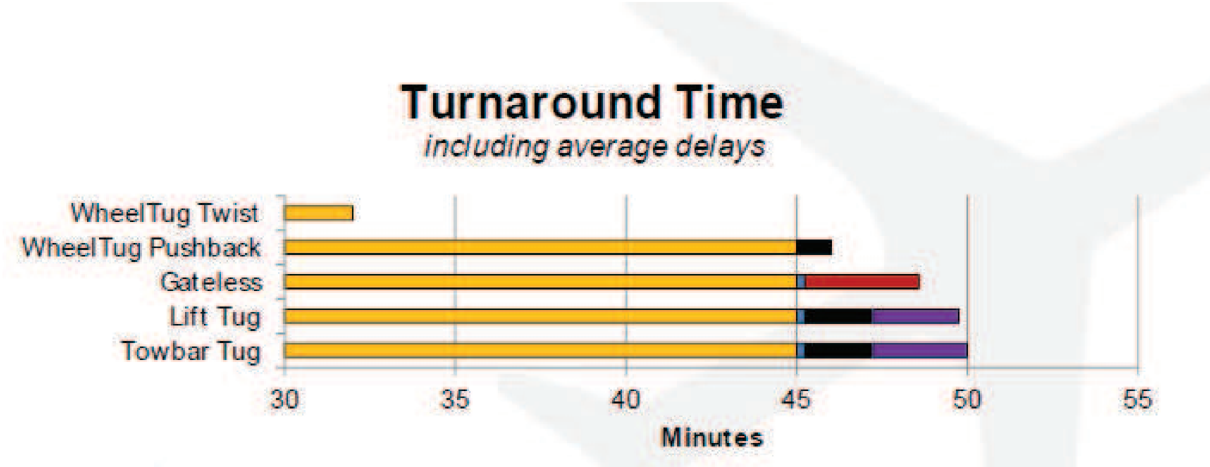

Figure 2 Wheeltug time savings [1]

Wheeltug counts this time as cost save for air operator and they count this amount of money to total savings of systems. This savings from possible time savings are bigger than direct saving from using electric taxiing, and Wheeltug is „charging“ air operators for every single usage of wheeltug as if the air operator saved quarter of hour of flight time. But in most cases are these time savings only theoretical. Because in most cases critical ground operation is baggage handling and not passenger loading, so there will be no time savings. Even in situation hen there will be some minor time saving this may bring to air operator only very small cost savings, because 20 minutes of saved time per day make no room for air operator to provide another flight as Wheeltug presumes. So there will have to be very difficult negotiations between the Wheeltug company and air operator to determine how high are the real savings from usage of the Wheeltug system, what may bring the introduction of the whole system to delay.

Another minor disadvantage of the Wheeltug maybe the fact, that the traction provided by front wheel may not be sufficient in some cases, for example if a RWY would be contaminated.

III. EGTS

The EGTS is electric taxiing system provided by Honeywell-Safran Company. It consists from two electric engines powered by APU mounted on the main landing gears. Pilots control system from an additional panel in cockpit. EGTS system is more robust and usage of main gear makes traction lesser problem than in the Wheeltug solution. The EGTS demonstrator was shown on the AIR SHOW 2013 in Paris.

Figure 3 EGTS

Usage of main gear makes also possible to use the EGTS on bigger airplanes, the only limitation is output of APU unit. But the advantage of main gear usage brings also several disadvantages.

a. Disadvantages of EGTS

Disadvantage of usage of the main gear is necessity of placing electric engines near brakes. Heat provided from brakes has negative impact on effectiveness of the electric engines as well as additional heat from electric engines decrease life expectancy of brakes. Cooling of such system is crucial and in very limited space of landing gear it is very challenging. From this reason company the L3 company, which also prepared the electric taxiing for aircrafts in cooperation with Lufthansa, withdrawned from this competition and ended its project.

Second disadvantage is the higher mass. Because of usage of two electric engines and additional cooling is EGTS system more than twice heavier than the Wheeltug. It brings additional fuel consumption during flight and it may be very negative element if air operator has problems with reaching limitation on maximum mass. Necessity to transport lower passenger because of addition mass of EGTS brings such great costs that the whole system would be ineffective.

IV. TAXIBOT

Third company providing innovative way of ground operations and taxiing is IAI Company with project Taxibot. Taxibot vehicle is similar to classic pushback tractor. But there are some important differences. The main difference is that there is no tow bar, the front wheel is lifted form ground and inserted in special cradle in the Taxibot. From this moment is whole system controlled from cockpit by pilots. Without need of installing any new control panels pilots are controlling taxiing as if they were taxiing with main engines. Movements of front wheel are monitored by Taxibot and truck steers according to them, as well if brakes are used taxibot finds by sensors are brake also. Acceleration is done by releasing of brakes.

When controlled by pilot the taxibot tow truck may be used to transport the airplane from gate to holding point of active runway. The way back is controlled by driver of taxibot which is present for whole time. In next generation of taxibot it is presumed that the system will be autonomous without need of driver.

Advantage of this system is that fuel consumption of tractor, especially when there will be sued electric powered truck, is much lower than fuel consumption of taxiing aircraft. Another advantage is that because of many possible tractor sizes and power settings there may be found ideal truck for every type of aircraft even for largest types, for which another electric is taxiing system unusable.

a. *Disadvantage of Taxibot*

System Taxibot has potential for large savings for air operators, but problem is that costs (higher cost of tow tractor and higher costs for ground operations) are carried by handling operators. There has to be consensus made about how the savings is going to be distributed back to handling operators. Another issue is of course fact that to ensure that all aircrafts will be provided by TAXIBOT towing there has to be sufficient number of these trucks and because of fact that price of TAXIBOT is more than twice than price classic tow truck, the investment in TAXIBOT would be very high.

Another problem is connected with higher movement of TAXIBOTs on taxiways and even on runways in some cases what should lead to higher risk of ground collisions. Introduction of Taxibot and other electric taxiing systems shall lead to change in ground control methods, especially with respect to maximal utilization of electric taxiing system.

V. CONCLUSION

Despite all aforementioned problems is electric taxiing progressive and innovative way how to improve effectivness of air transport, estimates show that electric taxiing may bring saves about half million of EUR per one airplane, so there will be strong pressure to overcome existing problem and since 2016 is electric taxiing going to spread widely around the globe.

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Low Cost Airlines and Their Presence in the European Market

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***Abstract*— The article is describing the low cost carriers established on the European market. The first part of this article deals with the information collected concerning the origin of low-cost airlines in Europe. The second part of the article draws upon the processed spatial analysis of two European regions - the region in which the impact of selected airlines is the largest and, vice versa, in a region where the scope of these airlines is the smallest. The last part of the article depicts a graphic representation of the scope of low cost carriers in Europe.**

Keywords- low cost airline, Europe, analysis, scope

I. INTRODUCTION

Nowadays we do not need to have wings to be able to get into our dream destination in a very short time. The solution is an air transport which will enable us to avoid a several hours of journey in uncomfortable positions on the bus or in the car. Air transport has become a common mode of transport for a large number of people. Recently significantly promotes the phenomenon of low-cost air travel. A very important incentive for the establishment and development of low cost airlines has been deregulation, initially in the U.S. aviation market and subsequently on European air transport market. Successful entry of low cost airlines on the market has caused that some classic airlines have started to implement some of the elements of the operating model in which low cost airlines operate.

Scope airlines is growing rapidly on aviation market. This type of airlines is attractive for people because of several reasons. The biggest advantage of low cost airlines is in that they offer lower fares than classic airlines, which is most alluring to potential passengers. Another advantage is the availability (offering a wide range of destinations) and also that have young a quality fleet.

II. FORMATION LOW COST AIRLINES IN EUROPE

In history there are very few industries that have developed and grown as fast as aviation. During World War II aviation developed mainly by technical progress. After World War II we can see bigger interest about aviation, especially in Europe. The reasons were clear. Across Europe, there was a rapid restoration of economic systems, and this contributed to the fact that increased demand for air travel.

The main development was associated with new onset so. air jet age. Major change in the mode of transport meant possibility of "low cost" flights versus "classical" flights method of flying. The emergence of low cost carriers is closely linked to the liberalization of air transport in the United States. Presence of low cost carriers over time spread throughout the world.

On the European market came first draft with the idea of low-cost transportation only in the '70s. In 1977 the planes Laker Airways began to fly under the name Sky Train from Gatwick to New York for a very low price. Unfortunately, in the 80s there was a bankrupt airline.

Low-cost air travel recoiled to the European market as late as 1985, when it was in Ireland based company Ryanair. Now is the European largest low-cost carrier.

The spatial development of low-cost airlines in Europe is shown in picture 1. Low cost airlines were incurred in 1995 in England and Ireland and gradually began to expand to the rest of Western Europe. Since 1997, the European low-cost network has developed itself and included more tourist areas in southern Europe. Since 2002, a network of low-cost carriers spread to Eastern Europe and Scandinavia.

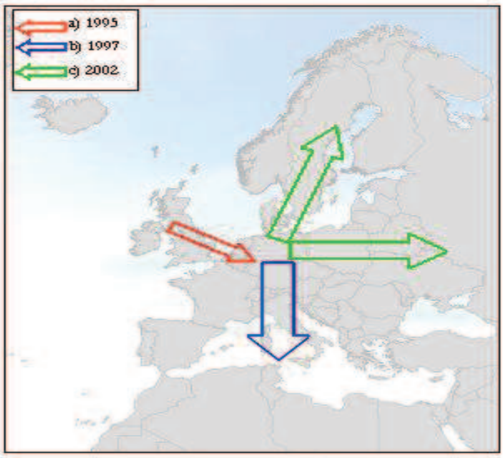

Figure 1 Scope of low cost carriers

III. SPATIAL ANALYSES OF LOW COST AIRLINES IN EUROPE

For processing of spatial analysis were selected airlines that are members of the ELFAA. To the Association of European airlines (ELFAA) is incorporated following 10 airlines: EasyJet, FlyBe, Jet2, Norwegian, Ryanair, Sverigflyg, Transavia, Vueling, Volotea a WizzAir. On the spatial analysis of these selected airlines, it was necessary to collect all the relevant information about the attended airports. It was also necessary to collect data relate to the number of passengers transported in 2012 at individual airports. Size of airports is determined by number of carried passengers. Distribution of airports by passenger traffic is shown in the following table 1.

TABLE - 1 TYPES OF AIRPORTS

Size of the airport	**Number of passengers**
Regional airport	To 200,000 passengers
Very small airport	Over 200,000 passengers
Small airport	Over 1 million passengers
Medium-sized airport	Over 5 million passengers
Large airport	Over 10 milion passengers
Very large airport	Over 25 milion passengers

Based on these data it was possible to determine for what types of selected airports airlines fly. Processing of the spatial analysis was divided for better clarity into six regions of Europe: Northern Europe, Western Europe, Central Europe, Eastern Europe, South-West Europe and South East Europe. The result was a detailed spatial analysis that selected low cost airlines have the greatest scope in the region of Western Europe and on the other hand the smallest in the region of Eastern Europe.

3.1. Western Europe

Western Europe is divided into two parts, namely the British Isles, where there is England, Northern Ireland and Ireland, and part of the western continental Europe, which covers several states such as France, Monaco and the Benelux countries (Belgium, Netherlands, Luxembourg).

The total area of Western Europe is 602,948 sq km, representing 5.92% of the total area of Europe. England is the largest state with an area of 244,820 sq km constituting 40.60% of the area of Western Europe. The second largest country in Western Europe is slightly smaller area of France with 211,209 sq km, accounting for 35.03% of the area of Western Europe. The smallest states of Western Europe include Luxembourg and Monaco. Both states have an area of around 2,000 square kilometres, which represent only 0.33% of the total area of Western Europe.

In 2012 lived in Western Europe 161.1 million people. Population in Western Europe constitutes 27.11% of the total population of Europe. Most populous countries of the region are the two largest countries England and France, where in that year there was population more than 60 million people. The sum of the populations of these two countries account more than ⅔ of the total population of Western Europe. At least populous countries in the western region of Europe is Ireland (where the population has increased in recent years and is approaching the border 5mil.), Luxembourg (where the population in recent years has not changed significantly and is about 500 thousand inhabitants) and Monaco (where in recent years the population decreased to the limit of 30 thousand inhabitants).

TABLE - 2 WESTERN EUROPE - BASIC DATA FOR ANALYSIS

Country	Population	Area sq km	The number of airports
Belgium	10 438 350	30 528	16
France	65 630 690	211 209	153
Netherlands	16 730 630	41 526	16
Luxemburg	509 074	2 585	1
Monaco	30 510	2 000	1
England	63 047 160	244 820	158
Ireland	4 722 028	70 280	20
Western Europe	161 108 442	602 948	365
Europe	594 336 800	10 180 000	1 274

3.1.1 Structure of Airports

In Western Europe, there are 365 airports. The largest number of airports is located in England (158) and France (153). Luxembourg and Monaco, they are the countries with one airport.

In Western European countries the selected low cost airlines serve all types of airports. The largest part of the aviation market in Western Europe include very small, small and regional airports.

In the region of Western Europe there are 5 very large airports, which carried the largest number of passengers for the region most. In Britain, in London there are two very large airports. This is a Heathrow Airport (LHR) with the number of passengers carried 69,995,273 and Gatwick airport (LGW) with the number of passengers carried 34,236,247. In France there are two very large airports in Paris. One is the Paris Charles De Gaulle (CDG) with the number of passengers carried 61,611,934 and the second one is the Paris Orly Field (ORY) with the number of passengers carried 27,232,263. The Netherlands is the third country in with a very large airport, in Amsterdam (AMS) with the number of passengers carried 51,035,590.

In Belgium, in Brussels, the low cost airlines serve only one major airport the Brussels (BRU) and the Brussels South Charleroi Airport (CRL). In Luxembourg, there is only one airport a small one, airport Luxemburg (LUX) with the number of passengers carried 1,919,694.

TABLE - 3 WESTERN EUROPE - STRUCTURE AIRPORTS

Country	25 million and more passengers	10milion and more passengers	5 milion and more passengers	1 milion and more passengers	more than 200 thousand passengers	less than 200 thousand passengers
Belgium	-	1	1	-	-	-
France	2	1	3	10	13	9
Netherlands	1	-	-	2	2	-
Luxemburg	-	-	-	1	-	-
Monaco	-	-	-	-	-	-
England	2	2	4	11	10	12
Ireland	-	1	-	2	2	-
total	5	5	8	25	26	21

3.1.2. Structure of Airlines

As mentioned above, countries with the largest number of airports are Britain and France. On the basis of Table 4 we can see airports of these two countries are the most served airports by the selected airlines. The largest portion in the aviation market of Western Europe is made up by the British airlines EasyJet, Flybe, Jet2 and an Irish airline, the Ryanair. The low cost EasyJet in these countries offers its services to all types of airports in addition to regional airports. As one of the selected airlines has in the list of destination airport Luxemburg (LUX) in Luxembourg. Ireland and Monaco are countries in which does not fly at all.

Airlines Flybe and Jet2 operate at all types of airports in Western Europe. Ryanair, the Irish low-cost carrier is the biggest competitor for a Flybe and Jet2 in the business. Ryanair is mostly orientated on very small airports, small airports and regional airports, which are located near major airports. Airlines Norwegian, Transavia and Vueling do not offer their services to all Western European countries, but in the countries where they operate, they are orientated mainly on very large airports, major airports and medium-sized airports.

Hungarian low-cost airline Wizz Air has a list of destinations with flying only via a few airports in Western Europe. These are mostly medium-sized airports and small airports.

Spanish airline Volotea operates in Western Europe at French airports, especially at small airports.

Sverigeflyg airline doesn't offer its services to Western Europe at all.

TABLE - 4 WESTERN EUROPE - STRUCTURE OF AIRLINES

Country/ airline	EasyJet	Flybe	Jet2	Norwegian	Ryanair	Sverigeflyg	Transavia	Vueling	Volotea	WizzAir
Belgium	VL	VL	-	-	SVL	-	-	VL	-	SVL
France	VVL2 VL SVL3 ML8 VML2	VVL2 VL SVL ML3 VML7 RL	VVL VL SVL VML3 RL	VVL VL ML	VL SVL ML6 VML10 RL7	-	VVL VL ML4 VML4	VVL	SVL ML9 VML4 RL	ML
Netherlands	VVL	VVL	VVL	VVL	VML2 ML	-	VVL ML2 VML2	VVL	-	ML
Luxemburg	ML	-	-	-	-	-	-	-	-	-
Monaco	-	-	-	-	-	-	-	-	-	-
England	VVL VL2 SVL4 ML6 VML4	VVL VL SVL3 ML8 VML8 RL12	VL SVL2 ML5 VML RL	VVL SVL	VVL VL2 SVL4 ML7 VML3 RL2	-	-	VVL SVL	-	SVL ML2 VML
Ireland	-	VL VML	ML	VL	VL ML2 VML	-	-	-	-	ML

Legend: RL – regional airport, VML – very small airport, ML – small airport, SVL – medium-sized airport, VL – large airport, VVL – very large airport;

3.2. Eastern Europe

Eastern Europe consists of countries of the former Soviet Republics, namely Russia, Ukraine, Belarus and the Baltic States of Lithuania, Latvia and Estonia.

Eastern European states cover an area up to 5,296,315 sq km, making up f 52.03% ,i.e. more than half of the total area of Europe. Most of this issue involves Russia, the European part consists of 4,310,000 sq km. Ukraine is he second state with the largest area is the Ukraine (603,700 sq km). The smallest state in Eastern Europe, Estonia which represents 0.85% of the area.

Population in Eastern Europe constitutes 29.37% of the total population of Europe. The largest share of this falls to Russia, which is the most populated country in Eastern Europe, but also across Europe (more than 113 million people). The second most inhabited country in the Eastern Europe is Ukraine with a population of over 44 million. The least populated country is Estonia with not more than 1,270,000 people living there.

TABLE - 5 EASTERN EUROPE - BASIC DATA FOR ANALYSIS

Country	Population	Area sq km	The number of airports
Lithuania	3 525 761	65 200	5
Latvia	2 178 443	64 589	4
Estonia	1 274 709	45 226	6
Ukraine	44 854 060	603 700	38
Belarus	9 643 566	207 600	7
Russia	113 102 000	4 310 000	147
Eastern Europe	174 578 539	5 296 315	208
Europe	594 336 800	10 180 000	1 274

3.2.1 *Structure of airports*

In Eastern Europe, there are a total of 208 airports. The largest number of airports is located in Russia (147 airports). The second country with the largest number of airports is Ukraine (38 airports). At least airports are located in the Baltic countries.

In the region of Eastern Europe there is just one very large airport serviced by the selected low cost airlines. It is the Russian Domodedovo (DME) airport, which handled 28,165,657 passengers in 2012 .

Large airport in Eastern Europe is the only one and is located in Russia. This is the Saint Petersburg Airport (LED) with the number of carried passengers 11,154,533.

In Eastern Europe compared to other European regions, there are not many airports that serve selected low cost airlines. In Lithuania, there are three airports handling from 128 thousand. to 2.2 million. passengers a year.

Ukraine and Latvia are the countries with one airport.

In Ukraine, in Kiev (KBP) there is a medium-sized airport, which carried 8,478,091 passengers in 2012. In Latvia, there is a small airport in Riga, handling 4,767,764 passengers.

In Belarus there is not an airport to where some of the selected airlines are offering their services.

TABLE - 6 EASTERN EUROPE - STRUCTURE AIRPORTS

Country/ airline	25 million and more passengers	10 milion and more passengers	5 milion and more passengers	1 milion and more passengers	more than 200 thousand passengers	less than 200 thousand passengers
Lithuania	-	-	-	1	1	1
Latvia	-	-	-	1	-	-
Estonia	-	-	-	1	-	1
Ukraine	-	-	1	-	-	-
Belarus	-	-	-	-	-	-
Russia	1	1	1	-	-	-
total	1	1	2	3	1	2

3.2.2 *Structure of Airlines*

Above mentioned, the state with the largest number of airports is Russia. In the Tab. 8 it is clear that in this country is only one very large airport Domodedovo (DME) to which provides its services only one of the selected airlines. This airline is EasyJet. Estonia is the only country in the region in which the Tallinn Airport (TLL) handles most of selected low cost airlines.

Greatest presence in Eastern Europe is made by the Norwegian Norwegian airline, which flies to all countries in the region except Belarus. It is aimed primarily at small airports in the region. Other low-cost airlines operating the airports in Eastern Europe are EasyJet, Ryanair and Wizz Air. EasyJet is aimed at larger airports. Ryanair and Wizz Air are aimed at small airports.

Airline Flybe has in the list of destinations just one country of Eastern Europe - Estonia. Low-cost carrier Vueling provides its services only at one airport in Eastern Europe. It is a large airport in Saint Petersburg (LED) in Russia. Low-cost airlines Jet2, Sverigeflyg, Transavia and Volotea do not act in any airport in Eastern Europe. Belarus is the only country in the region, where none of the selected airlines fly to.

TABLE - 7 EASTERN EUROPE – STRUCTURE OF AIRLINES

Country / airline	EasyJet	FlyBe	Jet2	Norwegian	Ryanair	Sverigeflyg	Transavia	Vuleing	Volotea	WizzAir
Lithuania	-	-	-	ML2 RL	VML	-	-	-	-	-
Latvia	-	-	-	ML	ML	-	-	-	-	ML
Estonia	ML	RL ML	-	ML	ML	-	-	-	-	ML
Ukraine	-	-	-	SVL	-	-	-	-	-	SVL
Belarus	-	-	-	-	-	-	-	-	-	-
Russia	VVL VL SVL	-	-	VL	-	-	-	VL	-	-

IV. GRAPHICAL VISUALISATION OF LOW COST AIRLINE COMPANIES IN THE WEB ENVIRONMENT

There was an idea to create an example based on web technologies.[2] The main focus was to demonstrate processed information in an easy and intuitive way. For this purpose an integrated world map was developed making airports visible. It was important to create a relation between air companies and airports and visualize it directly on a map. Also, for specific countries there was a need to have a wide coverage. High level of details is available for all countries in Europe, the biggest cities and areas in Africa, Russia, North and South America and few countries in Asia. It means that the user can see detailed traffic communication, cities, lakes and many others. The map features tools that can handle functions such as motion, zoom in and zoom out, clicking or connecting defined points on a map layer. There is small window on the map where additional information about airports, companies and flights are included.

Figure 2 Detailed map view

4.1 *Structure and description of page components and functions*

The page content is divided into the two main parts.

Most of the upper part is filled with map which is considered as most important component. The OpenstreetMap framerowk offers tools that can put over the map user defined information on independent layer. Individual map points are possible to select simply, by clicking on coloured circles. If an airport has defined destinations i.e. places where to flights, lines are created between them. In default state, all circles are green-coloured. After selecting, the original airport is marked with a bigger blue circle, while destinations are distinguished with smaller orange circles. All the not connected points are immediately hidden to avoid user confusion and to give him relevant information. For every point a short on-map description is provided. The user can see it while hovering over the point or clicking on it. Here, it is possible to find the name and code of the airport. Detailed description is can be seen on the right side of the map, but only when the point is selected. The table slides from right to left and provides useful information about the airport, its description, contact details, website or coordinates. At its bottom, there is a list of possible flight destinations, individually for every company. The table can be hidden by pressing the button, located on left. On figure 3 is shown upper page design.

Figure 3 Connection between airports (upper part)

The bottom of page consists of a table divided into the three menu items.

The first one includes list of all air companies that user can click on. Every company has own description defined as:

- ICAO / IATA as code of airport
- List of all aircraft used for transportation
- List of all countries where company flies

The second item has two sub-items; one for information visualised into the graphs and pictures. Another link points to statistics. There is information about airports, air companies, its routes or transported passengers.

The third link points to short description of author, page and reasons why the page was created and what is focused on.

Figure 4 Detailed description of air company with images (bottom part)

Moreover, every company on page has its own logo that represents it. In default state, the logo is in black and white colours. When the user clicks on one of the points visible on map, the logo of the company travelling from the desired airport changes to full colours. The whole page is depicted on figure 4.

Actually there are only 10 defined air companies. Because the page is supplied by database, it is very easy to add a new company or airport. It features a simple integrated user interface with few forms where the user needs to insert specific information and confirm it. If a new airport is set, it is immediately drawn on map and uses user's defined data. Also, for every already defined company it is possible to set the origin and the destination airport where one can fly to. As result, a yellow line is drawn as a visual connection of two points on map, when selected.

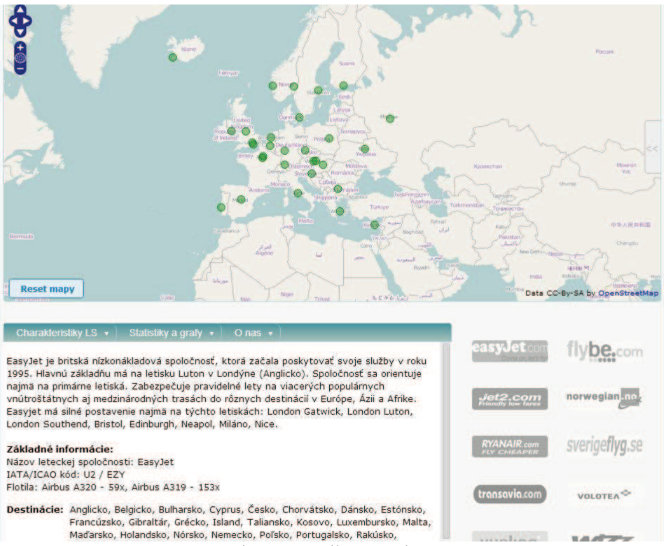

Figure 5 Full-page view

4.2 Implemented technologies

The website is based on a few popular technologies that cooperate and depend on each other. As data storage was used database management system called MySQL, where all data are stored. Also, this is the place where all the displayed information comes from. Data handling is done by hypertext pre-processor tools called PHP. PHP is scripting language that communicates with database and website itself and exchanges input and output data between them. The logic of website is based on JavaScript language that can handle and format these data using scripts. HTML with CSS (Cascade StyleSheet) allows creating and designing a page skeleton where all page components such as images, text, tables etc. are placed. The website integrates OpenStreetMap project technologies, specifically map, subjected to open-source licencing.

CONCLUSION

The establishment and development of low cost airlines was the result the liberalization of the European air transport market. The first low-cost airlines in Europe arose as Ryanair and EasyJet. Initially, these companies operated only in England and Ireland. Over time, low cost air travel at a slow pace spread throughout Europe.

The collected data and information, it is clear that selected Western European region is served by most airlines. The result of data processing show that the low cost airlines such as the Norwegian, Ryanair and EasyJet are the most active ones in the European market. They cover the largest number of airports in each of the six regions and their service all types of airports, presenting the most extensive route network in Western and Central Europe region.

The Sverigeflyg airline low cost airline has the slightest scope for pan-European market. It operates only in Northern Europe, and only at airports of Sweden.

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Aircraft crew radiation exposure

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Abstract* — *The following paper deals with the effects of radiation on flight crews. It describes the radiation in general as well as the basic measures and calculations used in the research. It provides the chronological review of valid legislation in the Slovak Republic and corresponding laws issued by European Commission. It compares the levels of radiation and based on the latitude and allowed flight hours within the limit of acceptable amount of radiation.

Keywords – cosmic radiation; crew radiation burden; radiation protection

INTRODUCTION

Air transport has an influence on the environment and environment has an influence on the air transport as weel as on individual users of air space (aircraft crew) where the radiation is one of the impact indicators of air transport on the environment.

When on December 17th 1903 Orville Wright performed the first controlled and engine powered flight with a machine heavier than air the mankind has after the lithosphere and hydrosphere fearlessly started conquering another environment the atmosphere. Coincidentally Maria Skłodowska-Curie and her husband Pierre received the Nobel Prize in physics for the research of phenomenon called radioactivity in the same year. In 1912 Austro-German physicist Viktor Franz Hess has conducted a series of balloon flights whose purpose was to measure the radioactivity in the atmosphere. He came to a interesting conclusion that in the height of 1500 – 2000 meters above the surface the radiation level was approximately the same as on the surface. However above the height of 2500 meters the instruments recorded a rise in radiation and in the height of 3600 meters the recorded values were 5-times higher as those on the surface. This measurement has confirmed that the source of radiation (ionization) comes from the outer space behind our atmosphere. For the discovery of the cosmic radiation Victor F. Hess was awarded the Nobel Prize in physics in year 1936.

COSMIC RADIATION (CR)

By the source we can divide the cosmic radiation into:

- Galactic Cosmic Radiation (GCR),
- Solar Cosmic Radiation (SCR),
- Van Allen Radiation Belts (VARB).

We can distinguish between primary and secondary cosmic radiation based on the origin.

Galactic cosmic radiation is constant and is formed by particles of high energy originating beyond the solar system in remote parts of galaxy. Intensity of GCR is higher in the period of reduced solar activity and vice versa.

Solar cosmic radiation is not constant. It is formed by the Sun during solar eruptions or by a discharge of coronal matter (solar wind). In 1942 there was a malfunction of short wave transmission caused by a high-energetic particles from solar eruption. It was a first recorded case of so called ground level event (GLE). For the aviation GLEs are especially significant because they cause outage of air navigation, safety and communication services. Specifically for the electromagnetic waves used in global navigation satellite systems (GNSS) such as GLONAS, GPS or European Galileo the changes of ionosphere conditions are of paramount importance. When using frequencies from 1.2 to 1.6 GHz the ionosphere can cause a signal delay equivalent to a distance errors of up to 100 meters.

Van Allen belts spread from the height of approximately 400 km to a distance of approximately 50 000 km. The Inner Allen Belt (IAB) is formed by a concentration of particles in the height of 3 000 km. The increased radiation mainly in the inner belt causes problems to satellites whose orbit crosses this region. One of them is also the Hubble Space Telescope which is being switched off every time it flies through the Inner Allen Belts.

RADIOACTIVITY AND IONIZING RADIATION

Radioactivity is a process where the unstable nuclide transforms to a stable state by emitting the surplus energy or particle.

Parameter A – activity – denotes the mean number of changes in the unit of time:

A = dN / dt Unit name is Bequerel [Bq] Unit **magnitude** [s^{-1}]

Atom is a fundamental building particle of molecule consisting of a mantle with negatively charged electrons and positively charged nucleus consisting of positively charged protons and neutral neutrons where the number of protons and neutrons defines the stability or instability of the nucleus.

Atom: $_{Z}X_{N}$ A- Atomic Mass Number

Z- Atomic Number

N- Neutron Number

Classification of nuclides: Isotopes - nuclides with the same Atomic Number, electric and chemical properties are the same, nucleus properties are different. Isotones – nuclides with the same Neutron Number. Isobars – nuclides with the same Atomic Mass Number and Atomic Number. Isomers - – nuclides with the same Atomic Mass Number and Atomic Number, two different energetic states of the same nucleus.

Stable atoms exist infinitely long. Unstable (radioactive) transform into the more stable state through a radioactive transformation.

Radioactive radiation is a radiation emitted by the atoms nuclei during the radioactive transformations. There are three kinds of radioactive radiation:

- Alpha radiation – is a stream of positively charged nuclei of helium that travel at speed of 20 000km.s^{-1}. They penetrate layers of air couple of centimetres thick or thin metallic foils. Alpha particles are particles of helium. It deflects in the electric as well as in magnetic field. Apha particles are launched from the nucleus at speed of $1x10^7$ to $2x10^7$ m.s^{-1} while emitting energy of 2 to 8 M_eV
- **Beta radiation** - are particles that are emitted by nuclei of radioactive elements during the beta disintegration. They travel very fast (280 000km/s). They carry a positive or negative electric charge and their movement can be influenced by the electric field. Beta particles are electrons or positrons. Their penetrating power is higher than those of alpha particles. They can penetrate through materials with low density or low thickness. To stop them a layer 1 meter thick or a metal 1 mm thick is sufficient.
- **Gama radiation –** Is a high-energetic electromagnetic radiation originating from radioactive and other nuclear actions. Gama radiation is often denoted as a radiation with energy. Roentgen radiation is one of those that fall into this category. Physical difference between a Gama and Roentgen radiation does not exist. They only differ in their source. Gama radiation is a type of ionising radiation. It penetrates materials better than the alpha or beta radiation.

Generally we can divide the radiation into:

- Ionising
- Non-ionising

Ionising is formed either by particles or electromagnetic radiation. Particles of ionising radiation are the following: alpha particles, beta particles, protons and neutrons. Ionising electromagnetic radiation is represented by Roentgen radiation and Gama radiation. Non-ionising radiation are: ultraviolet, light, infrared, microwave, airwaves.

Ionising radiation (IR) is a radiation transferring the energy in form of particles or electromagnetic waves with a wavelength of up to 100m or with a frequency of over $3x10^{15}$ Hz that has an ability to directly or indirectly create ions. Directly ionising radiation is formed by charged particles (protons, electrons, positrons, etc.) Indirectly ionising radiation includes uncharged particles (neutrons, photons, etc.) that don't ionize the environment however when interacting with the environment they release secondary directly ionising particles. Ionisation of environment is therefore caused by these secondary particles. The creation of ionising radiation is connected with the structure of atoms and their nuclei.

INTERACTION OF IONIZING RADIATION

All particles emitted during nuclear transformations are subject to a reciprocal action with substance environment that they travel through. This interaction process depends on the properties of ionising radiation and properties of environment through which it travels and leads to physical, chemical or biological changes of given environment.

IONISING RADIATION DOSIMETRY PARAMETERS

They characterize the energy absorbed in the matter or its ionizing utterances. They can be derived from the parameters describing the radiation array and interaction coefficients. We can define them directly and they are directly measurable. Dosimetric parameters for measurement and calculations are the following: transferred energy, absorbed dose, input power of absorbed dose, linear transfer of energy, dose equivalent that can be personal, spatial or directional. Dosimetric parameters for the purpose of limiting are the following: mean absorbed dose in organ, equivalent dose, effective dose, committed effective dose equivalent and collective dose.

Absorbed dose „D"[3] is a mean energy E transferred to a element of substance with a defined weight of m

D = dE / dm Unit is Gray [Gy] magnitude [J/kg]

Describes physical actions in a given substance. It relates to energy transfer at a specific given place. Dose input power is an increment of absorbed dose in time $D_T = dD / dt$ [Gy/s]

Equivalent dose „H_T"[3] was introduced because of different types of ionizing radiation cause at the same absorbed energy differential effects.

$H_T = W_R . D_T$ **Unit** is Sievert [Sv]

Where W_R is the radiation weigh factor chosen to describe the same biological effect for a variety of different forms of energy absorbed radiation.

Effective dose „E"[3] was introduced for a quantitative description of the possible after-effects of radiation. The effects of radiation are also strongly dependent on whether the whole body irradiated uniformly or only part of it. „E" allows you to compare health risk for non-uniform exposure of the organism.

$E = \Sigma_T W_T . H_T$ **Unit** is Sievert [Sv]

Where W_T is the tissue weight factor. For irradiation, the amount (Σ) covers only irradiated tissues. To illustrate the W_T of bone marrow is 0.12, skin 0.01, liver 0.05, gonads (sexual glands) 0.2.

Figure 1 Dosimeter-radiometer MKS-05 for household use [6]

BIOLOGICAL EFFECTS OF IONIZING RADIATION

Ionizing radiation could be partially or completely absorbed by a substance passing. The absorbed energy causes the substance physical, chemical, thermal, biological and other changes e.g. excitatory processes in biological microstructures. The initial damage will result to the greatest extent in primary builders of living matter: water, protein, nucleic acid (DNA), enzymes and other. Cell hit a certain amount of radiation is often able to "recover" and eliminate the damage caused by radiation. We are talking about restoring (reversible) changes. If the changes are permanent and the cell has impaired activity of enzymes, stopped synthesis of nucleic acids, chromosome changes or breaks up, then we are talking about irreversible (irreversible) changes. [4]

DNA is a molecule containing unique information about the structure and function of cells, tissues and organs as a whole unit. It contains genes which are part of the DNA chain. Human DNA contains from 65,000 to 80,000 genes and these various macromolecules are arranged in chromosomes. Chemicals and ionizing radiation can cause changes in these chromosomes what we call mutation.

The most frequent adverse effects of ionizing radiation on the human body are: acute radiation sickness, acute local changes, impaired fertility, harm fetal development, cancer, chronic inflammation of the skin, lens opacity, malignant tumors, and genetic disorders of offspring.

Dosimetry and radiation protection is tasked to monitor and eliminate the biological effects of radiation and radioactivity. Radiation protection means the protection of people and the environment from radiation and its effects including all way how to achieve it.

INTERNATIONAL ACTIVITIES OF PERSONNEL RADIATION PROTECTION

1991 - International Commission on radiological protection (ICRP) issued a document no. 60 which presented new recommendations and findings on the impact of radiation on aircrew.

1992 - European and radiation dosimetry group (EURADOS) established a working group on monitoring the exposure of personnel to cosmic radiation.

1996 - International Atomic Energy Agency issued in Vienna a comprehensive publication entitled International Basic Safety Standards for Protection against ionizing and for safety of radiation sources (IBSS).

1996 - Council Directive no. 96/29/EURATOM laying down basic safety standards for the health protection of workers and the general public against the dangers arising from ionizing radiation article no. 42 Air crew protection.

1997 – European Union states undertook to implement (IBSS) into national law by the end of 2000.

Directive of EURATOM, IBBS and other expert materials were used in the preparation of national legislation. The most important from them are:

Law of Slovak parliament (NRSR) no. 355/2007 of codex (Z.z.) on the protection, promotion and development of public health

Slovak government regulation no. 345/2006 of codex (Z.z.) on the basic requirements for the protection of the health of workers and the population against ionizing radiation

Ministry of Health decree no. 545/2007 of codex (Z.z.) laying down details of the requirements for radiation protection in activities leading to irradiation and activities relevant to radiation protection [1].

For the commercial air transport the directive of The Commission (ES) 895/2008 EU-OPS 1is mandatory. The paragraph **OPS – 1.390 Cosmic Radiation** establishes that the operator takes into account the radiation of all crew members by the cosmic radiation during the flight service (including the transfer) and takes the following actions in case of crews that are expected to be irradiated by more than a **1_mSv** per year:

- Interpret their irradiation
- When preparing the work schedule he takes into account the amount of irradiation so that the crews with high irradiation are lowered.
- Informs the concerned crew members about the health risks of their job
- Ensures that the schedules for female crew members who informed their operator about their pregnancy would maintain reasonably low level of radiation that the foetus is a subject of and ensures by all means that the irradiation dose will not exceed 1_mSv during the remaining pregnancy time.

Table 1: Issued in compliance with CARI-3 software (accuracy ±20%) [Source EU-OPS1. ACJ OPS 1.390(a) (1)]

Estimated number of flight hours corresponding to radiation effective dose of 1 $_m$Sv			
Altitude		**Latitude**	
Feet	***Km***	***60°N***	***Equator***
27 000	8,23	630	1330
30 000	9,14	440	980
33 000	10,06	320	750
36 000	10,97	250	600
39 000	11,89	200	490
42 000	12,80	160	420
45 000	13,72	140	380
48 000	14,63	120	350

Conclusion

In spite of the fact, we know history and physical nature of cosmic radiation, the way of measuring and evaluating amounts of radiation, effects of radiation on human organism, limits of radiation load, international and national legislation, in spite of the facts that it´s „obligatory“ and it should be controlled by Transport Authority of Slovakia and by Public Health Authority of Slovak Republic, in spite of the fact that it is concerning health, we dare to say that radiation load of crew of Slovak operators, is „taken lightly“, if it is not completely ignored. § 34 sec.2 letter a) government regulation SR no.345/2006 is clearly defining the board of aircraft in altitude higher than 8 km as a workplace with risk of higher natural ionizing radiation (IR) for personnel, according to § 45 sec. 3 letter e) Law no.355/2007 collection of laws., there is needed a permission for executing activities on workplaces with higher (IR). To get the permission, it is necessary for operator to have trained professional representative, with Professional competence for executing activities on workplaces with higher IR. Professional representative is responsible to make the crew familiar with personal amounts and keep the information until personnel reach the age of 75, at least 30 years after finishing the work with IR. To fit the legislative requirements for radiation protection of crew it is not enough to buy a software for example European program package for the calculation of aviation rout doses (EPCARD) http://www.helmholtz-muenchen.de/en/epcard-portal/epcard-home/index.html, because it is known that during (GLE) no. 60 from 15th April 2001, there was recorded higher amount of radiation in time of flight from Prague to New York, which was double of expected in time coincidence with maximum (GLE).[5]

We want appeal for respecting of legislation and we recommend operators to cooperate with experts in given area, because it is considering the health of our colleagues.

Acknowledgement

This paper is published as one of the scientific outputs of the projects supported by EU:
Centre of Excellence for Air Transport - ITMS 26220120065.

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Measurement of Probability of an Uncorrupted Mode S Replay Receiving in Real RF Environment

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***Abstract* — The paper describe the analysis that investigated the probability of receiving an uncorrupted Modes S message based on Cyclic Redundant Check (CRC) algorithm. The measurement was performed on the real data record from the receivers of multilateration system (P3D-WS LKPR) in the Czech Republic.**

Key words – CRC, Cyclic Redundancy Check, SSR Mode S, WAM, Multilateration, P3D-WS, interrogation, reply, 1090 MHz RF Band

I. INTRODUCTION

Essential assumption for an efficient operation any system based on data exchange is a feature that the transmitted message will be able to successfully decode on a receiver site. As far as systems such as SSR Mode A/C, SSR Mode S, ADS-B, ACAS, … are concerned, the situation is more complicated due to the fact that one spectrum is shared all systems and all users without any coordination for access to the band (1030/1090 MHz). It causes that the messages might be garbled (overlapped) in a receiver and could be incorrect decoded. For such schema of operation we must accept certain significant amount of lost messages. On the other hand such system is quite simple and cost effective from the world wide perspective. With a growing of operation on the 1030/1090 RF band the probability of correct message decoding is decreasing. In mode S messages, for detection and for prevention of usage such corrupted messages, the CRC (Cyclic Redundant Check) is applied.

II. CYCLIC REDUNDANCY CHECK (CRC) ALGORITHM

Cyclic Redundancy Check field is appended to the message to increase the level of assurance that the data are correct and increase system integrity. CRC is a mathematical process whereby a sequence of N data bits is manipulated by an algorithm to produce a block of n-bits, known as the CRC (where n is less than N). A check of the integrity of the data can be performed by comparing the result of the applications of the CRC algorithm with the declared expected result.

Each CRC is calculated as the remainder R(x) of the modulo-2 division of two binary polynomials:

$$\left\{\frac{[x^n \cdot M(x)]}{G(x)}\right\}_{\mathrm{mod}-2} = Q(x) + \frac{R(x)}{G(x)} \qquad \text{(Eq. 1)}$$

Where:

M(x) is the information field, which consists of the sequence of data items to be protected by the particular CRC, represented as a polynomial.

G(x) is the generator polynomial specified for the particular CRC (for our case see Eq. 3).

Q(x) is the quotient of the division.

R(x) the remainder of the division contains the CRC.

The bits of the message are regarded as the polynomial sequence M(x). For convenience in practice it is usual to multiply M(x) by x^n before performing the division, where exponent n is the order of polynomial G(x). This is equivalent to appending n zero-bits to M(x).

The algorithm by which a CRC is produced is defined by a generating polynomial G(x) (where the coefficient of x^n are either 0 or 1).

$$G(x) = \sum_{n=0}^{24} G_n \, x^n \qquad \text{(Eq. 2)}$$

Where G_n=1 for n = 0, 3, 10, 12, 13, … 24 and G_n=0 for otherwise n. Thus resultant polynomial is:

$$G(x) = x^{24} + x^{23} + x^{22} + \ldots + x^{13} + x^{12} + x^{10} + x^3 + 1 \qquad \text{(Eq. 3)}$$

To generate a CRC, a data block is divided by a G(x). The resulting remainder, which is CRC, is usually tagged onto the end of data block. When a data are subsequently checked, a division is performed on the whole data sequence which now includes origin data bock and added remainder. If no errors have occurred, the remainder of this division should be 0.

The algorithm in SSR mode S messages is a little bit complicated. The remainder before adding to the message data block is modulo-2 added by extra sequence (see Figure 1). This sequence is either A(x) or I(x).

A(x) represents 24 bits individual ICAO aircraft address. I(x) is used for DF11, where 24 bits sequence is formed by 17 zeros bits, 3 bits contains CL field and 4 bits contains IC field. For DF17 and DF18, an I(x) sequence is 24 zeroes bits sequence.

Thus if receiver knows A(x) or I(x) sequence then it can recognize an error-free message by the appearance of the remainder equals either A(x) or I(x).

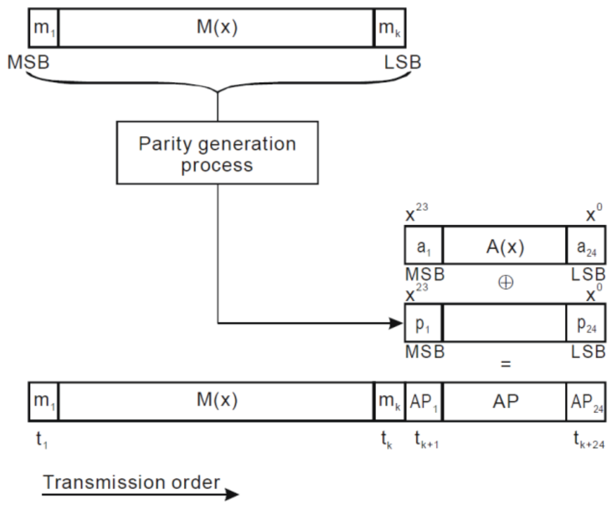

Figure 1. Downlink parity encoding process for DF 0, 4, 5, 16, 20, and 21 replies [2]

III. SOURCE OF DATE FOR THE ANALYSIS

The analysis whose partial results are presented in the following chapter was performed based on data records from Prague WAM (Wide Area Multilateration) system (P3D-WS LKPR). P3D-WS LKPR consists of 10 receiving stations deployed according Table 1 and Figure 2. The composite record of received messages (from 20. 11. 2012) from all 10 stations was utilized for measurement.

TABLE I. LOCATIONS OF RECEIVING STATIONS P3D-WS LKPR

Site	Description	Latitude	Longitude	Height
Post-0	Jeneč	50.08637	14.19982	446.964
Post-1	Česká Lípa	50.77734	14.50058	723.679
Post-2	Litický Chlum	50.10103	16.35028	682.108
Post-3	Šibeník	49.5611	14.66565	746.44
Post-4	Písek S	49.78493	14.03455	762.478
Post-5	Písek J	49.7848	14.03453	762.583
Post-6	Jirna	49.72843	13.02329	636.53
Post-7	Jedlák	50.54865	13.46206	914.368
Post-8	TB RXS-12	50.1062	14.26717	447.742
Post-9	TB RXS-14	50.10621	14.26688	447.764

Figure 2. Positions of receiving stations P3D-WS LKPR

IV. THE ASSUMPTIONS FOR SUCCESSFUL DETECTION OF CORRUPTED MESSAGES

Measurement was based on CRC mechanism which is applied in all mode S replies as was explained in chapter 2. In analyze, the ratio of the received messages identified as correct to messages where error have occurred was investigated. Based assumption is knowledge of expected reminder field result after Cyclic Redundancy Check which indicate correct message.

Common down-link messages occurred within recorded data (i.e. downlink formats) are: DF11, DF17, DF4, DF5, DF20, DF21, DF0, and DF16.

As far as DF4, DF5, DF20, DF21, DF0, DF16 are concerned, the expected result of a reminder after CRC algorithms application is 24 bits individual ICAO aircraft address. Nevertheless we are not able to allocate specific 24 bit aircraft address to particular message because we aren't able to simply associated particular message to specific aircraft which emitted it. In the other words, during passive receiving we expected that the remainder represents ICAO aircraft address but we are not able to validate that the bits sequence really represents address, or whether this is the event when this sequence indicate error message and thus it doesn't represent any real address of some aircraft situated somewhere within a coverage. Hence analysis based on those formats was unusable for our purpose.

From the point of the intended analysis very suitable message format was appeared DF17 due to the fact that for all correct received messages the remainder should equal 24 zeros bits sequence. Simply if we don't find remainder equals zeros, the message is corrupted.

As far as DF11 message is concerned the situation is a little bit complicated. Reply DF11 could be used both for Acquisition Squitter (remainder equal 24 zeros bits sequence) and Mode S All-Call reply (the reminder doesn't have to equal 24 zeros bits sequence). The Mode S All-Call reply could be elicited (by means of UF11 interrogation) by radar with II/SI≠0 or II/SI=0 or it could be elicited just by A/C/S interrogation with long P4 pulse. For DF11 (as a reply to Mode S All-Call interrogator) a 24 bits sequence is formed by 17 zeros bits, 3 bits contains CL field and 4 bits contains IC field. CL and IC fiend contain II/SI information (in more details see Annex 10, Volume IV, paragraph 3.1.2.5.2.1.3.).

V. THE MEASUREMENT RESULTS

The results presented in Table 3 are based on 10 million decoded messages which correspond to the number of messages received from all 10 receivers during 152 s. From the 10 million messages the 134 123 messages were identified as replay DF17 and 253 371 messages were identified as DF11. Certain insignificant error in analysis may occur when the header of a message is corrupted so unfortunately, that the message of one format is identified as a message of another format.

TABLE II. MODE S MESSAGE STATISTIC BASED ON 10 RECEIVERS

	Number of analyzed messages	Correct (crc=0)	False (crc≠0)
DF 17	134 123	48 813	85 310 (63.6 %)
DF 11	253 371	155 322	98 049 (38.7 %)

The analysis results based on DF11 messages must be interpreted rather as limit pessimistic results because as was mentioned above, among corrupted messages we could find Mode S All-Call replies elicited by radars with assigned II or SI code. Nevertheless during detailed analysis there weren't found significant number of those messages. Unfortunately this recognition doesn't correspond to the theoretical presumptions and it also doesn't correspond with the airborne measurements performed by EUROCONTROL in European high traffic density areas in 2011 [3]. This issue will be more precise investigated during a following research.

Above presented results in the Table 3 are a little misleading, due to the fact that the analysis is based on all received messages. It means that there are also involved messages come from airplanes situated far beyond an operational coverage. We could observe that the ratio of receiving of corrupted message increases with the distance of a transmitter (aircraft) from a receiver (see Table 4). So much more predicative approach is examining the probability of receiving an uncorrupted message in dependency on target distance from a receiver.

TABLE III. AN EXAMPLE OF A DEPENDENCY OF PROBABILITY OF FALSE REPLY RECEIVING TO A DISTANCE OF AN AIRCRAFT FROM RECEIVER.

24b. ICAO Aircraft Address	Average aircraft distance from receiving stations	DF 11 False (crc≠0)	DF 17 False (crc≠0)
3C6467	89 255 m	3.04 %	14.66 %
80043C	152 505 m	11.22 %	34.32 %
44D263	176 580 m	16.64 %	44.02 %

VI. CONCLUSION

In general, the probability of a message corruption depends on: 1090 RF band saturation, length of message (the longer message the more probability that the message will be garbled) and on a receiver (performance of the system and applied methods for decoding).

Because the environment (at the time of measurement) and receiver's conditions are the same for all received messages, the results are possible to generalize for long and for short messages. In accordance with theoretical assumptions the probability of receiving an uncorrupted long (112 bits) message is much more less in comparison to short (56 bits) messages. But exact rate specification turned out to be much more complicated due to dependency on many circumstances. Another research based on more sophisticated analysis will need realized for finding better description of real environment which is essential for creating applicable models.

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Airline Cooperation Forms

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Abstract — **The paper is about individual forms of cooperation, whose creation is closely associated with globalization and liberalization of the air transport market. Airline services are one of the most important parts of air transport market.**

Keywords – cooperation; airlines/carriers; agreement; air transport market

I. Introduction

Air transport is a unique segment in which despite of tough internal competition it was possible to create well-functioning global transport system that is dependent on commercial, operational, technical and technological as well as security cooperation of airline operators. And with respect to the nature of air transport the close cooperation on either bilateral or multilateral level is a necessity. After the liberalization of the air transport market the fight for every passenger and every ton of cargo is hard not to apprehend. In some instances it even borders with the economic efficiency and a basic definition of entrepreneurship that always says that it is a conscious activity that is performed in order to make profit. With regard to a never-ending effort to decrease prices in the competitive fight with the low-cost companies taking risks with artificially created low prices is a way to perdition. And in such competition one way of increasing the efficiency of the undertaking is the cooperation between the airlines that can have multiple forms.

Cooperation on the multilateral level is provided mainly by signing of international agreements that deal with the issues of air transport as well as by the membership in the international organizations of civil aviation that lay down worldwide accepted standards and practices such as ICAO, IATA or on the European level AEA. Over time a worldwide network of air routes has been created. These routes are carried out by a number of cooperating as well as competing airlines [1]. Based on hereof development for the purpose of maximum interconnection and consequence between individual connections it was unconditionally necessary to create mutual cooperation between carriers on various levels. It is important to realize that this cooperation is with respect to its character, system of functioning as well as the mutual relations settlement system agreed by traditional carriers. Low-cost carriers usually offer only one-way transport and the system of mutual settlement is not publicly known.

It is worth noticing that the majority of cooperation forms does not have an exerted Slovak or Czech name mainly because such cooperation is almost always signed in English and these terms have become a part of everyday running of the company. That is the main reason why even in the Slovak correspondence predominantly Anglicism or English names are used.

II. Airline cooperation forms

Known forms of airline cooperation include Interline, Pooling agreement, Royalties, Joint ventures, Franchising, Special prorate agreement, code-share agreements and the creation of global strategic alliances of airlines. Strategic alliances are not an unfamiliar phenomenon only in the airline business but also in other various branches of industry. Every year approximately 2000 various alliances and partnerships are formed and this number has an increasing tendency. In average it in-creases by 15% a year [2]. A good example from the segment of Hi-Tech technologies is a cooperation of companies Sony and Ericsson who joined their mobile phones divisions in order to become a stronger competitor in the mobile phones market.

In the air transport the airlines sign cooperation agreements in order to achieve higher income, reduce the unit costs, reduce or share the risk as well as consolidate the market position. Forms of cooperation can be tactical or strategic.

Tactical forms of cooperation have a marketing or commercial character. They usually are bilateral agreements between airlines that cooperate on a specific limited number of routes and by that they mutually gain access to the network of routes of the partner airline. This type of alliance for the first time started as a cooperation on the marketing level through Interline, Agreements on mutual settlement (pro-rate), Code-share agreements and later on it evolved into commonly coordinated establishments (Joint Venture) [3].

A. Interline

In order to increase the comfort of the passengers as well as to streamline the process of goods transport it was necessary to start recognizing transport documents on the basis of Interline Traffic Agreement (ITA). Majority of traditional carriers have signed this type of agreements because they form a basis of global transport system of airline network. A Warsaw Pact has defined standard terms and conditions and a proposition of this agreement. It states that a passenger is eligible to purchase a fare for an entire journey at one place even though multiple companies carry out the transport and he is eligible to pay for the journey in one currency as well. Similarly in case of transfer the airline and its partners guarantee to take care of passenger's luggage without his attendance. This agreement clearly states the conditions according to which the contracting parties i.e. airlines will accept the transport documents as well as define the way to settle their liabilities. These agreements can be of bilateral character so-called BITA as well as of multilateral character so-called MITA both of which are covered by an International Air Transport Association (IATA).

Based on the aforementioned cooperation a system of settlement of mutually interconnected transport between individual airlines has been established. It is being utilized within the framework of BITA and MITA while an important role is played by IATA which acts as a guarantee of these mutual relations. This system is based primarily on virtual utilization of IT systems that aid the process of fare pricing as well as control the reservation systems etc. Calculations are based on signed agreements and terms and conditions in them specified; clearly set air routes; exception points as well as on the commission or share of individual carriers on the mutual cooperation and their overall transport. Essential principle of settlement of mutual relations results from proration which is an act of division of the total price of transport among the cooperating companies when using the shared routes. Air-ticket as a transport document that consists of several coupons of which every single one corresponds to a certain leg of the connection e.g. Prague – Amsterdam via ČSA, Amsterdam – London via Air France-KLM, London – New York via British Airways forms a basis for the settlement. Based on the data from the air-ticket the revenues collected by the selling airline will be split among the airlines that participate on the route i.e. ČSA, Air France-KLM and British Airways. Prorate tariffs express the proportional value of flown legs from the price of the air-ticket (overall tariff). Considering the fact that it is possible to apply more than one tariff as well as to apply various discounts, frequent fliers programmes of individual carriers etc. the process itself is very complex and complicated. In the past airlines used to transfer the shares directly between themselves. This was carried out using system of invoices where the carrier that has issued the air-ticket for a flight of other carrier has received an invoice from the carrier who operated the flight. The issuing carrier then deducted the sales commission and its own share on the overall tariff and paid the remaining amount to the other carrier. With respect to ever-expanding number of carriers as well as the number of bilateral or multilateral agreements this process has soon become non-functional or more precisely immensely difficult to manage from the administration point of view. Based on aforementioned circumstances the IATA has set up a unified settlement office – IATA Clearing House. Existence of such body eases the mutual relations between carriers as well as it ensures the settlement of liabilities and accounts payable among the members of this institution for transport of passengers via member carriers as well as other mutual services such as sale of fuel or handling of aircraft.

It is important to realize that interline has an undisputable contribution for passengers where the carriers guarantee them that they won't even realize that some legs of the journey are performed by other carriers. Even though the carriers have their own identity preserved the passenger is charged unified tariff for the whole flight. Yield from such flight are then redistributed among participating carriers based on the principles of prorating.

B. Pooling Agreements

This type of agreement was in the past a reputable form of cooperation among two and in some special cases more carriers. They defined the conditions of the cooperation on selected routes. Signatories of such agreements were usually countries where the airlines had their headquarters. The basic principle of this agreement was that the carriers transferred an agreed amount of revenue for the performed flight to a common account (pool). Financial resources bound on this account where usually during the exchange of summer and winter flight schedule redistributed according to a prearranged key that usually reposed on the principle of offered capacity ratio. These agreements were highly variable however the principle was in majority of cases based on number of frequencies, operation times, capacity, pricing policy, tariffs, and way of revenue calculations as well as system of their subsequent distribution. The most important institute of these agreements was a pre-set coefficient that expressed the offered capacity disparity of involved parties.

An objective of these agreements was an effort to persuade the involved parties so that they would be interested in filling not only their aircraft but the aircraft of their partners and so that they will sell air-ticket for flights of their partners. When the utilization of the aircraft of only one party was significantly higher than the utilization of the other one a part of the revenues was transferred to a partner with less utilized aircraft via pool settlement. However with respect to the fact that throughout the duration of this cooperation the prices and capacities were mutually coordinated these type of agreements are considered to be an example of unfair competition and a cartel support that prevents the free competition.

C. Royalities

Even nowadays there are some strictly regulated air transport markets where a national carrier has to agree to grant commercial rights (license to provide aeronautical service) for a foreign carrier. This mechanism of consignment of part of revenues to a national carrier of a particular country who is responsible for issuing the appropriate licenses or business permits is called Royalties. They are usually defined as a form of charge per transported passenger or one kilogram of cargo.

D. Franchising

This type of cooperation is based on provision of rights to use business name or trade-marks of generally known and reputable carrier for a repayment. It is an agreement between a franchisor (company that grants the rights) and franchisee (Franchising company) that adopts some of the services or signs of franchisor for example the uniforms, on-board service standards, reservation system, revenue settlement system etc.

Even though the franchisee gave up its publicly recognizable identity it carries out all the activities based on its license within its airport slots and at the same time is responsible for any damage it may cause. One of the most important institutes of this legal relationship is usually the business name and know-how. For a franchisee it means higher utilization of its routes as well as access to knowledge and experience (e.g. training programs). For franchisor it's the income from licenses as well as expansion of connecting routes.

E. Joint ventures

Joint ventures agreements or common enterprise are partnerships on international routes where partners share the revenues or profits and it does not matter which one of the partners has provided the service and transported the passenger. They are based on similar pillars of cooperation as pooling agreements. They contain the same basis however the level of cooperation between the carriers is even closer. The form of cooperation has changed and partners are comparatively participating not only on revenues but also on costs of particular common routes. Actual execution and operation of routes can be carried out by one or both of the partners. Partners are in this form commonly participating on profit however in some cases even on the loss. Even though these agreements are in line with liberalized air transport market they have become unacceptable and it is only possible to use them with a consent of supervising governor through granting an anti-trust immunity among some partners in global airline alliances.

F. Special Prorate Agreement (SPA)

One of the closer forms of bilateral cooperation is Special Prorate Agreement where the involved parties agree on a price or tariff that is lower than the normally published one. They agree to transport interlining passengers or cargo based on these conditions on defined routes. Usually they are connecting routes which gives the partners an opportunity to compete with other carriers on the market who offer a direct connection.

G. Code-share Cooperation

One of the closest forms of cooperation between airlines nowadays is a cooperation through code-share agreements. The main principle of this liaison resides in sharing of the capacity of the carrier. One route can be denoted by codes of multiple carriers which means widening of the supply i.e. the network of the carrier. Harmonization of the reservation systems and dispatch processes is one of the vital conditions of these agreements. Passengers can take advantage of more connections with the same carriage conditions. At the same time it ensures better visibility (availability) of connections in individual reservation systems which increases the probability of flight reservation as well as higher saleability while eliminating other carriers. Equally agreements of this type include a "block space" clause which guarantees the carrier a fixed capacity (number of seats) on selected routes on flights of its contractual partner.

Individual forms of cooperation and their evolution are depicted on pictures 1 and 2. They show a usual expected development of airlines' partnerships as well as various rates of cooperation within partnerships.

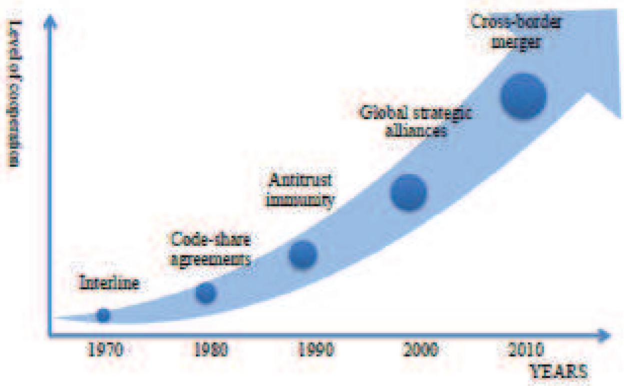

Figure 1. Expected development of partnerships [4]

Figure 1 gives an insight into changing forms of airline partnerships in time. The rate of cooperation is increasing with time i.e. the mutual interconnection of partnerships is increasing more and more. At the beginning the airlines cooperated on tactical level through Interline agreements and nowadays apart from the global alliance partnerships we observe a trans-border mergers of airlines. As an example we can mention the merger of French Air France with Dutch KLM into Air France-KLM or Korean Air and ČSA where the Korean Air bought 44% of shares of the ČSA.

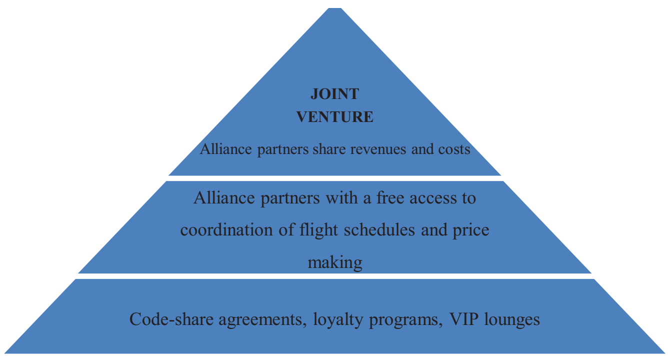

Figure 2. Various rates of cooperation in global airline alliances [4]

Figure 2 illustrates three layers of cooperation within the global airline alliances. The lowest and most spread layer hints at wide opportunities of alliance and its advantages when the partners cooperate. The second layer enables the free cooperation in areas of price making and flight schedules in the

North Atlantic region where it is necessary to obtain an anti-trust immunity from the US Department of Transportation. The closest form of cooperation is Joint Venture or a common enterprises of airlines for international routes where partners mutually share revenues or profits and where it does not matter which of the partners has provided the actual service and has transported the passenger.

III. Conclusion

This paper has been dealing with the examination of possible forms of mutual cooperation between individual carriers. From the integral point of view on the airlines it was necessary to outline the development which the airlines and their mutual cooperation undergo during their common operation at the market.

Various types of cooperation are known to be a suitable tool for expansion or strengthening of competitive advantage of carriers on the market. Creation of individual forms of cooperation is closely associated with globalization and liberalization of the air transport market [5]. Code-share agreement is interpreted to be the one of the closest forms of cooperation i.e. closing a code-share agreements between individual airlines whose main purpose is the widening of the carrier's network or gaining a priority when searching for a connection in the global reservation systems.

Acknowledgements

This paper is written as a part of research project VEGA 1/0838/13- The basic research of CHARGES POLICY AT THE SPECIFIC MARKET OF AIRPORT SERVICES.

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New Trends in Pilot Training

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***Abstract*— General aviation is undergoing a dramatic change. This change refers to flight training. Not so many years ago most fixed base operations were affiliated with one or more of the large general aviation aircraft manufacturers, and provided one-stop shopping for practically every need: flight training, aircraft rental, sales of new and used general aviation aircraft, fuel, maintenance and repair services, and charter fights. In this paper we will talk about new trends and new programs in pilot training. The final section of article deal about nowadays topical theme, UAVs. Although the name implies, that it is a device without a pilot, also it have to have its operators who need training.**

Keywords-Pilot Training, New Trainning Programms, Shortage of Aviation Personnel

I. Introduction

As the technology in aircraft has evolved, the representative devices used to train pilots have also advanced. The advent of state-of-the-art simulation technology has permitted wider use of airplane flight simulators for training and certifying flight crewmembers. These ground-based flight simulators provide more in-depth training than can be accomplished in airplanes and provide very high transfer of learning and behaviour from the simulator to the airplane. The use of simulation in aviation training now dates back more than 75 years. During the development of training devices for pilot training has also changed approaches to teaching of aviation personnel. Nowadays more and more often we can hear about improvements and new approaches to improving of aviation personnel. An important requirement is also the period for which should be personnel trained and able to work in a real operation.[1]

II. Shortage of Aviation Personnel in the Future

For the first time in the history of the air transport industry, there is a very real possibility that we could experience a shortage of qualified aviation professionals such as pilots, maintenance personnel, air traffic controllers and various other professionals.

Looking to the future, aviation stakeholders are confronted with a pressing human resource challenge: how to ensure we have a strong supply of skilled, competent, personnel to meet the demands of the global air transportation system of the future. Some of the considerations that arise in this regard include: By 2026, we will need 480,000 new technicians to maintain these aircraft and over 350,000 pilots to fly them. [2]

Between 2005 and 2015, 73 percent of the American air traffic controller population is eligible for retirement. Aviation will also need thousands of airline customer service personnel, air and ground crew and cargo handlers, not to mention many other aviation-related professions, such as travel and cargo agents, to meet the dramatic growth in the aviation industry.[2]

As aviation competes with other industrial sectors for highly skilled professionals, the solutions to attract and retain the best and brightest will be multi-faceted. These solutions will focus on ensuring that all interested candidates have access to quality and affordable aviation education and training. Solutions must also leverage technology to its fullest, utilizing distance learning and e-learning platforms as well as the latest consumer electronics products and telecommunications services.

ICAO (International Civil Aviation Organization) has focused his entire last year's journal titled ICAO Training Report to the increasing of inspiration for young people to work in aviation professions. This bulletin contains opinions from various representatives of airlines professions from all over the world. The main problem in a small amount of personnel they see in high costs of training and outdated teaching methods.

New curricula of teaching theoretical knowledge is based on e-learning, Internet communications, Smart phones and tablets. The use of these new technologies should increase the interest of young people to education in the field of air transport.

III. Pilot Training Yesterday and Today

Flight training was conducted on a one-on-one instructor/student basis, much like traditional master-and-apprentice training methods long used by trades people like masons and electricians.

That's still true but over the past several years flight training at large-scale professional pilot training programs has really begun to change. In this time is many more pilots, generated far more quickly than in the past, in fewer training hours, and using far fewer instructors.

Traditionally, quality of pilot training varied almost solely by quality of instructor. There was plenty of room for CFIs (Certified Flight Instructor) to go their own ways, and to pursue their own teaching philosophies.

The first step for increasing training programs has been to heighten efficiency by homogenizing flight training to get more consistency. Today's structured methods, particularly at larger flight schools, are designed to smooth out disparities between individual CFI methods through standardization, while increasing the number of students taught by each instructor. More students per teacher means greater training efficiency, and at the same time, reduced impact of the growing CFI shortage.

Many airlines are already doing training program, along with the big corporate flight training organizations, and Cessna is leading the way into even the smallest flight schools with its exciting new multimedia Private Pilot program.

Increased training automation is also good news when it comes to CFI compensation. With instructors devoting less time per individual student, they'll have time to take responsibility for more of them, meaning CFIs can ultimately earn higher salaries. One reason airline pilots make more money than other pilots, is because their piloting skills are amortized over so many passengers.[8]

Figure 1 Aviation Academy

IV. NEW EDUCATIONAL PROGRAMS IN PILOT TRANING

A. *CRM Assessment A Pilot's Perspective*

The International Federation of Air Line Pilots' Associations (IFALPA) has long recognized that relying solely on a pilot's technical knowledge and skills is not sufficient to safely operate complex aircraft in today's flying environment. Flight crews need specific skills and strategies to assist them in coping with the dynamic demands of piloting and in reducing errors. IFALPA supports integrating CRM (Customer relationship management) into flight crewmember training as a tool to minimize the consequences of human error and to improve flight crew performance. Industry recognizes CRM as a 'best practice' when fully integrated into initial licensing and recurrent training programs, including Multi-Crew Pilot Licensing (MPL) and Advanced Qualification Programs (i.e., AQP, ATQP).[4]

Pilots should be taught the limitations of human performance and be trained to develop skills to detect and manage error. Just because crews can demonstrate effective crew coordination while being assessed under jeopardy conditions does not guarantee they will actually practice these concepts during normal line operations. Industry studies show that line audits, where crews are observed under non-jeopardy conditions, provide more useful data.

B. *The Evolution from TRAINAIR to TRAINAIR PLUS*

The original ICAO TRAINAIR program was part of a broader UN (United Nations) initiative that provided much needed competency-based training knowledge, tools and materials to government training providers across multiple sectors for over two decades. In 2011, after the completion of a comprehensive series of reviews of the core TRAINAIR scope and objectives, ICAO has re-introduced the program as TRAINAIR PLUS — better aligning it with the new ICAO Training Policy. [5]

As an effective tool to implement competency-based and cost-effective training, TRAINAIR PLUS plays a critical role in human resource and skills devel opment. Originally, the TRAINAIR programme was part of a broader UN initiative that provided much needed competency-based training knowledge, tools and materials to government training providers across multiple sectors for over two decades.[5]

As part of the evolution from TRAINAIR to TRAINAIR PLUS, ICAO has now implemented a more formal assessment process addressing the following critical areas affecting the provision of effective aviation training[5]:

- Organization and official certifications.
- Training delivery.
- Facilities and technology supporting training.
- Instructor qualifications.
- Training design and development.
- Training quality systems.

C. *Training program according to Indonesia*

The education and training programs conducted can be divided into four training departments, namely[6]:

1. The Pilot training department consists of:
   - fixed wing pilot training program,
   - rotary wing pilot training program,
   - flight operation officer training program.
2. The Aviation Safety training department, consists of:
   - the Air Traffic Control (ATC) training program,
   - the Aeronautical Information Services training program,

- the Aeronautical Telecommunication training program,
- the Airport Fire Fighting training program.

3. The Aviation Technical training department consists of:
   - the Aircraft Maintenance training program,
   - the Air Telecommunication and Navigation training program,
   - the Airport Electrical training program,
   - the Airport Mechanical training program,
   - the Airport Building and Runway training program.
4. The Aviation Management training department consists of:
   - the Aviation Management training program,
   - the Airport Operation training program,
   - the Aviation Administration training program.

The Aviation Technical and Safety Academy (ATSA) of Surabaya is expected to participate in the road map to zero accidents through the development of human resources in the air transportation sector by generating competent and competitive aviation professionals.

Figure 2 Indonesian Civil Aviation Institute of Curug

V. UNMANNED AIRCRAFT VEHICLE

Civil aviation has, to this point, been based on the notion of a pilot operating the aircraft from within the aircraft itself and, more often than not, with passengers on board. Removing the pilot from the aircraft raises important technical and operational issues for the aircraft, the aviation system and the personnel involved, the extent of which is being actively studied by the aviation community and ICAO.[7]

Like pilots of manned aircraft, remote pilots must comply with the laws, regulations and procedures of those States in which operations are conducted. The remote pilot-in-command will have responsibility for the safe conduct of the flight and will need to comply with the rules of the air. UAVs (Unmanned Aircraft Vehicle) pilot is also a pilot and he must undergo pilot training.[7]

Figure 3 UAV - Northrop Grumman X-47B

A. Unmanned Aircraft Vehicle pilot training

Unmanned Vehicle University is the first school in the Nation for UAV Pilot Training

Unmanned Vehicle University is the only University in the World that is licensed to grant degrees in UAV Engineering and a Professional Certificate in UAV Project Management.

The UAV pilot training program consists of three phases. Phase 1 and 2 are conducted at home. Phase three is conducted at one of our flight schools. At the end of the program, students will receive the UAV Pilot Certificate that shows 10 hours of simulator, 16 hours of ground school and 24 hours of flight training for a total of 50 hours of training. All flights are conducted at AMA (Academy of Model Aeronautics) fields with AMA instructors in accordance with FAA (Federal Aviation Authority) AC 91-57. The cost of the three phase program is $3500.[9]

- **Phase 1** (At Home) Students will complete the Small UAV Ground School which consists of the following topics: Checklists General characteristics Dimensions & weight Motors Propellers Electronic speed controls Wireless links Fuel/Flight Battery Flight Parameters Limitations Emergency Procedures Normal procedures Performance Flight times & wireless transmission Weight and balance Air Vehicle Systems Description Handling, service and maintenance[9]
- **Phase 2** (At Home) As soon as payment is received, we will ship a simulator to you in the mail. The simulator consists of software and a controller that plugs into the computer USB port. After you install the software you will be able to fly 47 different small UAVs from 6 different sites. Students will receive instruction on both fixed wing and rotor wing aircraft. Students will practice unusual attitude recoveries and takeoff and landings. One of our highly qualified instructors will call you and provide instruction on the

phone while you are at home. This hands on experience will prepare you for flight with several real small UAVs during your 3 day flight training class.[9]

- **Phase 3** (At Flight School) After completion of the home based ground school and simulator training, students will be scheduled for 3 days of basic flight training at one of our flight training centers. Students will fly both fixed wing and vertical takeoff (quadcopter, helicopter) small UAVs depending on location. Propulsion systems are both electric and gas.
  - ✓ Day 1 Pre-flight briefing Manually fly fixed wing UAV
  - ✓ Day 2 Pre-flight briefing Manually fly rotor wing UAV (hex/quad/heli-copter)
  - ✓ Day 3 Pre-flight briefing Program autopilot Fly on autopilot.[9]

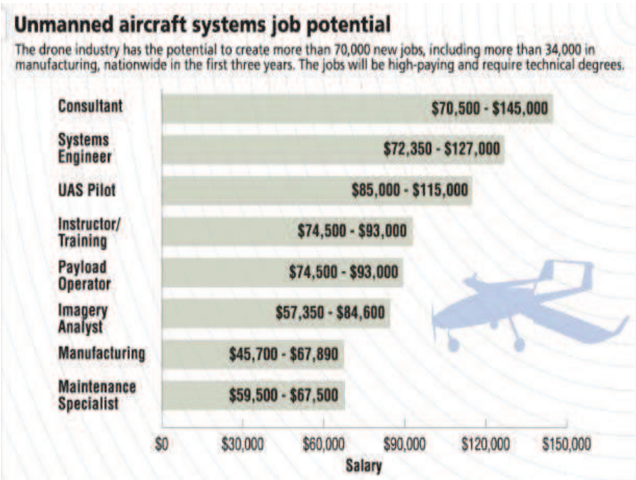

Figure 4 UAV Job Potential

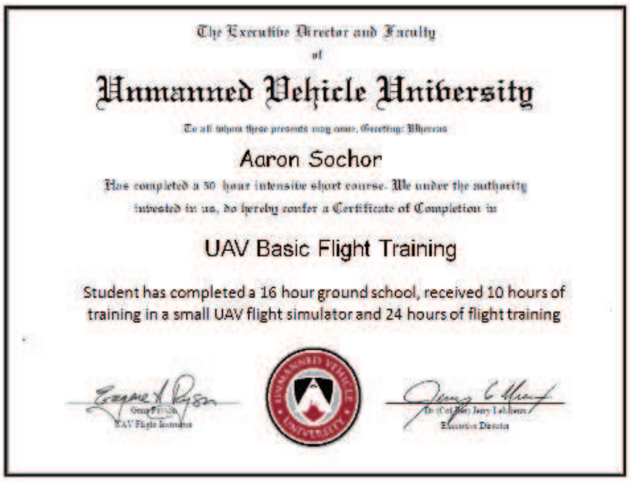

Figure 5 Unmanned Vehicle University Certificate

CONCLUSION

A new trend in the flight training is the introduction of modern flight simulators and changes in teaching methodology. Whereas nowadays reducing the number of flight training instructors, companies are formed groups of students in one class. By creating this environment is disappearing subjective approach to students, but streamlines the training cost for instructors. To attract new student, companies are using modern technology. Companies create a variety of applications from aviation to smart phones to reach potential students. The novelty of today are Unmanned Aircraft Vehicles that start to integrate airspace and UAV is also use for civil operations, nowadays. With the arrival of these means there is a need to train qualified personnel able to safely manage these unmanned aerial vehicles.

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Issue of Aircraft Leasing -Damp Lease

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Abstract — **Lease of aircraft is contractual arrangement whereby a properly licensed air operator gains commercial control of an entire aircraft without transfer of ownership". (ICAO Doc 8335). I would like to explain some of the terms related to leasing of aircrafts and show an illustrative example of one type of aircraft leasing - damp lease.**

Keywords-component; aircraft leasing; wet lease; dry lease; damp lease; ACMI.

I. AIRCRAFT LEASING LEGISLATION

European Regulations concerning lease of aircraft (Approval Requirements)

Regulation (EC) No. 1008/2008 of 24 September 2008 on common rules for the operation of air services in the Community (Recast)

Article 13 of Regulation (EC) No. 1008/2008 deals with aircraft leasing. Article 13(2) requires prior safety approval (in accordance with applicable Community1 or national law2) for dry lease agreements to which a Community air carrier is a party (i.e. dry lease-in and dry lease-out) or wet lease agreements where the Community air carrier is the lessee of the wet leased aircraft (i.e. wet lease-in). [Note: Future EASA Implementing Rules for Air Operations will require notification to the CAA before wet leasing-out an aircraft (Part-ORO, paragraph ORO.AOC.110(f)).]

1 Community law – lease approval issued under Council Regulation (EEC) No 3922/91, Annex III (EU-OPS), OPS 1.165
2 National law – lease approval is issued under national CAA.

Wet leasing-in of an aircraft registered in a third country (i.e non-Community lessor) requires an approval under Article 13(3) of Regulation (EC) No. 1008/2008.

Council Regulation (EEC) No. 3922/91, Annex III (EU-OPS) - applies only to commercial air transport aeroplanes

EU-OPS, OPS 1.165 refers to Leasing. Prior lease approval is required for:

- *a Community operator entering into a dry lease-in agreement;*
- *a dry lease-out agreement to a Community operator;*
- *a wet lease-in agreement.*

Although EU-OPS 1.165 does not refer to an approval when dry leasing-out an aircraft to a third country operator, it does require an Exemption from OPS 1.165. [Note: As Regulation (EC) No 1008/2008 requires approval when dry leasing-out to a third country.

II. TYPES OF LEASES AND THEIR DEFINITIONS

- ***Dry Lease Agreement***
- ***Wet Lease Agreement***
- ***Damp Lease***

Explanation of terms:

Dry Leasing - is defined under EU regulations as an "agreement between undertakings pursuant to which the aircraft is operated under the AOC of the Lessee".
There is generally two types of dry lease, an Operating Lease and a Finance Lease.
Operating Lease: generally a lease term that is short compared to the economic life of the aircraft being leased. An operating lease is commonly used to acquire aircraft for a term of 2-7 years. With an operating lease the aircraft doesn't appear on the LESSEE's balance sheet.

Finance Lease: also known as a capital lease, is defined when on of the following conditions are met:-

1. at the end of the lease term the LESSEE has the option to purchase the aircraft at an agreed price.
2. the lease payments are more than 90% of the market value of the aircraft.
3. the term of the lease is over 75% of the aircraft's usable life.

Wet Leasing - is defined under EU regulations as an agreement between air carriers pursuant to which the aircraft is operated under the AOC of the Lessor.

Damp Leasing - is defined as a wet-leased aircraft that includes a cockpit crew but not cabin attendants.

ACMI leasing – Aircraft, Crew, Maintenance, Insurance

Community operator - is an operator, which is a holder of an Operations Certificate issued by the Civil Aviation Authority of an EU Member State (+ Switzerland, Norway, Island and Lichtenstein).

Leases between Community operators - Each of lessor and lessee must obtain prior approval from its authority (except in case of wet lease-out)

Wet lease-in from non-EC operator to Community operator - Approval required, and lessor's operation and maintenance standards are equivalent to EC standards

Wet lease-out - Community operator remains operator

III. A SPECIFIC EXAMPLE OF DAMP LEASE "ACMI-IN" PROJECT

The Canadian carrier Sunwing Airlines (SWG) will lease (ACMI) of 1 Canadian aircraft with pilots to Travel Service in following summer season 2014. The aircraft will be based in London – LGW.

Project specifications: Full charter agreement between British tour operator Olympic Holidays and Travel Service (TVS) and subsequent Damp lease between SWG and TVS under which TVS will lease ACMI aircraft from SWG for this project. Sunwing pilots will operate flights from LGW only within EU territory under this Damp lease program. Pilots have Canadian or EU citizenship and their estimated length of stay in UK is 2-6 months. TVS Cabin crew will be trained for SWG SOP. The Lessee will be Czech operator (TVS). The SWG aircraft will be based in UK based on full charter agreement between British tour operator and Travel Service and the aircraft will operate flight program under TVS call sign only within EU. Flights will be operated only into 2 EU countries – Greece and Cyprus. Travel Service is community carrier.

Following basic documents are needed for approval of the project by national CAA and other institutions:

1) UK CAA DfT requires following things for issuing of the Approval:
Whilst Travel Service is a Community carrier and would not itself need any additional approval to operate from the UK within the European Common Aviation Area, as Travel Service is wet leasing in aircraft from outside the EEA, permission under Article 223 of the UK Air Navigation Order is needed. If Travel Service were to use its own aircraft then no such permission would be required as it would be the operator of the flight.

Required Application Information and documents:

Wet or Damp Lease-in of a foreign registered aircraft –the following information is needed:

- *Aircraft type and model;*
- *registration(s) of the aircraft;*
- *name and address of the foreign operator (Lessor);*
- *the period of the lease; and*
- *routes to be flown.*

In addition, the following documentation should accompany the application letter:

- Copy of the **lease agreement** or description of the lease provisions;
- A copy of the report on the safety assessment/audit carried out by the lessee on the foreign operator;
- **Air Operator Certificate (AOC)** and/or Operating Licence and/or Certificate of Competency issued by the aeronautical authority of the State of Operator; (The AOC information should detail the aircraft type(s) and registration(s) to be used by the UK air carrier and the AOC areas and types of operation.)
- **Certificate of Registration** issued by the aeronautical authority of the State of Registry for all the aircraft to be used on services to the UK;
- **Certificate of Airworthiness** issued by the aeronautical authority of the State of Registry for all the aircraft to be used on services to the UK. A copy of the last annual maintenance inspection report should be included to validate the certificate;
- **Noise Certificates** issued by the aeronautical authority of the State of Registry for all the aircraft to be used on services to the UK. Or a copy of a noise exemption obtained from the Regulatory Policy Group of the UK Civil Aviation Authority. (All aircraft operating scheduled/charter passenger/cargo services must be Chapter 3 compliant).

- **Certificate of Insurance** - liability for passenger and third party risks for aircraft to be used. The level of insurance must meet the minimum requirements of insurance for passenger and third party liability set out in Article 6 and 7 of EC Regulation No. 785/2004.
- **Enhanced Ground Proximity Warning Systems (EGPWS)** – confirmation that the aircraft is fitted with a recognised Enhanced Ground Proximity Warning System (EGPWS).
- **Dangerous Goods and Munitions of War** – confirmation that no dangerous goods or munitions of war will be carried (if so, provide letter of exemption issued by UK CAA Dangerous Goods Office);
- **Airborne Collision Avoidance System (ACAS II or TCAS Version 7)**. Confirmation that an Airborne Collision Avoidance System (ACAS II or TCAS Version 7) is fitted (if not, provide exemption statement by the airline's State aeronautical authorities);
- **UK Approach Ban requirements**. A statement that the airline's crews are aware of the UK Approach Ban requirements as set out in Article 108(6) of the UK Air Navigation Order 2009, and that flight crews will be issued with written instructions with regard to Article 108(6) prior to operating the flights into the UK;
- **Aerodrome Operating Minima**. A statement that the airline's flight crew's Non Precision and Category 1 Aerodrome Operating Minima comply with Article 108(3) of the Air Navigation Order 2009.

2) <u>UK Immigration Department requires following things for issuing of Work Authorisation for Sunwing staff (pilots, engineers, other supported staff):</u>

- DfT Approval to operate air services in the UK.
- Exact bio-data of the pilots who will be operating out. The details required are:

  - *Full name*
  - *DOB*
  - *Nationality*
  - *Passport no*
  - *Type of work specification*

3) <u>Czech CAA must approve the project and it must issue an Approval</u>

Wet lease in (Damp lease) assesses the CAA in terms of:

- *To ensure an acceptable level of safety*
- *Economic*
- *Ensuring the rights of passengers.*

EU Airlines can wet lease-in an aeroplane from a corporate body or natural person other than a Community operator with the approval of the CAA only.

The CAA will only approve wet lease-in of an aeroplane from a corporate body or natural person other than a Community operator (hereinafter a third country operator) under exceptional circumstances, such as lack of suitable aeroplanes in the Community market.

General conditions:

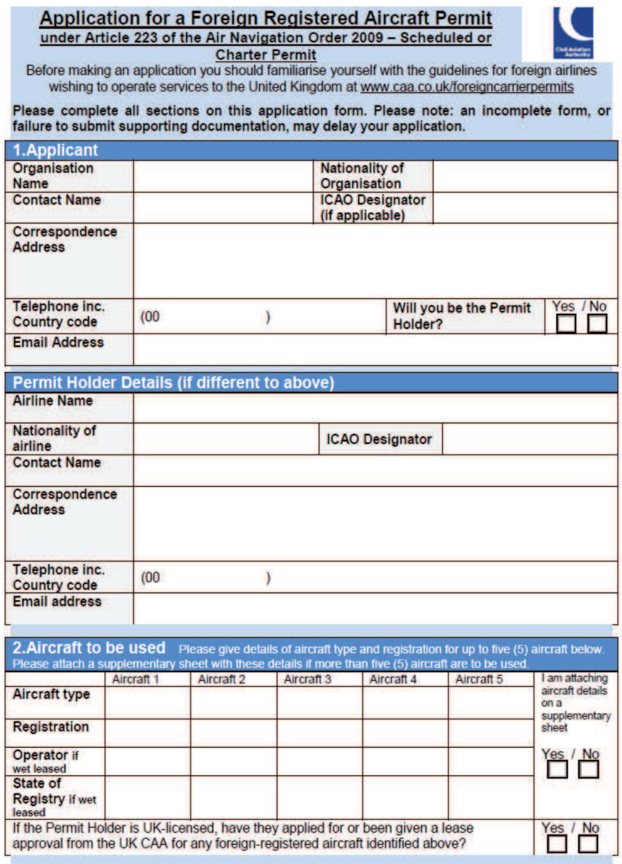
1.Lease-in means to cover the capacity needs of Airlines, which operates an aeroplane of a similar type or version registered in the Czech register.

2.The leasing agreement is concluded for a period of seven months as a maximum and may be renewed once for seven months as a maximum.

3.The aeroplane type/model shall be listed in the EASA transferred aeroplanes, unless the type certificate issued directly by EASA.

4.Airlines shall audit the lessor´s operations and maintenance to confirm compliance with operations standards and flight crew training standards under EU-OPS, maintenance standards under EC regulation no. 2042/2003, Annex II PART II.

More at: *www.caa.cz/file/357_1_1/*



Application for a Foreign Registered Aircraft Permit
under Article 223 of the Air Navigation Order 2009 – Scheduled or Charter Permit

Before making an application you should familiarise yourself with the guidelines for foreign airlines wishing to operate services to the United Kingdom at www.caa.co.uk/foreigncarrierpermits

Please complete all sections on this application form. Please note: an incomplete form, or failure to submit supporting documentation, may delay your application.

1.Applicant

Organisation Name		Nationality of Organisation	
Contact Name		ICAO Designator (if applicable)	
Correspondence Address			
Telephone inc. Country code	(00)	Will you be the Permit Holder?	Yes / No
Email Address			

Permit Holder Details (if different to above)

Airline Name			
Nationality of airline		ICAO Designator	
Contact Name			
Correspondence Address			
Telephone inc. Country code	(00)		
Email address			

2.Aircraft to be used Please give details of aircraft type and registration for up to five (5) aircraft below. Please attach a supplementary sheet with these details if more than five (5) aircraft are to be used.

	Aircraft 1	Aircraft 2	Aircraft 3	Aircraft 4	Aircraft 5	
Aircraft type						I am attaching aircraft details on a supplementary sheet
Registration						
Operator if wet leased						Yes / No
State of Registry if wet leased						
If the Permit Holder is UK-licensed, have they applied for or been given a lease approval from the UK CAA for any foreign-registered aircraft identified above?						Yes / No

Picture nbr.1 – Application for foreign registered aircraft permit – page

For CAA Use Only:	CRM Number:	Date Received:

3.Flight schedule

Date(s) or Day(s)	Flight no(s) - use two or three-letter airline code ignoring codeshare	Route / Sectors and Timings (Zulu / UTC) - use three or four-letter airport codes	Origin / destination for which traffic rights are required from UK	Please tick if this is an all cargo flight?
Examples:				
01/04/2014	ABC123	LHR (06:30) – EDI (07:45/10:00) – KEF (13:30/14:30) – BOS (19:00)	LHR–BOS EDI–BOS	√
123–5–7 1234–6–	ABC123 ABC456	LHR (15:00) – LAX (02:00+1) LAX (06:30) – LHR (16:30)	LHR–LAX–LHR	
				☐
				☐
				☐
				☐

I am attaching this information on a supplementary sheet: Yes ☐ / No ☐

Please note: You will need to gain a certificate from the UK Border Force (UKBF) stating that your proposed system for notifying UKBF of Advanced Passenger Information (APIS) is recognised and approved.

Are these Scheduled or Charter Flights?	Scheduled ☐ Charter ☐
Please state the name of the ATOL holder on whose behalf the flights are being undertaken.	
I declare that this is an urgent humanitarian (for example, for disaster relief) or emergency flight (for example, for urgent medical reasons), which is required to take off or land at very short notice in exceptional circumstances.	Humanitarian ☐ Emergency ☐
If these are scheduled or series charter flights, please state the beginning / end dates of operation (or IATA season).	

4.Evidence of insurance

Your application must include a copy of a valid insurance certificate in accordance with Regulation (EC) 785/2004 covering the aircraft listed in Section 2 or any attachment of fleet information

5.Declarations

You are required to make the following declarations before your application can be processed

Declaration	Please select	
I declare that the aircraft listed in section 2 (or the attachment) has / have a valid Certificate of Airworthiness	Yes ☐	No ☐
I declare that the Operator will comply with the following Annexes to the Chicago Convention:		
1) Personnel Licensing (annex 1)	Yes ☐	No ☐
2) Rules of the Air (annex 2)	Yes ☐	No ☐
3) Applicable Aircraft Operations (annex 6)	Yes ☐	No ☐
4) Airworthiness of Aircraft (annex 8)	Yes ☐	No ☐
5) Dangerous Goods (annex 18)	Yes ☐	No ☐
6) Safety Management (annex 19)	Yes ☐	No ☐
I declare that each of the aircraft listed in section 2 (or the attachment) (a) has a valid noise certificate or noise certification documentation as specified in ICAO Annex 16, Volume 1, and (b) complies with the minimum noise standards for operations in the EU as explained here	Yes ☐	No ☐
Where aircraft to be used exceed 10 tonnes MTOW: I declare that I am aware of the Security Direction, as explained here	Yes ☐	No ☐

Picture nbr.2 - Application for foreign registered aircraft permit – page 2

For CAA Use Only:	CRM Number:	Date Received:

6.Signature

Please tick the box to declare that you understand that it is a criminal offence under Article 241 of the Air Navigation Order 2009 to provide false information for the purpose of obtaining a foreign registered aircraft permit.	☐

Name		Date	

The permit holder may be required to be designated by its home state under the terms of the relevant Air Services Agreement in order to operate the permitted services.

Where this form requires you to provide additional documents such as an insurance certificate, you must send these with this form, including for any leased aircraft. You can find further information about this at www.caa.co.uk/foreigncarrierpermits. The CAA may require additional information to establish the validity of applications and associated documents.

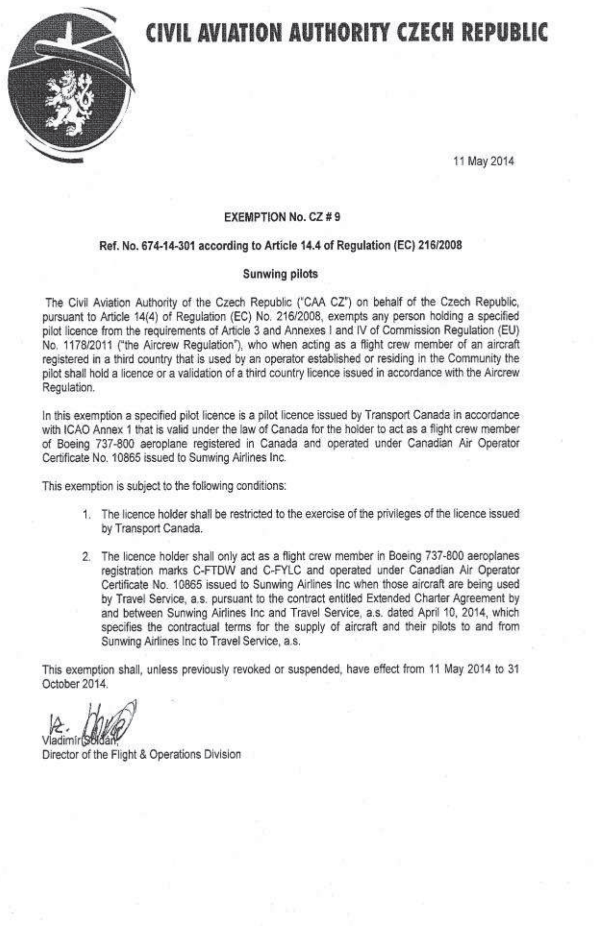
7.Payment

This application is subject to a fee of £75 (GBP) that must be received by the CAA before the application will be processed. The CAA can only receive payment for this application by credit / debit card and will contact you during UK office hours (Monday to Friday 09:00 – 17:00 local time) to take credit / debit card information. Please note that payment of the £75 fee is to process the application only. It is not a fee for the Permit itself, which, if granted, is provided free of charge.

Please enter below a contact name and telephone number for CAA to call to obtain payment

Name of payer	
Telephone including country code of payer	(00)

Picture nbr.3 - Application for foreign registered aircraft permit – page 3



CIVIL AVIATION AUTHORITY CZECH REPUBLIC

11 May 2014

EXEMPTION No. CZ # 9

Ref. No. 674-14-301 according to Article 14.4 of Regulation (EC) 216/2008

Sunwing pilots

The Civil Aviation Authority of the Czech Republic ("CAA CZ") on behalf of the Czech Republic, pursuant to Article 14(4) of Regulation (EC) No. 216/2008, exempts any person holding a specified pilot licence from the requirements of Article 3 and Annexes I and IV of Commission Regulation (EU) No. 1178/2011 ("the Aircrew Regulation"), who when acting as a flight crew member of an aircraft registered in a third country that is used by an operator established or residing in the Community the pilot shall hold a licence or a validation of a third country licence issued in accordance with the Aircrew Regulation.

In this exemption a specified pilot licence is a pilot licence issued by Transport Canada in accordance with ICAO Annex 1 that is valid under the law of Canada for the holder to act as a flight crew member of Boeing 737-800 aeroplane registered in Canada and operated under Canadian Air Operator Certificate No. 10865 issued to Sunwing Airlines Inc.

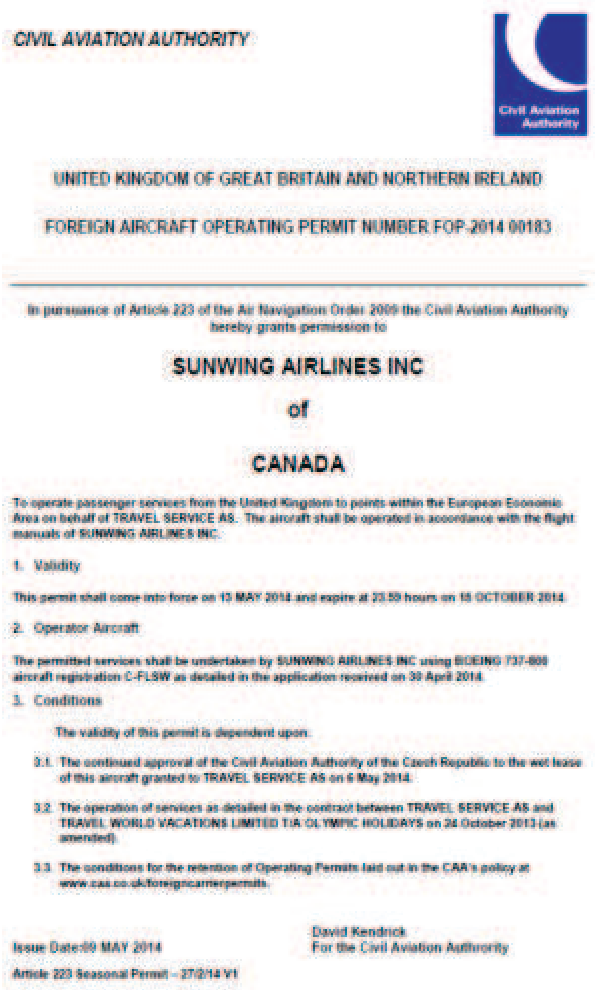
This exemption is subject to the following conditions:

1. The licence holder shall be restricted to the exercise of the privileges of the licence issued by Transport Canada.
2. The licence holder shall only act as a flight crew member in Boeing 737-800 aeroplanes registration marks C-FTDW and C-FYLC and operated under Canadian Air Operator Certificate No. 10865 issued to Sunwing Airlines Inc when those aircraft are being used by Travel Service, a.s. pursuant to the contract entitled Extended Charter Agreement by and between Sunwing Airlines Inc and Travel Service, a.s. dated April 10, 2014, which specifies the contractual terms for the supply of aircraft and their pilots to and from Sunwing Airlines Inc to Travel Service, a.s.

This exemption shall, unless previously revoked or suspended, have effect from 11 May 2014 to 31 October 2014.

Vladimír Sokdal
Director of the Flight & Operations Division

Picture nbr.4 – Approval of the wet lease project from Czech CAA



CIVIL AVIATION AUTHORITY

Civil Aviation Authority

UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND

FOREIGN AIRCRAFT OPERATING PERMIT NUMBER FOP-2014 00183

In pursuance of Article 223 of the Air Navigation Order 2009 the Civil Aviation Authority hereby grants permission to

SUNWING AIRLINES INC

of

CANADA

To operate passenger services from the United Kingdom to points within the European Economic Area on behalf of TRAVEL SERVICE AS. The aircraft shall be operated in accordance with the flight manuals of SUNWING AIRLINES INC.

1. Validity

This permit shall come into force on 13 MAY 2014 and expire at 23.59 hours on 15 OCTOBER 2014.

2. Operator Aircraft

The permitted services shall be undertaken by SUNWING AIRLINES INC using BOEING 737-800 aircraft registration C-FLSW as detailed in the application received on 30 April 2014.

3. Conditions

The validity of this permit is dependent upon:

3.1. The continued approval of the Civil Aviation Authority of the Czech Republic to the wet lease of this aircraft granted to TRAVEL SERVICE AS on 6 May 2014.

3.2. The operation of services as detailed in the contract between TRAVEL SERVICE AS and TRAVEL WORLD VACATIONS LIMITED T/A OLYMPIC HOLIDAYS on 24 October 2013 (as amended).

3.3. The conditions for the retention of Operating Permits laid out in the CAA's policy at www.caa.co.uk/foreigncarrierpermits.

Issue Date:09 MAY 2014

David Kendrick
For the Civil Aviation Authority

Article 223 Seasonal Permit – 27/2/14 V1

Picture nbr.5 – Approval of the project from UK CAA

IV. SUMMARY:

The issue of aircraft leasing is very current and constantly evolving. Airlines use different types of aircraft leasing based on company policy, economic strategy and current needs.

The airline must choose which type of lease is it appropriate for the chosen project or the situation. Generally and simply speaking, for quick solutions are usually used wet lease. For medium-long projects - damp lease and for long lasting projects - dry lease. Of course this does not generally apply to all projects. It depends on the conditions affecting the project - and from the perspective of both sides - from the lessee and the lessor.

Bibliography:

[1] Internal information materials of Travel Service airlines

[2] Internal information materials of Sunwing Airlines

[3] UK CAA - https://www.caa.co.uk/

[4] Czech CAA – http://www.caa.cz/

[5] UK Immigration Department - www.gov.uk/border-force

Database of safety events and their use in the evaluation of operational safety

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Abstract— **This article deals with the safety of air transport, which is considered the safest way to transport passengers and cargo. It deals with the use of safety data, collected either in individual companies operating in air transport or in multinational database systems, to the development and evaluation of a set of safety indicators.**

Keywords-safety; indicators; safety management system; database; EICCARS

I. Introduction

Safety is currently very inflected theme and there are efforts to maintain an overall acceptable level of safety. However, it is important to establish the level we want to keep or to which we want to get. To determine the level of safety may serve a set of safety indicators. By using of safety indicators we get a numerical representation of the occurrence of each event which will be monitored or quantitative expression of other indicators related to safety such as the maturity of the safety culture in the organization - this indicator is related to the number of messages in the voluntary reporting system, the number of safety trainings, etc. Another indicator is not directly linked to the realization of incidents/accidents, but it is linked with the effectiveness of events investigating by the internal organs. Its effectiveness lies in the duration of the investigation from the beginning to the closure and also with accepted safety precautions established on the basis of the investigation.

II. Necessity of introducing safety indicators

Safety in air transport has previously been evaluated primarily by the number of air accidents. But this indicator is unusable for some time due to the small number of accidents and therefore it is not entirely indicative of the overall safety of the airline, or other organizations involved in aviation. Later this indicator was transferred to the number of serious incidents, i.e. events that are not themselves air accidents with fatal consequences, there could be also no damages, but its nature can significantly contribute to the triggering of an accident. But even monitoring the occurrence of serious incidents is no longer sufficient. The frequency of accidents and serious incidents is currently very low. So if the airline is without aircraft accidents and serious incidents, it does not mean that its safety is on a high level. In the current concept of safety it is necessary to evaluate basic operational processes, search for small deviations, etc. For this reason, it is appropriate that the safety staff in the aviation should take inspiration in other areas of human activity where the work environment is highly risk and possible realization of the accident should have major consequences. These sectors are nuclear power engineering, chemical industry, etc. In these sectors the set of safety indicators is implemented. These safety indicators monitors the occurrences of events, which themselves does not have a potential of accident, but in the case of circumstances, there would be a realization of such several events, the potential of accident is very real. For this reason, the occurrences of these events are monitored and safety personnel are tasked to develop and implement such safety measures to prevent the occurrence of these events.

A similar task waits for the safety managers in civil aviation where the first set of safety indicators, based on a reactive basis of the monitoring occurrences of accidents, serious incidents are currently produced and there is an attempt to implement preventive / predictive indicators.

III. Getting the data for the implementation of safety indicators

Many companies operating in the air transport have own system to monitor events with impact on safety. These systems consist of an event database, which are in such a data format in order to simply filter the database according to the currently defined requirements.

By these databases, however, there is one issue. Databases are mostly created and managed by one safety manager, who adapted and completed it to his own requirements. It follows a difficult consistency between the databases of all the companies in the evaluation of specific indicators. This problem can be solved by nationwide or multinational database, managed by international authority. In the case of Europe, it could be solved by the ECCAIRS database, used by the EASA Member States, by EUROCONTROL, etc. In 2009, ICAO has also recommended that the database should be used by all Member States. This database can be accessed only by registered users - mostly these are national aviation authorities, respectively authorities having responsibility for the investigation of air accidents. In our country, it is the Civil Aviation Authority of the Czech Republic (only access to the database of events related to their association with the Czech Republic) and Air Accident Investigation Institute (inserting of events relating to the Czech Republic and viewing events throughout the database). The database has a well-defined data structure and data to fill the methodology ADREP. This methodology covers several fields to be entered in the context of importing data into the database ECCAIRS, to ensure comparability and effective measurability in all countries contributing to this database.

In this methodology there is accurate naming and labelling of each event, there are comments assigned to these events to make it clear to which event group is such events. The structure is always divided from generic to specific events. E.g. generic event fire is further divided into fire by place of origin to the fire in the cabin, cockpit fire, a fire in the cargo compartment and several other subgroups.

The methodology also by similar manner defines other important areas in the database. These are mainly interacting causes, phase of flight, type of consequences, etc.

IV. Data evaluation and monitoring of indicators related safety events

From the above it follows that if we set such criteria for individual safety indicators that are consistent with the database system ECCAIRS, it will be simply possible to work with database in case of safety indicators data collection and subsequently evaluated them.

This must be preceded by feasibility study consisting of individual reports survey, respectively reports from individual countries whether if they proceed strictly in accordance with the methodology and whether the data can be with comparisons between each other. Last but not least it is necessary to survey the number of reports in the database from each country if it corresponds to the actual number of the events. This is necessary because of the informative value. It will be followed by the establishment of a group of indicators in the way, to be able to take data from this multinational database. Some inspiration may be a national program for the Safety of Civil Aviation of Finland, which has a specified group of about 40 indicators, most of which is already possible to connect directly to the database ECCAIRS. For the remaining indicators, there is a need to make adjustments to the definition to be unequivocally established by what criteria use the information from the ECCAIRS.

V. Data collection and evaluation for SMS performance indicators

Another group of safety indicators are indicators of safety management system performance. For this type of indicators we can no longer take data from the ECCAIRS. Data for the performance indicators of safety management system is necessary to take from internal databases where is monitored the event investigation process, then safety measures and their possibly effectiveness in the next period. Further it is possible to evaluate the effectiveness of safety training, etc.

This can be obtained from the safety department managers who should analyse the effectiveness of various corrective measures, to evaluate the need to implement training, etc. It is necessary to directive determine what data will be monitored and evaluated within each period.

The effectiveness of safety management should also reflect the overall safety level of the organization, because the effectiveness of safety management is reflected in the ability to prevent the realization of events with an impact of safety in the form of incidents or serious incidents accidents.

VI. Conclusion

Current efforts to increase safety in aviation must work through the implementation and monitoring of safety indicators. Using the database of safety events that are currently held with almost any operator, we can monitor the trend for each type of event. Internal database will be used to evaluate trends within organizations. However, if you want a more global view on safety in the air transport, it is necessary to monitor multinational databases - ECCAIRS the EU, for the use of safety indicators. This internationally database allows with the arrangement its effective data acquisition for the safety indicators and allows evaluation of safety between different countries using established data structures.

Acknowledgment

This paper was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS14/167/OHK2/2T/16.

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Design of the RNAV GNSS procedures for a small aerodrome

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***Abstract*—The content of the article is the proposal of calculating minimum descent heights, decision heights and corresponding limits of the minimum runway visual range of approaches for global satellite navigation systems (GNSS) using uncertified software and display of approach procedure in graphic information system.**

***Keywords*: approach procedure, geographic information systems, GNSS**

I. INTRODUCTION

In Slovakia and the Czech Republic are currently registered 15 public and 15 non-public international airports, 69 public and 23 non-public domestic airports. Approach to land as per the gadgets under conditions of reduced visibility values is only possible at 14 airports.

The increase of registered carriers and the number of registered aircraft can be expected in future years, mainly in the segment of small private helicopters and airplanes in a light weight category and in a airplanes manoeuvrability category A that will be used for sports, tourists, commercial flights, flights for ambulance services and flights associated with aerial works in agriculture, forestry and other sectors of the national economy. Development of this aviation activity will require the extension of the number of existing airports used at reduced values of visibility and building new heliports and mounting surface for helicopters for air ambulance services that enable operation even under difficult weather conditions.

The appropriate solution for services at small airports with a limited number of movements in low visibility values, in terms of cost for the construction and operation of ground facilities, is the structure of approach procedures using the satellite navigation systems. Basic evaluation of the most suitable approach procedure using satellite navigation systems with respect to a particular configuration of the terrain, obstacle and operational situation around the airport is possible even without the use of professional software package designed for the creation of a comprehensive proposal environment based on standards documents ICAO PANS - OPS and FAA TERPS, as example WX1 Series ™.

II. PROCEDURE OF CALCULATING THE APPROACH

For the calculation and construction of approach procedures was used the following software:

- SketchUp - a graphical tool for constructing envelopes of minimum security obstacle clearance during approach procedures using the given technical means of navigation.
- Google Earth - a virtual global geographic information system to accommodate those envelopes in a particular area and to calculate the fundamental values of approach procedures.
- Map SR M 1:50000 - digitized map to compare the measured and calculated values of coordinates of points, altitudes and distances.
- Microsoft Office Excel 2007 – table editor for specific mathematical calculations.
- Planning Software - software from Trimble Navigation Ltd. for calculating the visibility of satellites and the rate of deterioration of the accuracy of the positioning.
- Software AUGUR - to calculate the visibility of GPS satellites and determine the prediction of an independent monitoring GNSS receiver signal integrity (RAIM).

The content of solutions is a draft calculation of minimum heights of descent, heights of decision and of corresponding limits of minimum runway visual range. These values were calculated based on the findings of the most dangerous obstacles and the use of standards defined by our current aviation regulations. The most dangerous obstacle was detected by placing the protective envelope composed of protective obstacle limitation calculated based on ICAO standards into a geographic information system and identify its collisions with terrain or artificial obstacles.

The solution is implemented in the following sequence:

- Evaluation of airport / area in terms of specified conditions of shame - characteristics airport / area;

- Evaluation of the obstacle situation (completing obstacles to used map or to database of graphical information system, evaluation of collision obstacles with obstacle limitation, finding the most dangerous obstacle in the approach procedure);

- Evaluate the utility of GNSS in the approach area (analysis of GNSS satellite visibility from the area of an airport, calculating RAIM prediction);

- Determination of minimum approach.

III. DETECTION OF THE MOST DANGEROUS OBSTACLES IN THE APPROACH PROCEDURE AND CALCULATION OF SAFE ALTITUDE (OCH)

- Creating envelopes of obstacle limitation in viewing scale geographic information system.
- Evaluation of collision of terrain and obstacles planes.
- Completing obstacles in the terrain around the landing area into a geographic information system
- To plot the base point of an airport / centres of heliport (ARP) and the axis of RWY / FATO (final approach and take-off) and the location of envelopes of individual obstacle limitation in agreement with those agreed points into a geographic information system.

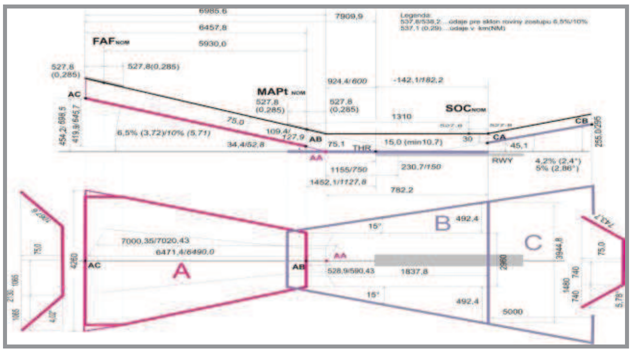

Figure 1 Drawing of envelope consisting of protective obstacle limitation surface for non-precision approach according to area navigation (RNAV) with the use of the basic GNSS for aircrafts CAT H

A. Preliminary calculations and plotting

Calculation of dimensions and creating envelopes composed of the protective obstacle limitation surface (OAS) for the non-precision approach procedure for RNAV using basic GNSS approach for the vertical guidance with basic GNSS satellite enlargement to aid (SBAS)

1 envelope is composed of protective plane of final approach and initial and middle stages of missed approach;

2 envelope is composed of protective plane of central region approach,

3 envelope is composed of planes OAS calculated for SBAS approach.

B. Solution procedure

- Plotting the projection of descent axis in 3D (projection into the protective plane of the final approach) using the recommended basic gradient of sinking descent plane.
- Placing 1st and 2nd envelope in agreement with the agreed point and the projection of descent axis into a geographic information system.
- Determination of the most dangerous (control / critical) obstacles.
- Checking the correct positioning of the envelope through the checkpoint
- Finding of envelopes collisions with terrain and in case of collisions pushing the 2nd envelope on projection of descent axis upstream the approach into the zero collision with terrain and obstacles with the current extension of 1st envelope to the required length.
- Location of the 3rd envelope in agreement with the projection of THR RWY in the amount of ELEV ARP and detection of planes collision with the terrain. Regarding the collisions determination of the most dangerous height by increasing absolute amount of envelope until zero collision with terrain and obstacles.
- Calculation of OCA / OCH and position MAPt and the setting of minimum approach

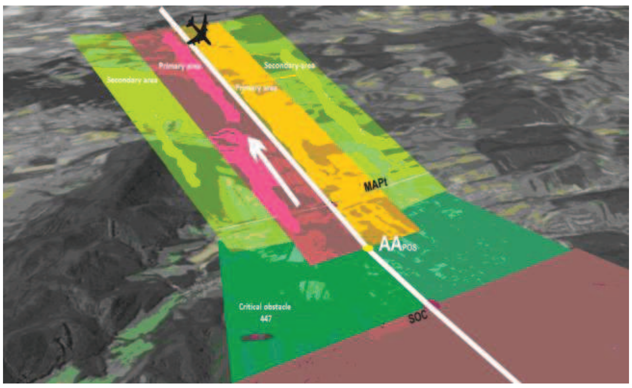

Figure2.Displacement of 1. Sheet along the projection of an axis descent upstream a direction of an approach - identifying the most dangerous (control / critical) barriers

IV. EVALUTION OF GPS USABILITY IN THE APPROACH AREA

Analysis of visibility of GPS satellites from the airport area

- Creating of elevation masks:

CAT	RWY	GRD KL [%]	GRD ST [%]	Scoped definited MDH/DH	RVR [m]			
					without SPZ	basic SPZ	partialy SPZ	completely SPZ
A BGNSS	010	6,5	5,0	above 650 ft	**1500**	**1500**	**1400**	**1000**
H BGNSS	042	10,0	5,0	above 650 ft	**1000**	**1000**	**1000**	**800**
A SBAS	190	3,0	2,5	200 ft	**1000**	**800**	**700**	**550**

TABLE1 Example of calculation of the lowest operating minimum of non precision approach and BGNSS RNAV approach with vertical guidance APV SBAS for the airport Svidnik

- Calculation of RAIM prediction (Calculations using a software to calculate the visibility of GPS satellites and determination RAIM prediction function)

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V. CONCLUSION

Simulation of placing the protective envelopes level that has been practiced the Google Earth area, has demonstrated its usefulness to educated estimation of operating minimums of small airports or heliports in conditions of low visibility.

Spatial display offers the possibility of using for simulation of instrument approach in preparing crews of combat aircraft for the flight to an unknown airport or landing area. The crew has the opportunity to become familiar with the terrain peculiarities and gain the spatial imagination about the position of landscape and artificial barriers relative to the flight path at a critical stage of an approach. It has the opportunity to evaluate critical moments of the biggest possible rapprochement with obstacles and prepare for the emergency procedures in case of specific incident in flight.

Spatial display offers also the possibility of increasing the efficiency of flight crew training of general and business aviation for the flights that are completed by approach according instruments to airports which are new for a crew and airports located in difficult geographical conditions with the number of obstacles hazardous for flight operations.

Display can be used in the preparation of students and specialists dealing with proposals of approach procedures. Spatial simulation of various modes of approach using different technical means of navigation options allows graphically presenting the possibilities and comparing the differences in procedures constructions based on navigation performance of these devices.

Simulation can serve as an illustrative example of the standards application set by current terms for the proposals of the approach procedures and to demonstrate their influence to ensure the specified protection from obstacles in the individual sections of approach procedures.

GNSS Landing System

Future of precision approach

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***Abstract* – Continuous growth of air transportation demand means that many large airports are being forced to increase their operating capacity. One possibility is increased use of procedures for precision approach. This paper describes the present situation of systems used for precision approach operations. The article points to the fact, that Global Navigation Satellite System (GNSS) Landing System is the future of Air Traffic Management System.**

Keywords – GNSS, GBAS, GLS, ILS, precision approach.

I. Introduction

With the increase in air travel, airports need to find new solutions to handle additional aircraft movements without incurring the costs of building more runways.

Implementation of approach procedures with vertical guidance at all runway ends is one of the ways to increase operational efficiency, improve safety and increase runway capacity in bad weather.

Today's Instrument Approach Procedures are divided into three distinct types: [1]

- **Non-Precision Approach (NPA)** uses conventional navigation aids such as NDB, VOR and DME to bring the aircraft to a point where the runway is in view and a visual landing can be performed. NPA procedures, which do not include vertical guidance, used to require multiple level-offs at step down fixes during the approach. [2]
- **Approach procedure with vertical guidance (APV)** is an instrument procedure, which utilizes lateral and vertical guidance but does not meet the requirements established for precision approach and landing operations. (Baro-VNAV, SBAS)
- **Precision Approach (PA)** uses an instrument landing system, which provides both lateral and vertical guidance on a stabilised continuous descent path. (e.g.: ILS, MLS, GLS).

II. Precision Approach

The main benefit of precision approach is reduction of the approach minima, what can result in less distribution, delays, and diversions to alternate airport.

From the aspect of approach accuracy, we have three categories that are defined by the following parameters: Decision Height (DH), Visibility (Vis) and Runway Visual Range (RVR):

Category	*DH (ft)*	*RVR (m)*	*Vis (m)*
Cat I	≥200	≥550	≥800
Cat II	100-200	≥300	
Cat III a	<100	≥175	
Cat III b	<50	50-175	
Cat III c	no limitations	no limitations	

Table 1: Categories of precision approach [4]

A. *Instrument Landing System - ILS*

Nowadays ILS is the primary system for precision approach and it provides continuous information about the lateral and vertical position. The ILS consists of two radio beacons and three markers:

- VHF Course Beacon - Localizer (LLZ) - which provides horizontal guidance,
- UHF Descent Beacon - Glide Path (GP) - which provides vertical guidance and
- VHF Position Beacons – Markers - which provide along track position fixes,
- the final requirement in an ILS is the lighting system.

ILS has been offering the standard precision approach and landing for over 40 years. During this time it has undergone a number of improvements to increase its performance and reliability. In relation to future aviation requirements, the ILS has some limitations: [8]

- site sensitivity (Localizer and Glide Path are susceptible to reflections from buildings, terrain and foliage)
- high installation costs;
- single approach path;
- multi path interference;
- channel limitations - 40 channels only.

B. Microwave Landing System - MLS

MLS was designed as an alternative to the Instrument Landing System (ILS). It provides precision navigation guidance for alignment and descent of aircraft on approach to a landing by providing azimuth, elevation and distance.

Its advantage is the number of frequencies (two hundred channels are available between the frequency ranges of 5031.0 – 5090.7 MHZ), compact ground equipment and complex approach path.

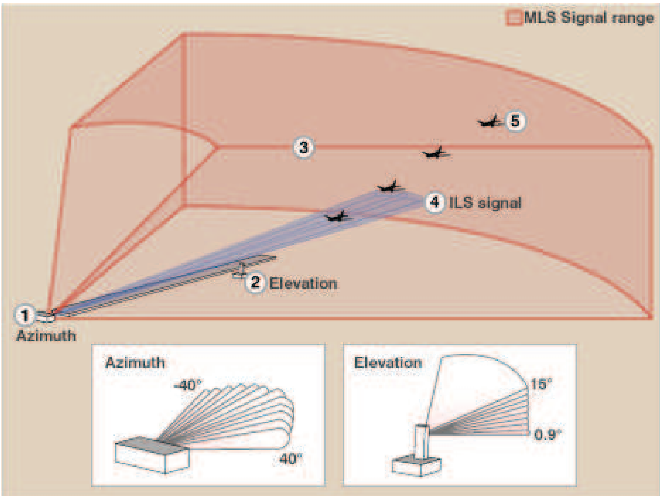

Figure 1. MLS guidance system [9]

Azimuth guidance system (number 1) helps pilots work out how far from centre of runway they are. Elevation guidance (number 2) tells pilots how far above ground they are, and helps aircraft descend on the correct path. MLS covers a far wider area (number 3) than that provided by ILS (number 4), and is much less prone to interference. ILS transmits radio signals in a narrow beam, and can experience interference from other aircraft and terrain. Up to 30 planes per hour can land at runway using MLS. Only 20-24 planes per hour could do so using ILS. [9]

MLS is rarely used on European airports and it has not been installed in the Czech and Slovak Republic. Eventually, this technology was overtaken by the rapid increase of the global positioning system (GPS).

C. Precision approach radar - PAR

PAR provides both vertical and lateral guidance (for a ground controlled approach). The radar approach is not able to provide visual approach indications in the cockpit.

Controllers observe each aircraft's position on the precision approach radar display and issue instructions to the pilot. Controller provides highly accurate navigational guidance in azimuth and elevation to a pilot. It is similar to an ILS but requires the flight crew to listen and comply with controller instructions. PAR approaches are very rare, mostly used by the military. [10, 11]

D. Global Navigation Satellite System Landing System - GLS

The aim of Global Navigation Satellite System (GNSS) Landing System implementation is to provide an alternative to the ILS supporting the full range of approach and landing operations. Potential benefits of the GLS include significantly improved take-off and landing capability at airports worldwide and at reduced cost, improved instrument approach service at additional airports and runways. [12]

GLS is a precision approach operation using the GBAS (Ground Based Augmentation System) components.

III. GBAS DESCRIPTION

GBAS is a system that provides differential corrections and integrity monitoring of GNSS.

It consists on three major elements:

- space segment,
- ground segment and
- airborne segment.

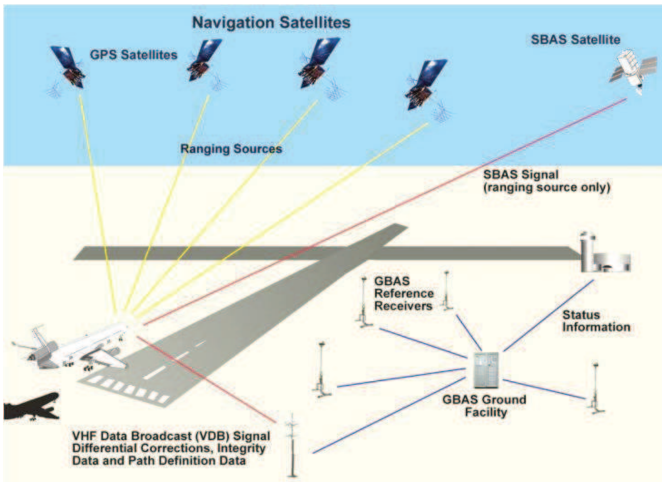

Figure 2. GBAS architecture [13]

A. Space segment

The space segment consists of GNSS satellites. At present, there is only two GNSS constellations in operation: the USA's Global Positioning System (GPS) and the Russian Federation's

GLObal NAvigation Satellite System/ Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS).

Galileo will be the third GNSS constellation approved for aviation use and is an initiative of the European Union and the European Space Agency. It is based on a constellation of 30 satellites (27 operational satellites plus three spares) supported by ground stations (control centres in Europe and a network of sensor stations and uplink stations installed around the globe). By 2015, 18 satellites should be in place, followed by the rest in 2020. Till today four satellites were launched into orbit.

Chinese's BeiDou Navigation Satellite System is another constellation under development. The system is designed to provide global coverage around 2020. [15]

GNSS is a worldwide position, navigation, and time determination system. It may be supplemented by a Space-Based Augmentation System (SBAS), e.g. European Geostationary Navigation Overlay Service (EGNOS) or Wide Area Augmentation System – (WAAS).

B. *Ground segment*

GBAS ground equipment generally consists of:

- at least three GNSS/GPS receiving antennas (reference receivers),
- Ground Facility = central processing system (a computer), and
- Very High Frequency (VHF) Data Broacast (VDB) transmitter.

All these facilities are situated usually on or near an airport. [16] Antennas placement requires careful evaluation of local sources of interference, signal blockage, and multipath. Location of the VHF data broadcast antenna should ensure that the coverage area is sufficient for the intended operations.

The GBAS reference recievers/antennas receive the GNSS signals from satellites and the information generated in the receivers is sent to a processor. The central processing facility defines errors in the calculated positions, adds additional parameters (i.e. integrity parameters) and approach path information, produces a GBAS correction message and sends it to the VDB transmitter. The VDB transmitter modulates and encodes this message and broadcasts it to the airbone GBAS equipment.

The GBAS ground station performs the following functions: [13]

- Provide locally relevant pseudorange corrections;
- Provide GBAS-related data;
- Provide final approach segment data when supporting precision approach;
- Provide ranging source availability data; and
- Provide integrity monitoring for GNSS ranging sources.

C. *Airborne segment*

The airborne equipment consists of a GPS antenna, a Very High Frequency antenna, and associated processing equipment. The GBAS uses the VHF radio link to provide aircraft with GPS corrections, integrity, and approach path information.

On board the aircraft, GBAS avionics within the Multi-Mode Receiver (MMR) technology allows simultaneous implementation of GNSS, VOR and ILS using common antennas and hardware. [16] Although, MMR is a good concept, it is expensive. General aviation favours a single GBAS receiver. Rockwell-Collins has its GLU-925 (GNSS Landing Unit) that is certified for GBAS CAT I operations and Honeywell is developing an Integrated Navigation Receiver (INR).

IV. GLS BENEFITS AND DISADVANTAGES

GLS has several advantages in comparison to traditional ILS. [17, 18]

The biggest advantages of GLS for airports is the number of different approach procedures that can be used with just one station, increase airport capacity (simultaneous operations to parallel runways) and airport access improvement, even where ILS cannot be installed for terrain or economic reasons.

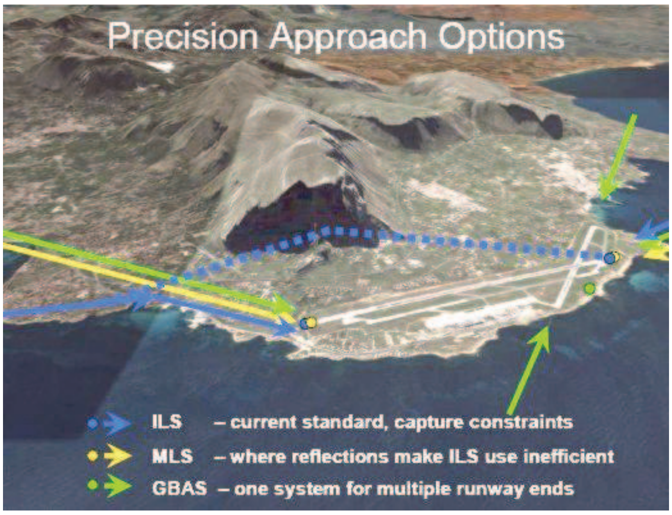

Figure 3. GBAS as one of the available precision approach options [19]

Core benefits for airlines:

- higher precision guidance,
- minimal pilot training (GLS was developed as an "ILS look-alike" system from the pilot perspective and provides guidance similar to ILS approaches for the final approach segment), [20]
- fuel saving, noise abatement and reduced emissions (considering GLS supports curved and segmented approaches) especially in locations, which do not currently enable an ILS installation.

For air navigation service providers using GLS means reduction of infrastructure investment and overall maintenance costs, whereas one GBAS station can support all runways at an airport and it should have less frequent and less costly flight inspection requirements than the ILS.

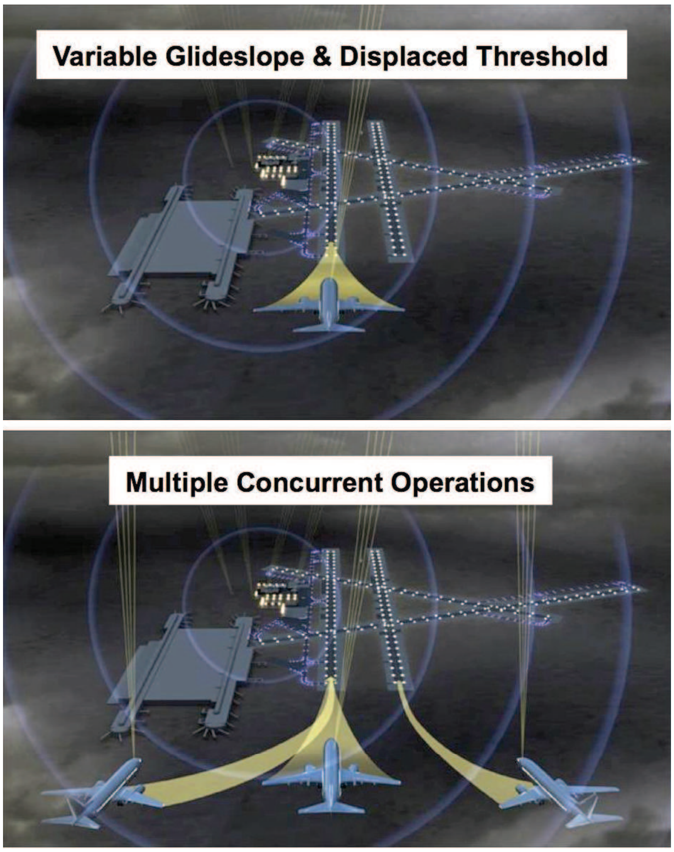

Figure 4. GBAS can serve all runways [25]

Other benefit may be flexibility to add or change final approach procedures without changing system configuration.

Otherwise, GBAS is fully dependant on GPS. So GLS weakness is GPS interference or jamming that could disable entire system.

Costly Precision Approach Lighting system is required for every runway.

V. PRACTICAL IMPLEMENTATION OF GLS

GLS was approved for CAT I operations. The Federal Aviation Administration (FAA) work program is now focused on validating standards for CAT II/III, which can be available in 2018. [16]

The first fully operational GLS approach to CAT I decision height was made by an AirBerlin flight to Bremen airport in Germany on 9th of February 2012. [21]

Certified GBAS CAT I equipment is currently available from major avionics suppliers, more than 200 aircraft worldwide are already equipped and an increasing number of airlines are choosing GBAS. [21] Boeing and Airbus are actively working on GLS CAT III certification criteria and large part of their fleet have been certified for GLS CAT I operation.[17]

Nowadays, there are several GBAS stations installed, for example:

- Bremen Airport (BRE) and Frankfurt Airport (FRA) in Germany,
- Malaga Airport (AGP), Spain;
- Newark Liberty International Airport (EWR) and Houston George Bush Intercontinental Airport (IAH) in USA;
- Sydney International Airport (SYD), Australia.
- Galeão–Antonio Carlos Jobim International Airport (GIG) in Rio de Janeiro, Brazil
- Chennai International Airport (MAA), India

Several companies are working on GBAS projects: IACIT, SELEX, NPPF Spectr, Indra, Thales, NEC, Park Air, GM Merck and others, but only Honeywell has a certified station named SmartPath® SLS-4000 (Until mid 2011) [13].

Honeywell worked closely with governmental agencies and air navigation service providers such as the Federal Aviation Administration (FAA), International Civil Aviation Organization (ICAO) and EUROCONTROL to assure a common strategy for the operational validation and development of the SmartPath Precision Landing System [22].

In June 2013, the first prototype of NORMARC 8100 CAT III GBAS was installed at Frankfurt Airport. Indra Navia developed this system under the European SESAR (Single European Sky ATM Research) program. [23]

VI. CONCLUSION

ILS and MLS have high operating costs and have to be installed at each end of the runway. ILS also has some operational limitations. GNSS Landing System improves safety, increases capacity, and provides operational benefits to airlines, pilots, airports and Air Traffic Services providers. But until GBAS (CAT II/III) Standards are developed, GLS cannot be considered as a candidate to globally replace ILS or MLS.

Full benefit will be delivered once Galileo and other GNSS constellations become available.

ACKNOWLEDGMENT

This work has been supported by the Grant Agency of Slovak Republic under the grant "Basic research of safety at airports with poorly developed infrastructures using GNSS navigation." VEGA No. 1/0844/12.

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CRM in Small Airway Companies

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Abstract **– This article deals with the functioning of CRM (Crew Resource Management) in small companies. Great part is devoted to a survey, its detailed evaluation and analysis of the provided responses, as well as analysis of individual interviews with employees of the selected companies. Based on the results, measures leading to better communication at the workplace and more satisfied employees were designed.**

Keywords – Crew Resource Management (CRM), crew communication and cooperation, human error

I. INTRODUCTION

In the beginning, it is necessary to define the term CRM. Crew Resource Management is efficient use of all resources available to the crew – hardware, software and lifeware – to achieve safe and efficient air traffic. [1] CRM forms more and more important part of the training if air personnel in all companies. In this connection, the name changes to Total Company Resource Management -TCRM, which includes not only air personnel training, but also the ground personnel training including the whole management of the airway company. The quality of the training of air crews increases also thanks to the positive approach of cockpit and board stewards. It becomes clear that it is very practical to combine the training of pilots with the training of the board stewards who can inform each other about the communication problems on board and thus prevent fatal consequences. The chain is as strong as its weakest link. Even with the closest connection, defect in any process can lead to catastrophic consequences.[2]As part of various trainings, air crew comes across the CRM subject. In most companies, these trainings are organized according to the operational handbook approved by the Civil Aviation Authority. The objective of CRM trainings is to improve communication and management skills of the crew members, improve working conditions and environment for the crews and everyone included in the air traffic and increase the knowledge of the crews and management concerning human factor and its influence on safety. From the regulation L 254/166 CS of the Official Journal of the European Union from 20th August 2008, ensues the obligations of the operator of an airway company to organize CRM trainings both for board stewards and air personnel. [3]

II. THE CAUSE OF ACCIDENTS

Small (up to 25 employees) and very small (up to 5 employees) companies are required to maintain CRM standards identical to the big companies. In practice, however, these small companies show a very benevolent approach to the implementation of CRM in real operation. It is partly caused by the limits of the companies, both financial and with regard to capacity, but also often by underestimating of the importance of CRM as an element necessary for safe operation. The below stated statistic follows that the most often cause of air accidents is human factor [4]. Nowadays, the equipment of also small aircrafts (business jets and business turboprops) allows high level of reliability. We must ask whether the inconsistent application of CRM is not the cause of accidents. The cause of air accident can be anything. In most cases, it is a sequence of random events which, combined, lead to a tragic end. But each accident has its main cause. Generally, we can divide the accident into main causes. Statistics are maintained by a number of organizations, one of them being ACRO (Aircraft Crashes Record Office) seated in Geneva. That is our source of the main causes of air accidents displayed in Figure No. 1. It shows that human error is most often the cause of air accidents.

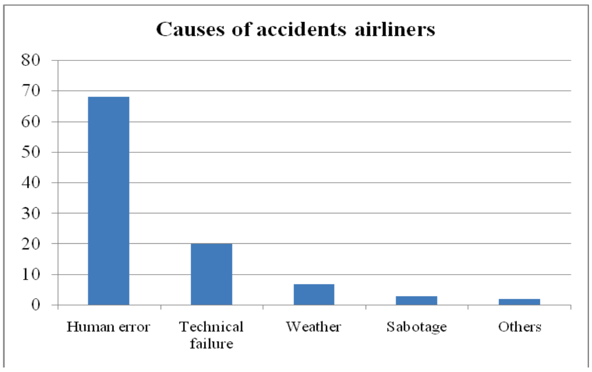

Figure 1. *Causes of transport aircrafts crashes*

III. THE SURVEY

Based on this information, I executed a survey study with three small companies operating in the Czech Republic (CTG flight services, Czech Connect Airlines and Silesia Air). The target group was the air and board personnel. The respondents provided their answers to a small survey of 20 questions. This survey was sent to the respondents as a web link, so the answers were completely anonymous. The objective of the survey is to execute the analysis of CRM of small companies which will help to improve the communication at the workplace. The survey was prepared to be convenient for electronic communication. As part of the research, we approached 50 employees. The survey was filled by 45 respondents, which represents 90% return rate. With regard to the role of the survey in the research, research methodology and form of distribution, this return rate is very satisfactory. The priority of this survey is to find out how the employees perceive CRM and in particular how they evaluate communication at their workplace. The survey includes recommended wording and organization of questions, but also a tool to measure opinions and standpoint spectrum. The evaluation spectrum requires the respondent to express his opinion on the matter by marking a certain position on a scale mirroring number of possible views of the matter. We used the closed type questions.

After the survey, there were individual interviews, where the employees could provide their opinions on CRM, relationships at the workplace and between the colleagues. Thanks to these interviews, we cold analyze in detail individual issues, unlike with answers provided to the survey only, and clarify the greatest issues with CRM in small companies.

IV. ANALYSIS OF RESPONSES

Question whether the employees are properly trained in the beginning and then at repeated CRM trainings showed that all employees of the selected companies went through such training. Therefore, we can confirm that Standard Operations Procedures are maintained.

The surveys show that the survey was legible for all respondents. 10 respondents used the option to present their opinion. All employees have at least secondary education ending with maturita exam. 63% graduated from university. Therefore, the personnel is very qualified. The employees are also very experienced, 43% have been in the airway industry for 7 years and more. Concerning their work, the employees express positive opinions with the exception of communication with their immediate superior. Most think that communication with their superiors is prevented by personal relationships and that they cannot confide in them. Despite this fact, the question whether the employees are happy with their superiors was answered positively by 39 employees. Most employees (82%, see Figure 2) think they can communicate efficiently. As many as 60% of the respondents use basic assertiveness in their communication. Also, a great percentage responded that their personal relationships are reflected in their communication with colleagues and that this is not always beneficial.

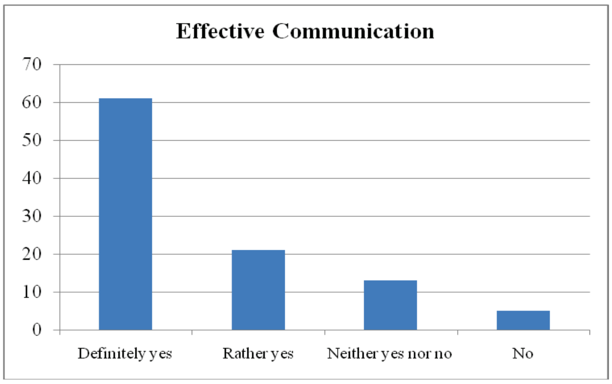

Figure 2. *Effective Communication*

Interviews showed that the main problem for up to 80% employees is the fact they work in a very stressful environment. Employees work under never-ending stress. Regular changes of the plan and pressure from the company management causes stress on the workplace. This problem is caused by a very small collective. People are afraid of losing their jobs, so they give up to the company management even though they sometimes disagree with it personally. The company management knows about this problem, but they are not trying to solve it, because 60% of the employees came in terms with the situation. They do not want to go against the company management Even though this looks innocent at first sign, it does not have to be the case and the employer should solve even those hidden problems at the moment they are created.

V. PROPOSALS AND MEASURES

The results of the survey and interviews led to some proposals that might help to improve communication in the company and thus contribute to happier employees and their better performance.

1) Introduce monthly meetings of the management and employees. Air personnel is usually informed about changes after they are implemented, by phone or e-mail, which is late and the form is also very inconvenient, so I would like to propose to organize monthly meetings where the employees will learn about the designed changes and plans for the next period. This proposal should contribute to better knowledge of the employees and their better mutual communication and better communication with the company management.

2) Help of external psychologist. Most people go through a crisis time to time. In airway industry, these problems can have fatal consequences. Therefore, it would be convenient to have the option to visit a company psychologist, if necessary. He could also help solve personal problems between individual employees.

3) Improve the planning system. Unpredictable circumstances and constant changes of flights cause problems in planning. The employees are informed about the changes in the plan very late and therefore, unnecessary disputes occur at the workplace. It would be better to plan the crews for a longer period and then make sure they have enough rest and define their off-time in advance. This measure should decrease the stress caused by constant changes in planning.

4) Introduction of teambuilding activities. Even though there are only small collectives, I would recommend introduction of these activities (trips) where employees would get to know each other from different prospective, too. This measure would contribute to openness between the employees and superiors, and also would make the collective stronger.

5) In the Czech Republic, it is required to repeat the training on simulator once a year. Despite the financial demands, it would be convenient of the crews to participate in this training at least twice a year, similarly to Germany, where this is required by the Civil Aviation Authority.

6) However, the most important is the support of the company management of the above stated proposals and CRM principles.

VI. CONCLUSION

The objective of this article was to find out how does CRM work with small airway companies. Human factor is becoming a key factor of safety. There are many safety tools (operational procedure, checklists, instructions) that help the crews to prevent mistakes, but checklists only work if they are used, autopilot only controls the plane correctly if set flawlessly by the crew. Therefore the best protection against mistakes in multi-member crews is good crew cooperation. [5] That is why in particular small companies must provide proper CRM trainings. A small collective can often create above-standard relationships. These can be both positive and negative. Most relationships are at a correct level and CRM only works in the way it is presented to the employees.

I submitted my proposals to the selected companies and currently, the measures are implemented in practice. Only one company started to implement the proposal immediately by widening CRM activities, introducing monthly meetings and employing external psychologist. The other two companies are aware of the importance of CRM, however, due to their organizational structure and small number of employees, they will implement the recommended measures progressively, or only partly with the help of external professionals. The study itself connected with talking to employees, made some employees and also employers express their opinion and start thinking about the necessity of better cooperation with their colleagues.

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Abstract— **The contribution is aimed to identify the actual status of management systems as implemented by airports in the Slovak republic and prospects of their implementation. It analyses quality management systems and their applications in air transportation in the Central –European region. Further analysis is concerned the Slovak airports in terms of adopting management systems in the various areas of management in compliance with the corresponding standards. Based on the controlled interview, the assessment is focused on the potentials of implementing such management systems at Slovak airports.**

Keywords Quality management, Quality Management Systems, Integrated System of Management, Quality, Air Transportation, Airport, Standard.

I. INTRODUCTION

Currently, one can scarcely find a company not involved in quality related to the most efficient way of management within the firm. Company management and quality are closely related areas, with aviation companies as no exceptions. They keep looking for new ways and forms of improving the level of air operation safety while acquiring the best possible economic benefits and strengthening their position in the market. For this reason, companies involved in air transportation are to be flexible in adapting to the continuously changing conditions and requirements of the market. Consequently, most of them have decided to implement certified systems of management either in the field of quality, environment, safety and protection related to health and labour etc. As in Slovakia there is no national carrier, we have focused on analyzing use management systems at selected airports of the Central-European region and then particularly in Slovakia.

II. MANAGEMENT SYSTEMS

Currently management systems are used for various field of management. The widest application are concerned with the standards issued by the International Standardization Organization abbreviated as ISO, which are implemented within various types of organizations, with those operating in civil aviation as no exception. ISO standards are concerned with various areas: Quality Management Systems are assessed on ISO Standards of the 9000 order, Environmental Management Systems by the ISO 9000 of the 14000 order, Information Safety Management by ISO standards of the 270200 order. Systems of Labour Health and Safety management are based on the standards of OHSAS of the 18000 order. Further, they can be applied in other systems of management e.g. by the AQAP standards within the branch-related standards etc. A great number of organizations are employing several management systems simultaneously, which then make up a single functional unit with joint elements such as in the field of controlled documentation. Such system is then termed as an Integrated Management System. Management systems based on an appropriate standard can be certified by an accredited and certifying organization. Obtaining a certificate on adopting and exercising a management system is a process within which a decision on the need to adopt a management system is to be made as first. Then it comes to the implementation followed by certification of the system, which is expected to be further maintained and improved. At defined periods of times of external audits, the organization is to prove compliance of the adopted management system with the appropriate standards.

III. MANAGEMENT SYSTEMS IMPLEMENTED AT THE AIRPORTS OF EUROPE

The Václav Havel International Airport Prague is the largest airport in the Czech republic and one of the major facilities of this kind in the Central and Eastern Europe. It is situated in the NW part of Prague, in the Ruzyňe District, Prague 6. The Prague Airport has adopted a certified environmental management system by the CSN EN ISO 14 001:2005. This management system is based on company liabilities in terms of environmental protection while defining their extent and strategic goals. In compliance with the rules stated in the norm, the airport is subjected to a minimum of one audit and in every there years a re-certification audit is to take place.

The Wien - Schwechat Internationl Airport is situated 18 km SE of t the Austrian capital Vienna, not far from the city of Schwechat. The former military airport currently features three terminals and belongs to the most frequented airports of Europe. The airport has not adopted any of the ISO standards based management system yet. Despite of the fact that it does not hold any of the certifcates on implementing and maintaing a management system in compliance with he appropriate standards, the airport keeps being interested in the impacts to the environment and the inhabitants living in its vicinity. Studies on the noise affecting 11 000 households living around he airport are made regularly, using a network of 14 fixed points of measurements.

The Franz Josef Strauß Airport in Munich is the second largest airport of Germany after the one in Frankfurt am Main. It started operation in 1992. The old Munchen-Riem Airport was too small and failed to meet the requirements posed by the new era. Currently, the Munich Airport is a crossing of air carriers such as the Lufthansa and consequently to the Star Alliance air carriers, having raised in international ranking as a result. Starting with 2002, the airport has adopted a certified Quality Management System by DIN EN ISO 9001 standards. The certification involved ground, personnel and transportation services, services in terminals and air traffic control. At the same time, the Munich Airport has implemennted for more than 10 years an environmental mangagement system, the EMAS, and also certified Environmental Management System, the EMS, in compliance with the DIN EN ISO 14 001 standards. The airport has also acquired certificates with clearly defined policies of quality and environmental protection while simultaneously meeting the requriments of the appropriate standards.

The Fryderyk Chopin Internation Airport in Warsaw, is handling almost 50% of passenger traffic in Poland. It has and implemented three management systems based on ISO standards, namely the the Quality Management System by ISO 9001, Environmental Management System based on ISO 14001 and the Occupation health and Safety management System based on PN-N 18001. All the three systems have been certified, maintained and subjected to regular internal audits as well as checks and recertification audits performed by the appropriate certification bodies. This aiport is one of the first Polish companies to have introduced and maintained an integrated management system.

The Ferenc Liszt International Airport in Budapest is the major and most important airport of Hungary, originally named Ferihegy International Airport. That´s where the earliest system of collective responsibility, the CSR, was introduced, subsequently joining the CSR Excellence programe based on European Foundation for Quality Management model, the EFQM. The airport has taken the responsibility to cut energy consumption, reduce noise level in the airport vicinity and to become regular participant to various environmental actions in the region, such as planting trees and various sanitation programmes.

The Zürich Airport is the major international hub in Switzerland. It is situated in the Canton of Zürich, North of the Dowtown Zurich and is known as the residence to the Swiss national air carrier the Swiss International Air Lines and a charter airline, the Edelweiss Air. The responsibiity for air traffic control is with the Skyguide. At the airport, a system of environmental management by ISO 14 001 standards is adopted with the certificate awarded in 2001. The overall planning for construction is performed with due regard to the living environment, i.e. constructional projects are evaluated in terms of their impact to the ecology, not only in the phase of building but also for the period of their future use.

IV. IMPLEMENTATION OF QUALITY MANAGEMENT SYSTEMS AT AIRPORTS IN THE SR

Based on the available information and the controlled invterviews made with the staff responsible for airport management, a comprehensive view of the current satus in applying management systems at Slovak airports has been obtained.

The M. R. Štefánika Airport Bratislava was certified by STN EN ISO 9001: 2008 standards in 2010. Prior to that date, a safety management system was used for air traffic control, in line with tthe provisions of Air Law L14 Volume I. „Design and operation of airports“, Slovak CAA requirements for operational safety, National Programme of Slovak Civil Aviation Safety launched by the Ministry of Transportation, Construction and Regional Developmaent of the Slovak Republic. (Currently a completely new wording of the AIr Law L 19 is being prepared for the SMS.)

The Košice Airport is the only international airport in Slovakia having implemented and integrated a management system consisting of a quality management system by the STN EN ISO 9001, an Environmental Management System by STN EN ISO 14001and a Safety management System and labour health protection in compliance with the OHSAS 18001 standards.

Certification at the Košice Airport started with the certification of the separate systems of management on 16 February 2005, obtaining a certificate by the STN EN ISO 9001: 2000 standards. Adopting the standards facilitated more simple implementation of the integrated management system in 2007. It also bore relation to the change in the joint stock holders´ structure effected in 2006, with the Vienna Airport becoming the majority owner. Currently, plans are being made for the certification of the information safety management system by ISO standards of the 27 001 order.

The Aviation Engineering and Repair Airport Trenčín is holder of the quality management system by ISO 9001:2008 standards, certificate of accreditation by the STN EN ISO/IEC 17025: 2005 standards and further ones in compliance with AQAP standards. The Aviation Engineering and Repair Airport receive orders only on having achieved compliance between certified standards and customer requirements. The airport management proclaimed that no certification of other systems was planned as all of them have been implemented in line with currently applicable requirements of the European Union.

The Spišká Nová Ves Airport has implemented and certified management systems the Quality management system by ISO 9001:2008, the Enviornmental Management System by the ISO 14001:2004 and the System of Safety management and labour health protection by the OHSAS 18001:2007 standards. At this airport the quality management systems have been adopted only due to obtaining state orders, wchich require certification of the appropriate systems. No further management systems are to be introduced nor contemplated by the airport management.

The Žilina - Dolný Hričov Airport has no management systems implemented or certified and no further adoption nor certification is intended, due to the financial demandedness of certification as a main reason.

Airport Poprad- Tatry and Airport Piešťany have adopted a quality management system of the services related to the air operation – a Safety Management System based on the requirements of the Slovak Civil Aviation Authorities so as to ensure operational safety and the National Programme of Slovak Civil Aviation Safety launched by the Slovak Ministry of Transportation, Construction and Regional Development. They have no intention to implement nor certify further system s of management. Again, the main reson behind is in the financial burden of certification and the fact that they have not been required to do so by any of the authorities.

The airports in Sliač, Nitra and Martin proclaimed no interest in certification. The Sliač AiIrport has even started certification but had to be declined due to lack of financial means. The same is applicatble to the airports in Nitra and Martin.

Airpots in Prievidza, Dubnica nad Váhom - Slavnica, Svidník, Partizánske - Malé Bielce have proclaimed no use of certification for their operations adding that the process would mean extra burden both in terms of extra administration and finance.

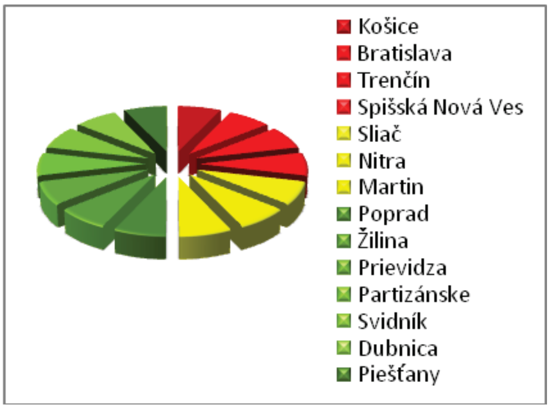

Fig. 1 – Management systems implemented at Slovak airports (□ – adopted, □ – willing to adopt, □ – not interested in adopting it)

Figure 1 shows an overall view of the situation on the adopted management systems in terms of quality management, environmental management, safety management, occupational health and protection at Slovak airports as detailed earlier. Four airports (Košice, Bratislava, Spišská Nová Ves and Trenčín) have adopted the quality Management System (29%), the next three of them (Sliač, Martin and Nitra) are contemplating the introduction (21%) and half of Slovak public civil airports neither have nor contemplate the implementation of integrated management systems (50 %).

CONCLUSION

As we have managed to find out from the survey, the approaches to wards the implementation of systems of quality management, environmental protection or OHSAS at the airports is rather variable. A great number of airports in Slovakia are contemplating the introduction of management systems while considering eventual certification of no use, financially demanding and a source of extra burden. As much as 50 % of Slovak airports have no intention of prospectively introducing management systems at all. To them belong international airports such as the ones in Poprad an Žilina. On the other hand, certification is contemplated by small airports such as the ones in Sliač, Martin and Nitra.

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Current approach to risk-based passengers security screening

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***Abstract*—** *This paper is aimed at presenting security screening of passengers based on risk assessments. This approach covers the concept Checkpoint of the Future - Smart Security. Work describes the current stage of implementation of the concept and its short, medium and long term plans.*

Keywords- passenger; risk assessment; policy and regulation; bahavior analysis;

I. Introduction

Aircraft hijackings in the late 1960s and early 1970s led the member states of the International Civil Aviation Organization (ICAO) to adopt Annex 17 to the Convention on International Civil Aviation, commonly known as the Chicago Convention. Annex 17 requires each member state to designate a single agency to develop national policy on aviation security - specifically, objectives, policies, and programs to prevent unlawful acts that threaten the safety of civil aviation.

No EU-wide aviation security policy existed until 2002, when the European Parliament and Council agreed upon Regulation No 2320/2002 establishing common rules for civil aviation security. Those regulations were revised substantially in 2008, with Regulation No 300/2008 repealing and replacing the 2002 regulation. Consistent with ICAO Annex 17, each member state of the EU must have a national civil aviation security program, with a single agency in charge.

ICAO Annex 17 sets forth the minimum aviation security standards expected of all member states [1]. Supplementing Annex 17 is the Security Manual for Safeguarding Civil Aviation Against Acts of Unlawful Interference, commonly referred to as ICAO DOC 8973. It provides detailed procedures and guidelines on how states may go about implementing the provisions in Annex 17, but is guidance, not a standard [2].

Standard 3.1.3 of Annex 17 states that each contracting state "shall keep under constant review the level of threat to civil aviation within its territory, and establish and implement policies and procedures to adjust relevant elements of its national civil aviation security program, based on a security risk assessment carried out by the relevant national authorities.

The fact is that whether we like it or not, airport security is an important and necessary part of the air transport system [3]. The possibility of man-made flight is only a century old and its continued success relies on its reputation as a reliable, safe and secure way of getting from A to B. Today's passenger security screening process works—but at great cost to authorities, the airline industry, and to passengers themselves [4]. Given the predicted growth in air travel—and continuously evolving security threats—today's model is not sustainable for the long term.

While airports have taken significant steps to improve the passenger experience over the last decade, the security process remains as taxing today as it was 10 years ago. Trusted traveller programs and a risk-based approach have been touted as holding the key to shorter queues, but as the restrictions on the carriage of liquids, aerosols and gels remain in place, and as the threat presented by terrorism remains high, real improvements at the security checkpoint have proved almost impossible to come by [5].

II. TSA Pre-Check and IATA Checkpoint of the Future

Risk-based approach is central to a number of different initiatives, including ACI EUROPE & AEA Better Security project, the US Transportation Security Administration (TSA)'s Pre-Check program and IATA Checkpoint of the Future. Under these concepts, low-risk passengers would enjoy expedited processing, while those deemed high-risk would face a more stringent security process [6].

TSA Pre-Check program and Checkpoint of the Future detail the considerations that the aviation community needs to address in order to move away from the rigid and predictable "one-size-fits-all" approach that characterizes today's passenger security screening environment to a risk based approach based on security outcomes, process improvement, and technology [7].

Risk based screening is based on the following premises:

- The majority of airline passengers present a low risk to aviation
- Some assessment may be made using travel data

- Further assessment can be made through passengers voluntarily providing more information about themselves, through known traveler programs
- Behavior detection and interviewing techniques can be also employed to assess risk
- Security can be increased by focusing on unknowns

A. TSA PreCheck program

It was created in cooperation of TSA, CBP and U.S. air carriers. The TSA has put PreCheck program into operation on October 2011. It is designed to improve and speed up security checks, with a focus on the identification of low-risk travelers [8]. Passengers wishing to participate in this program must undergo a security clearance, which includes the analysis of criminal history and examination by intelligence databases. Approved participants have to identify themselves by boarding cards and barcode, which contains biometric data. After positive verification are passengers, as participants of TSA PreCheck program, directed to the dedicated lines, where they are subjected to less intensive security check [9].

Prescreening allow TSA to determine security steps necessary to maximize the probability of detecting threats to individual travelers. This approach also minimizes false positive and false negative values and reduces likelihood of a potential attack [10].

B. Checkpoint of the Future (Smart Security)

Airports Council International (ACI) and the International Air Transport Association (IATA) have signed a Memorandum of Understanding to develop Smart Security (SmartS).

SmartS replaces the Checkpoint of the Future, reflecting the start of a new phase of pilot testing involving first generation checkpoints [11]. Components of the concept has been tested individually since 2012 and now, under SmartS, several components will be tested together to see how they interact with one another in an operational environment.

The Checkpoint of the Future was launched in 2011 and, a year later, IATA and ACI, together with several national regulators, defined a roadmap for the future of passenger screening, with blueprints for 2014, 2017 and 2020. Between 2012 and 2013, tests were conducted at several airports, including Geneva, Heathrow, Gatwick and Amsterdam Schiphol. From 2014, SmartS pilots will be conducted at airports, including Schiphol and Heathrow, to test multiple components simultaneously.

Goals of the Checkpoint of the Future are:

- Strengthened security
    - Focus resources based on risk
    - Increase unpredictability
    - Better use of existing technologies
    - Introduce new technologies with advanced capabilities
- Increased operational efficiency
    - Increase throughput, optimize asset utilization
    - Ultimately, reduce cost per passenger
    - Maximize space constraints
    - Maximize staffing resources
- Improved passenger experience
    - Reduce queues and waiting times
    - Use technology for a less intrusive and disruptive search

The assessment assumes that the following areas might be included in the scope of the Checkpoint of the Future:

- Passenger Differentiation
- Known Traveler
- Data Integration
- Checkpoint Configuration
- Technology and Detection Standards
- Randomness
- Passenger Experience and Throughput
- Biometrics and Identity Management
- Behavioral Analysis

Known Traveler

A pre-screening program could allow government agencies to perform detailed background checks for a subset of travelers who voluntarily enroll in a program to supplement physical screening at the airport. In addition, consideration may be given to individuals with pre-existing national security clearances.

Identity Management

Identity management could enable automation and process improvement; and could also provide a mechanism for cross-referencing a passenger's identity to their risk assessment at the checkpoint. Biometric collection, identity authentication and later verification is envisioned, coupled with passenger data and risk assessment, to ensure the passenger's identity is true, their passage through security validated, and the appropriate level of screening applied.

Behavior Analysis

Behavior analysis is considered an additional element of risk assessment that could be combined with other elements or used alone [7]. The application may range from individual questioning to a broader observation as the passenger moves through the airport. The results from the analysis can be combined with other assessments to determine the level of screening to be applied.

Policy and Regulation

The Checkpoint of the Future concept is consistent with general shift towards risk based security measures, and is considered to complement the baseline SARP contained in ICAO Annex 17. Regarding passenger differentiation, it is widely agreed that any risk based passenger screening approach should respect fundamental human rights and privacy, and not in any way profile a passenger based on gender, religion, or race.

Risk Assessment and Differentiation

The principle of risk assessment is to objectively enable appropriate screening measures to be applied to passengers and to enable an efficient throughput, based on what is known or unknown about them [7]. Risk based screening considers variations in the level of screening that can be applied to individual passengers or groups of passengers. Risk assessment will be a continuous process that starts at reservation and ends at boarding. Contributing factors to risk assessment might include some or all of:

- Flight – route or type (business, tourism)
- Traveler type (such as crew, staff, military personnel)
- Passenger data
- Watch-list check from match with travel document information
- Rules based analysis of reservations and check-in data
- Membership of a known traveler scheme subject to
- Background checks
- Current and valid membership
- Presence on Interpol Lost and Stolen Passports database
- Checks against other Government databases
- Associated passengers on the same flight
- Behavior analysis
- Alternative measures such as random selection for enhanced screening, trace detection and explosive detection dogs

Alternative Measures for Unpredictability and Deterrence

Random selection, remote screening prior to arrival at the checkpoint, and use of explosive detection dogs, all provide additional or alternative measures to the risk assessment modules as described above.

Short term goals (2014)
With a view toward the near term, the Checkpoint of the Future in 2014 focuses on:
- Integrating new procedures to facilitate risk based screening and decision making
- Optimizing resource and asset utilization
- Integrating available technology and repurposing existing equipment

The key features available in the 2014 Checkpoint of the Future include:

- Risk Assessment
    - Some use of API and PNR data for pre-screening risk assessment
    - Covert and overt behavior analysis techniques deployed at checkpoint
    - National known traveler program and differentiated checkpoint screening program
    - Alternative measures to support reduced random requirements

- Technology
    - Remote image processing from checkpoint at an airport specific basis
    - Biometric verification e-Gate at the checkpoint for known travelers
    - Explosive detection as an alternate measure prior to screening line
    - Real time data collection of checkpoint KPI (e.g. passenger queue time and throughput)
    - Limited deployment of flexible algorithms for advanced X-ray threat identification
    - Passenger Security Scanners deployed as the secondary search device for passengers

Remote Image Processing

Screening of images at a central point, rather than at each lane could maximize both technical assets and staff utilization.

- Operations
    - Dynamic passenger guidance of screening process and way-finding at entry and in checkpoint
    - Queue management program to display queue time and customer service support
    - Improved staff allocation and use of behavior analysis
    - Checkpoint lane design improvement
    - Program for regular passenger feedback

Lane Design

Improved equipment and process automation could maximize throughput in the short term, with the implementation of flexible lanes, able to adjust screening sensitivity depending on risk assessment, envisaged for 2020. The introduction and increase of automation into the checkpoint will allow passengers and their bags to be automatically routed through the process in a controlled and orderly manner, optimizing passenger throughput and security officer resources.

Medium term goals (2017)
The 2017 Checkpoint of the Future is focused on updating technologies and processes to increase the security value of the checkpoint, while maintaining a strong focus on customer service to enable greater passenger satisfaction.

The key features available in the 2017 Checkpoint of the Future include:

- Risk Assessment
    - National Targeting Centers or Passenger Information Units to analyze passenger data and other inputs, implemented in some States to provide input to overall risk assessment
    - Covert and overt behavior analysis techniques deployed at checkpoint with limited connectivity to checkpoint for real-time update to risk score
    - International cooperation and recognition of known traveler programs
    - Dynamic risk score adjustment based on identity is in operation at select checkpoints

- Technology
    - Remote image processing from checkpoint at airport and country levels
    - Identity management system based on travel document (e.g. passport) is common at checkpoints across the globe
    - Automated biometric gates to determine access to known traveler lane
    - Risk assessment and identity management systems connected via a secure information network
    - Real time data collection of checkpoint KPI
    - Regular deployment of flexible algorithms for X-ray targeted threat detection
    - Passenger security scanners are the primary device for passenger screening

- Operations
    - Separate known traveler queue and lane with biometric identity authentication at entry
    - Dynamic device monitoring to support operational management decision making
    - Dynamic passenger guidance of screening process
    - Queue management program
    - Improved staff allocation and use of behavior analysis
    - Checkpoint lane design
    - Program for regular passenger feedback

Long term goals (2020 +)

A passenger will have a level of security screening based on information from states of departure and arrival through bilateral risk assessments in real-time.

The key features available in the 2020 Checkpoint of the Future include:

- Risk Assessment
    - Passenger and flight data risk assessments are common practice with international cooperation
    - Unpredictable alternative measures are in effect to deter and detect
    - Automated behavior analysis with real-time update of the risk score to the checkpoint
    - Known traveler program and differentiated checkpoint screening program across multiple Countries

- Technology
    - Stand-off identity management system based on biometric capture and verification
    - Automated biometric gates to confirm eligibility for all passengers regardless of status
    - Real time risk score updates and level of screening decisions
    - Alternative measures for explosive detection incorporated into checkpoint and front-of-house processes
    - Screening technology complete with advanced threat detection and dynamic adjustment based on the risk score of the passenger
    - Remote image processing with automatic decision algorithms
    - Passenger security scanners are the primary device for passenger screening

- Operations
    - Dynamic passenger guidance of screening process and way-finding at entry and in checkpoint
    - Queue management program to display queue time and customer service support
    - Improved staff allocation and use of behavior analysis
    - Fully flexible checkpoint lanes able to screen all risk categories of passengers
    - Program for regular passenger feedback that incorporates modern technology

ACKNOWLEDGMENT

Risk based screening and related concepts, present and possible future concepts are discussed by the leading airline, airport and aviation organization representatives, organizations concerned with the rights of passengers as well as passengers themselves [12].

There are arguments against these concepts: decisions will end up being made on racial grounds, we can’t treat people differently, and it is impossible to test that the system is working. But there are also some pros. Passengers benefit from more secure, faster, convenient and less-intrusive security screening. Airlines benefit from higher customer satisfaction and reduction in departure delays [7]. Airports benefit from greater operational efficiencies and increased revenue opportunities. Governments benefit from an improved ability to counter threats, ability to focus resources where risk is greatest, and leverage investment made on existing technologies. Manufacturers benefit from greater use of technologies.

It is long way to implement all planned and related features of risk based screening to real operation. The most important is determination the national policy and regulation (which information about passengers are relevant a rules how to use them), which will be balanced with human rights. As the Changi Airport Group’s Tan said: “These concepts have thrown up some interesting ideas for the industry to deliberate. The idea of differentiating passengers and implementing appropriate screening measures is very bold in its objective. I don’t believe that the industry is ready to move into the area of passenger differentiation currently as there are obvious challenges, ranging from the availability of passenger information to conduct proper risk assessments, and issues pertaining to discrimination.”

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Flight safety in view of adherence to established limits of flight time

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Abstract: **The article is focused on finding of level of meeting the required limits of time in service, time in flight shift and time of a rest for flight crews by means of questionnaire, filled out anonymously by pilots of several airline companies in which the EU OPS Norm is applied**.

Key words: Questionnaire, flight duty, limits

I. INTRODUCTION

It is commonly known that the most of accidents in aviation was caused by human factor error. By this it is not meant that only flight crews are responsible for all such caused accidents, but it is necessary to minimalism the influence of this factor on them. Time in duty of a flight crew is a topic which is directly connected to this problem and the task of legislative limitations in this field is to minimalism the factor of fatigue and performance decrease linked to caution interruption below flight safety interruption as much as possible Every living organism including a human being is capable to deliver various performance during the day no matter of if it is mental or physical activity. Each individual has specific biological watch in its organism that work on the basis of concrete external and internal factors. These watches are set to a predetermined daily rhythm and their disconnection and repeated setting to balance takes specific longer period in terms of several days. It is immensely demanding for a flight personnel, in many cases even impossible, to create sustainable regular daily rhythm. In the text there are measured analyzed responses to questionnaire, which based on the pilots responses was supposed to find out what is the real situation in the field of limits adherence. There are included very sensitive questions in the questionnaire therefore total anonymity of pilots participating in the survey was ensured.

II. LEGISLATIVE PLATFORM

The duty hours of a flight crew are strictly limited. There is a Bonding EU OPS Norm for countries united in ECAC, specifically its part Q “Time of flight duty hours limitation and duty and time for rest requirements.“ However, his norm does not cover all scale of the problematic and orders providers to include these unprocessed parts into internal regulations and processes. Due to an increase of flight safety and legislation unity in certain countries there are published national regulations covering the entire field of scope of crew time limitation (e.g. in the Czech Republic Regulation MD no. 466/2006 el. about flight safety norm), thus all airline providers in a given country work with the same limits. Of course, within the own need due to working reasons providers can make these limits more strict but in no case to diminish them.

A. The most important limitations

Cumulative duty hours1, at which it is necessary to define a term duty first. A duty is defined as a period of time that begins by the moment at which a provider requires a crew member to start duty and finishes as long as a crew member has no other duties, i.e. A crew member does not sit in a plane directly and fly, but performs other than flight activity.

Total duty hours assigned to individual crew members must not exceed:

- 190 hours of duty during 28 days in a row, divided into this period accordingly as balanced as possible,
- 60 hours of duty during 7 days in a row.

Maximum daily flight duty period[2], where compare to the previous limit the term flight duty period. This term means

[1] Cumulative duty hours. [20.3.2014]. Available on the Internet: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:254:0001:0238:EN:PDF

[2] Maximum daily flight duty period. [20.3.2014]. Available on Internet: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:254:0001:0238:EN:PDF

any period during which a person is working on a plane as a member of its crew. It starts in a moment in which the provider requires from a crew member to assign to a flight or to flight series and ends in a moment of last flight finish, during which an assigned person is working as a crew member.. Maximum daily flight duty period is 13 hours. These 13 hours will decrease by 30 minutes for each part of a flight, including the third part, but the most by 2 hours which in practice means the sixth and the following parts (Table 1).

TABLE 1 Dependence of maximum basic daily flight duty on the amount of parts of flight
Source: *Own processing*

Part of flight	1	2	3	4	5	6	>6
Max. Daily flight duty (hrs)	13	13	12,5	12	11,5	11	11

Rest3 can be divided into two parts, according to whether a given flight starts at the home airport or other convenient airport. At flights from the home airport a period of a basic rest is determined by the period with the same lasting as was the lasting of the previous duty hours, or 12 hours according to what lasts longer. With flights from other convenient airport the period of a basic rest is determined by the time period with the same lasting as was the lasting of the previous duty or 10 hours depending on what is longer. In such a case a provider is obliged to secure a possibility of 8 hour sleep with an adequate observing the trip and other physiological needs for crew members.

III. MEETING LEGISLATIVE FORM

Legal regulations at any sphere of a human activity should be strictly observed, especially in aviation where even the smallest fault can represent a loss of lives. There cannot be forgotten a fact that from a short term perspective any limitations represent increased financial means. It is obvious that observing the duty periods of a flight crew means considerable limitation of a flight time, higher expenses for crew accommodation; more inter landings and respective airport fees, etc. In this sense there is a question whether a word phrase "What is written it is given" is really observed in practice, and whether there was no shift of safety to a side track in favor of financial benefit. For finding of current situation of adherence the regulations about duty period of a flight crew, there was on the basis of the EU OPS regulation, Chapter Q "Time of flight duty hours limitation and duty and time for rest requirements." created a questionnaire which subsequently anonymously filled out totally 42 pilots working in airline companies.

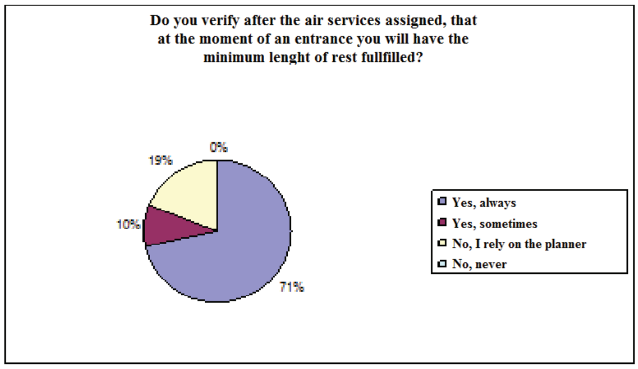
[3] Rest. [20.3.2014]. Available on Internet: http://eur-lex .europa.eu/ LexUriServ/LexUriServ.do?uri=OJ:L:2008254: 0001:0238:EN:PDF

IV. ANALISIS OF QUESTIONNAIRE RESPONSES

Considering the limited scale possibilities of this article, from this questionnaire we take and analyze only responses to questions related directly to adherence of the mentioned limits of duty period, rest and not other questions that were subject of this questionnaire (e.g. Understanding of regulations within this field, knowledge of regulations, etc.).

A. Verification of a rest period

The same, as the period spent on duty is regulated, the period of rest is regulated as well. However, the regulation doe not determine that a member of a flight crew is obliged to verify after duty assignment whether he/she has fulfilled requirement form minimum period of rest at the moment of starting the duty, it is significant to follow this issue for flight planning reasons. In airline companies a flight planner is responsible for this task, who assigns crews for a specific flight, but also he/she can make a mistake and it is recommended that also crew members will follow their limits. For solving this problematic in practice there was edited a question in the questionnaire with the following: "After flight duty you will verify whether you are going to have minimum period of rest fulfilled at the moment of starting the duty." (Graph 1). 71% of the responses is of a type of "yes" and 0% is of a type"no, never", what is a very positive result because, as mentioned above, preferably the flight planner is responsible for this question. .10% of questioned pilots said that they verify it seldom and 19% rely on a flight planner only.



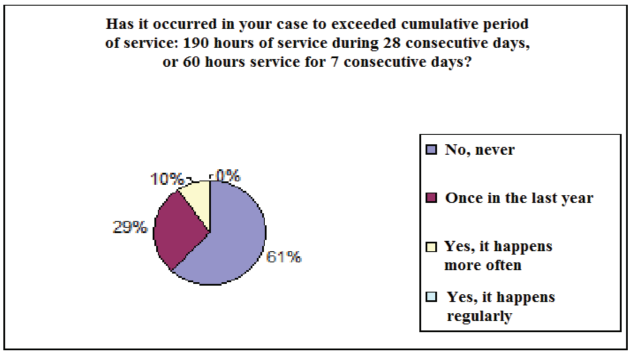
Graph 1: Response to a question in a questionnaire.
Source: *Own processing*

B. Flight duty period verification

When starting the duty each flight crew member should be aware of what time he/she can spend on flight duty or duty in order to avoid missing limits. Similarly as in the previous case, neither this feature is determined for crew members by a regulation, but only generally the limit must not be exceeded. A flight planner is assigned for control in an airline company. To question: "Prior to each start of a flight duty or duty, are you aware of what maximum times can you spend on duty in order to avoid exceeding of maximum periods determined?" 76% of questioned pilots replied "yes, all the time" and 19% claims that "rarely it is not known to them. " Repeatedly it can be said that a professionalism of pilots is vivid here, when they verify meeting the limits in their own interest.

C. Exceeding of cumulative duty hours

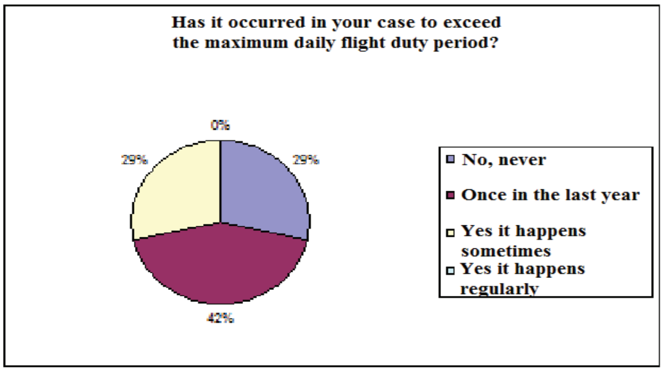
In the questionnaire by means of a question: "Did happen in your case to exceeding of cumulative duty hours, i.e. 190 duty hours during 28 days in a row, or 60 duty hours during 7 days in a row?" ached verification of observing this regulation (Graph 2) with 61% group participation, which claims that they have never experienced exceeding the limits provided. 29% of pilots involved in the survey claims that it happened once in the last year. Without deeper thinking an opinion can appear there that 90% group is enough to proof the limits are successful. It could be valid in another type of an activity but in aviation this group should attack threshold of 100%. For clarification of the problem it is suitable to create a model situation. The average daily amount of flights in worldwide measured is at level 50,000 and mostly the crews consist of 2 pilots. It means that for realization of these flights 100,000 pilots are needed. To have a picture, very simply said, if 10% of them exceeded the limit, i.e. 10,000 pilots, whom it is possible to assign to 5,000 flights in total.



Graph 2: Response to a question in a questionnaire.
Source: *Own processing*

D. Exceeding of maximum daily flight duty period

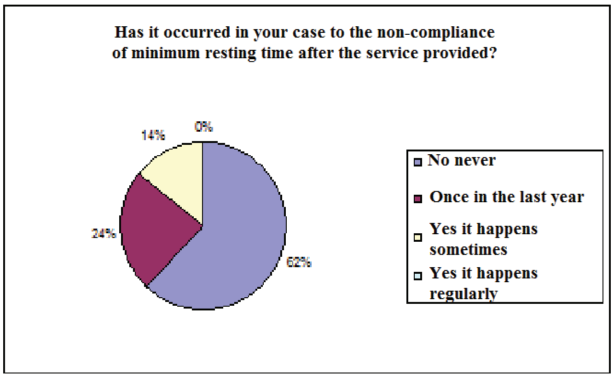
Maximum daily flight duty period is the most strict limitation, which needs to be strictly observed due to the reason of fatigue build-up in case that several limits in the days following each other. In the questionnaire the following question elaborates this: "Did exceeding of maximum daily flight duty period happen in your case?" where 29% from the pilots (Graph 3) filling out the questionnaire mentioned that it never happened to them, 42% mentions, that it happened once in the last year. The sum of these values provides result of 71 %, acceptable responses for safety. One excess of the limit that happened during the last year could be also caused by the limit exceeding due to uncomfortable conditions in service. Such a problem is managed by the regulation and that allows exceeding the limit. The situation is worse in case of responses that result in exceeding of daily limit more often; specifically 29% of pilots mentioned this. More regular exceeding of limit can result in build-up of fatigue and creation of long sleeping debt.



Graf 3: Response to a question in a questionnaire.
Source: *Own processing*

D. Misobserving the minimum rest period

The rest period is tightly linked to a duty or in a flight duty. The longer the flight duty itself lasts, the longer basic rest itself has to be. Misobserving of the given limits of rest was tested by means of the question: "Did misobserving of the minimum rest period happen after the duty in your case?"62 % of responses (Graph 4) show, that misobserving of the minimum rest period never happened and 24% claim that it happened once in the last year. No regulation tolerates one exceeding, but from a different angle of view it can be claimed that it is acceptable threshold, if it is only a small time reserve (up to one hour). In case that it would be a value in several hours, for a crew it could mean a big burden and flight itself could be endangered. 14 % of the responses created a result that claims that misobserving the limit happens more often.



Graph 4: Response to a question in a questionnaire.
Source: *Own processing*

Conclusion

The objective of the article was to find out by means of anonymous questionnaire for civil pilots how are the limits of flight crew duty fulfilled in reality. As seen from the questionnaire, the situation is not so positive as it could be expected, however only 42 civil pilots replied to the questionnaire. It can be concluded that in some cases the pilots did not start their duty despite the fact that they did not feel well or they suffered from fatigue. Such practice is unacceptable. It could be sufficient if the pilot would consciously start or would be forced to start duty with misobserving the given limits for rest by an employer, and the flight safety can be seriously endangered and not only on the board but also on the ground.

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MEASURING PILOT PERFORMANCE UNDER REAL FLIGHT CONDITIONS

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***Abstract* – The article is devoted to the methodology of measuring pilot performance under the conditions of real flight. It provides the basic information on a research project realized to obtain new information regarding training and education of pilots. The introduction is focused on the analytical part of the project and the outputs in terms of the current state of the art. Detailed view is cast on the issue of measuring pilot performance under specific conditions of the cockpit or the flight simulator. The article is zooming in on the two selected and developed methods of pilot performance in terms of the defined indicators evaluated, conditions of compliance for conducting research and procedures of the – methodology of pilot performance measurements.**

Keywords: pilot´s performance, research of training procedures of pilots, precision of piloting, level of pilot workload.

I. INTRODUCTION

Preparation of the aircrew is one of the key factors affecting air operation safety. By inconsiderate cuts in financing of pilot training, results in lowering the level of professional habits of pilots and thereby to the reduction of flight operation safety. For this reason, it is important to conduct research for new methods of aircrew training, which could lead to lower financial burden without exerting negative impact to flight safety. Currently, world trend is necessitating the more intensive integration of flight simulators into pilot training in .

The stimuli as above have turned into basic drivers pulses for the company of Education training & consulting company, j.s.c. and the Faculty of Aeronautics TUKE, which in the period of 2012 up to 2014 were solving project titled as „Research of training methods of pilots using flight simulators ", ITMS code of the project: 26220220161, which was cofinanced from EU resources.

The strategic aim of the project was research into increasing air transportation safety and the folow-up transfer of scientific findings into economic practice [1].

The basic outline of the project was:

- Analysing the state of the art in preparation and training of pilots,
- Identifying insufficiencies in this area,
- Suggesting new methods of pilot training, which could increase the level of safety while simultaneously reducing financial burden of these trainings,
- Formulating of hypotheses at the level of confirming the identified insufficiencies and verification of the contribution of suggested new methods of pilot training for improving the current status
- Developing the methodology of research activities
- Verifying new procedures for the purpose of practical applications.

II. METHODS USED TO ANALYZE THE STATE OF THE ART

The analytical part of the project involved mapping of the state of the art in the field of applied procedures as part of the preparation and training of the aircrew with emphasis on the efficiency of using flight simulators and on their contribution to increasing air traffic safety.

Stage one of the analytical activities was focused on the legislative framework, which is a controlled process of aircrew training and preparation. Special attention was paid to training procedures for pilots and the requirements for the training on flight simulators.

The next stage of the analysis focused on the individual subjects of air transportation in both the domestic and international environment, in civil and military sectors. For this activity, of good use were information obtained directly from the individual subjects of air transportation by way of discussions on the occasion of personal visits at selected firms and institutions. Further sources of information were the websites of those companies, which could not been visited in person.

As a matter of fact, the key issue of the project is in the focus of both local and international businesses. That is why, it was necessary to identify and analyse similar research projects with the aim to find out the state of the art in the issue so as to establish a follow-up on the outputs of similar projects.

The most important element of air transportation safety is human factor, of course. Consequently, an analysis of the causes of those aviation accidents was performed, which resulted from training procedures of pilots.

An important part of the analysis was made up by a questionnaire–based survey regarding the state of the art of training procedures for pilots and use of flight simulator as part of pilot training. It meant contacting aviation companies and institutions, which were directly or indirectly involved in air transportation. The survey was also freely available for the wide professional public in via a web application of.formees.com/cz.

III. ANALYSING TE STATE OF THE ART

The analysis was focused on the preparation and training of pilots with the purpose of identifying the insufficiencies in this field and obtain stimuli for the research part of the project. The following points are bringing closer the basic areas of interest of the analysis.

A. Legislative framework

Within the framework of analysing air law directly specifying the conditions and requirements for pilot training as well as flight simulator applications in the training process, focus remained on the legislative environment of aircrew preparation in the Slovak republic, i.e. on the environment, which forms part of the European environment and is regulated by the European Aviation Safety Agency, the EASA, applicable to the European environment.

B. Aviation subjects directly involved in the process of pilot training and preparation in the domestic and international environments

This stage of the analysis was focused on firms and companies representing all the elements of the air transportation system in the context of pilot training and preparation:

- Air carriers, holders of the AOC in commercial air transportation,
- Flight training schools and organizations, FTO/ATO,
- General aviation,
- Air force units,
- Flight simulator manufacturers,
- Operators of flight simulators.

The areas of interest covered information regarding brief characterization of the subject, its history, process of obtaining certificates, training procedures applied for pilots and use of flight simulators during pilot training.

C. Identification and analysis of similar research projects

These activities involved conducting analyses of the available information regarding:

- Research projects focused on the procedures of pilot training and preparation,
- Factors affecting pilot performance i.e. air transportation safety,
- Methods of measuring pilot performance,
- Use of flight simulators in pilot training and the efficiency of their utilization,
- Wide spectrum of the issue of pilot training and preparation.

D. Causes of aviation accidents resulting from pilot training procedures

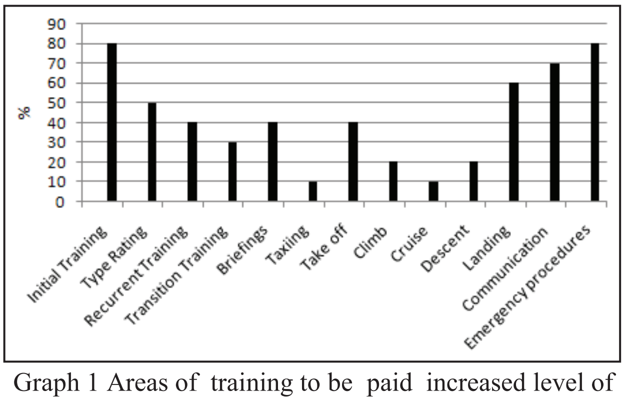
The causes of aviation accidents were analysed with the purpose of identifying those cases, which resulted from pilot training and preparation procedures so as to identify the insufficiencies in this area on the basis of real consequences.

E. Questionnaire-based opinion poll regarding the state of the art in the pilot training procedures and utilization of flight simulators as part of pilot training [2].

As par to the survey, the information obtained were related to the following areas:

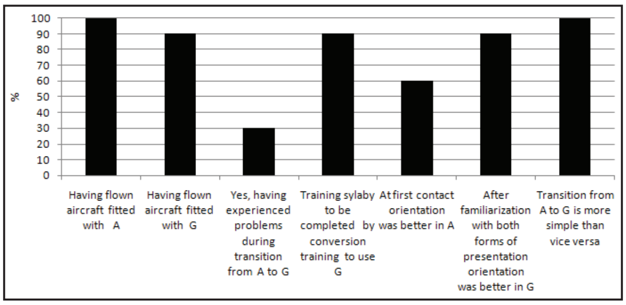
- Identification of pilot procedures involving the most frequent use of flight simulators,
- Using/not-using flight simulators to verify correctness/efficiency of the established flight procedures,
- Identification operational and training procedures in which the respondent is aware of insufficiencies, which could result in changing the training procedures in order to eliminate the deficiencies,
- Effect of changing flight data presentation on pilot performance (e.g. changing form analogue to glass cockpit and vice versa).

Graph 1 is expressing the basic ideas of the survey respondents regarding identification of flight operational and training procedures in which they are aware of insufficiencies that could result in changing the training procedures so as to have them eliminated.



Graph 1 Areas of training to be paid increased level of attention

Graph 2 is expressing the basic ideas of respondents regarding the changes in flight data presentation affecting pilot performance when changing from analogue to glass cockpit form of presentation.



Graph 2 The issue of changing presentation from analogue to glass cockpit

IV. OUTPUTS FROM THE ANALYTHICAL PART OF THE PROJECT

A. Changes in the presentation of basic flight, navigation and engine data

The analyses of simulator-based pilot training procedures concluded that the issue of changing the from of basic flight, navigation and engine data presentation on the instrument panel in the cockpit does affect pilot performance in terms of piloting, with symptoms of deviations from the actual position of the aircraft and the actual flight trajectory from the required flight and navigation parameters.

The current development in the field of basic flight, navigation and engine data presentation on the cockpit dash-board is heading towards the gradual replacement of classical analogue indicators by grass cockpit indicators, which in some cases bring about fundamental changes in the way of presenting the information needed for the navigation of an aircraft. We assume that the issue of changing presentation is symptomized differently at various categories of pilots in view of the proficiency, number of hours flown etc. The most important influence on pilot performance resulting from changing the presentation is assumed for the following combinations:

– Changing from analogue presentation to glass cockpit for pilots who have flown only by analogue instruments so far,
– Changing from glass cockpit presentation to analogue form for pilots who have flown only by glass cockpit instruments,
– Changing presentation for pilots, who have flown alternatively and are flying by both forms of presentation, whereas the changes occur following a longer period of time.

On the basis of the research outputs, two hypotheses were defined for the purpose of the research activities within this project in order to be instrumental in obtaining new knowledge in the course of the research in the field specified as above :

Hypothesis 1

Based on the findings of the analysis, we assume that the influence of changing presentation from analogue to glass cockpit is negative regarding the performance of those pilots who during their short flight career have flown only by analogue data presentation spending only a small number of hours in the air (cca up to 100 hours flown), or are utter beginners familiarized only with the basics of flying on instruments. This category of pilots will form the Test sample of pilots No. 1, called as Beginners. We assume that if the change in presentation is proceeded by a training on flight simulators, then it will less negatively affect pilot performance [3].

Hypothesis 2

Based on the analysis we assume that the influence of changing from analogue to glass cockpit or vice versa is more apparent on the performance of those pilots, who have spent a greater number of hours flying on one form of data presentation or the change was proceeded by a greater the other way of presentation. In view of the fact that aircraft are operated offering both forms of presentation, these pilots are currently confronted with changing presentation, some of them within shorter periods of time (e.g even within a day) and some for a longer section of time. This category of experienced pilots will make up the Test sample of pilots No. 2.We assume that if the change in presentation is proceeded by a new method of training and preparation, it will have lower negative impact on the performance of pilots [3].

B. Failure of the artificial horizon

The analyses of simulator-based training procedures concluded that the failure of the artificial horizon does influence pilot performance in view of flying on stand-by instruments , which is apparent by deviations of the actual aircraft position from the required flight and navigation parameters. At current forms of presenting flight and navigation information, the following basic situations may develop:

– When flying on instruments with analogue form of presentation, failure of the artificial horizon and the necessity to perform piloting on the basis of stand-by flight instruments such as turn and bank indicator with a lateral bank indicator (by the „ball“) and the vertical speed indicator, or using the stand-by artificial horizon not situated directly in front of the pilot (resulting in violating of the established procedures of scanning flight and navigation information) and usually this back-up horizon of smaller by design, i.e. does not provide so precise information as the main artificial horizon. This situation does affect piloting in terms of maintaining the required bank and pitch of the aircraft but does not seriously affect navigational procedures.
– When flying on glass cockpit presentation, with the digital information failed, there arises the need to fly on stand-by flight instruments such as accelerometer, altimeter, stand-by artificial horizon and a simple magnetic ball compass, usually an analogue one. The stand-by artificial horizon is not located directly in front

of the pilot (a fact resulting in violating the established procedures of scanning the flight and navigation instruments for information) and this bakc-up artificial horizon is smaller by design, so it does not provide as accurate information as the main artificial horizon. This situation does affect piloting in terms of maintaining the required bank and pitch thus influencing the navigational procedures, too.

Hypothesis 3

Based on the analysis findings we assume that the effect of main artificial horizon failure and the need to perform piloting on stand-by instruments is more apparent on the performance of those pilots, who have not undergone training on stand-by instruments for a long time using a flight simulator, or a real aircraft. This category of experienced pilots will make up the Test sample of pilots No. 3. We assume that if flying on stand-by instrument is proceeded by absolving a new training and preparation, then flying by stand-by flight instruments will be of less negative influence in terms of pilot performance. [3].

V. METHODOLOGY OF MEASSURING PILOT PERFORMANCE UNDER REAL FLIGHT CONDITIONS

Changes in the form of presentation of flight and navigational data in terms of pilot performance was assessed within the project research by way of measuring precision of piloting and the level of load. Definitions of the mentioned indicators of assessment are as follows:

Precision of the piloting techniques in terms of the research requirements was defined as deviation of the actual flight parameters in the determined phases of flight from the required flight parameters.

Level of load for the purpose of research was defined as deviations of the selected psycho-physiological parameters of the pilot from the initial level of the parameters of the same person.

In view of the external condition, the research flights were performed under the following conditions:

- Sufficient visibility of the natural horizon,
- Performed in the area below or above the cloud base,
- Performed in an area with maximum wind speed up to cca 7 $m.s^{-1}$,
- Non-turbulent environment,
- With sufficient clearance above obstacles and lateral separation form them so as to prevent the pilot form unnecessary monitoring safe altitude or lateral separation,
- Performed under suitable light conditions in terms of flight data instruments readability.

Within the framework of the research, all phases of flying on aircraft and on flight simulators related to the research (piloting in the working zone) were performed as flying on instruments.

A. Measuring pilot performance by way of defining the deviations of parameters form the required parameters in the appropriate phases of flight

The individual true deviations were defined with a time separation of 1 second for cca 1 minute of the given modes of flight. For each mode, 3 measurements were made.

For the purpose of recording the true parameters of flying, the research made use of the following procedures:

- Recording flight parameters on the TRD40 flight simulator by means of a SW Instructor station, function Performance,
- Recording of flight parameters when flying on real aircraft using the flight data recorder supplied by TRADIP, s.r.o.,
- Recording flight parameters (maximal deviations from the required parameters) by the pilot-instructor.

Deviations of the actual parameter of flights from those required were monitored during:

- Straight-and-level-flight for an altitude and heading (with the pilot instructed to fly at a required altitude and heading),
- Horizontal turn for an altitude, bank and heading (with the pilot instructed to fly at a required altitude, bank and radios of turn , or the final heading of the turn),
- Climb or descent turns, for vertical speed, bank and heading (with the pilot instructed to maintain a required bank, vertical speed and radius of turn, or the final heading of the turn).

Figure 1 illustrates the deviation of the true vertical speed from the required vertical speed + 300 ft/min.

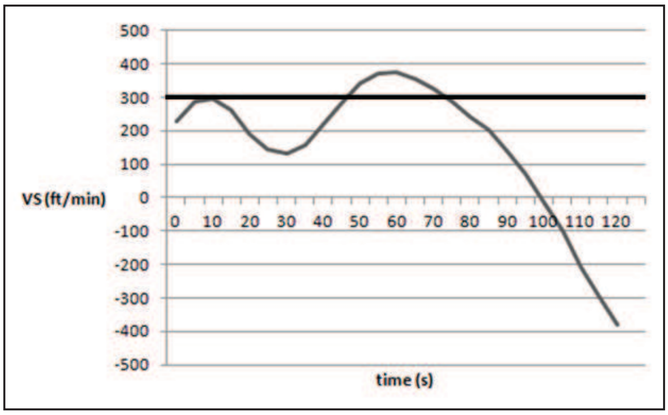


Fig. 1 Precision of piloting technique – flight data recorder

Figure 2 is a record of flight parameters completed by the instructor.

Record of data-flight				Doc. No.
Manouver/Mode	Beginning of measurement UTC Ending of measurement UTC			
	Parameter set	Deviations	Parameter set	Deviations
Straingt-and-level flight	heading		altitude	
Horizontal turn L	bank 30°		altitude	
Climb turn at R	bank 15°		Vs 500 ft.m⁻¹	
Descent turn at L	bank 15°		Vs 500 ft.m⁻¹	

Fig. 2 Precision of piloting techniques – instructor

B. Measuring pilot performance by way of recording his psycho-physiological parameter.

For the purpose of quantifying the level the level of pilot load the following parameters were recorded:

- Pulse frequency,
- Breathing frequency,
- Body temperature,
- Body activity (3D actigram),
- Intensity of muscular activity.

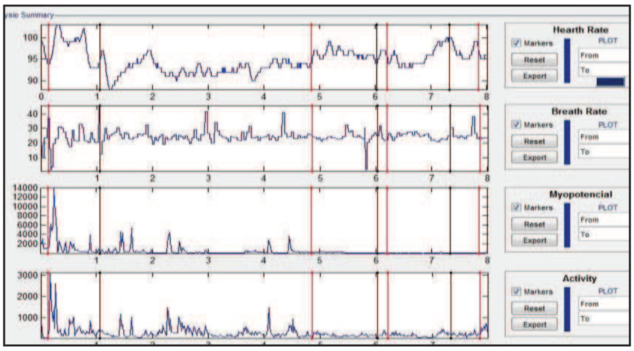


Fig.3 Record of pilot´s psycho-physiological parameters

Within the framework of the project we worked with the hypothesis by which we assumed that from a certain level of pilot´s load, in compliance with the stated definition, this load is negatively influencing pilot´s performance, e.g. also from the point of precision of piloting techniques. It means that by measuring pilot´s load we are able to quantify pilot performance. For this purpose, the research project made use of measurement equipment of the Faculty of Biomedicine Engineering, CZIHE Prague.

The basic parameters and the setup of the measurement instruments:

- Telemetric sensing unit
  - in on-line mode, wireless communication via a wireless XBee interface
  - in off-line mode the possibility of recording the data on the SD card
- Sensor module for sensing pulse frequency
- Sensor module for sensing body temperature
- Sensor module for sensing body activity (3D actigram)
- Sensor module for sensing breathing frequency
- Sensor module for sensing intensity of muscle activities

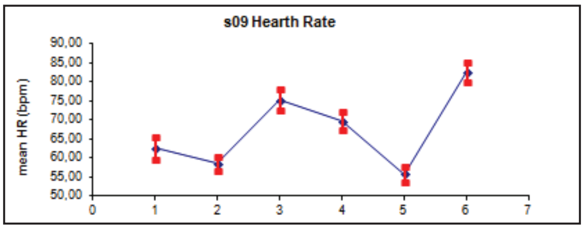


Fig. 4 Average values of heart pulse with the standard variation [4]

CONCLUSION

Use of simulators enables training of border-line situations, which cannot be performed under real training flight. Applying new training methods potentially reduces financial burden of training without degrading the level of air traffic safety. Furthermore, the new training methods may contribute to raising the level of air traffic. Shifting the main share of training from real aircraft to modern flight simulators brings about direct financial savings in terms of the costs of fuel and wear of aviation equipment, and the undisputable positive contribution for the living environment as well.

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Safety Culture vs. Strictness of Regulations

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Abstract- **This article focuses on the influence of safety culture in individual countries on the strictness of their aviation regulations. It describes safety culture and shows its influence on the example of the mandatory runway infrastructure of small aerodromes, which have implemented an instrument approach.**

Keywords- ***Safety Culture, General Aviation, Aerodrome, non-precision approach, runway lighting***

I. INTRODUCTION

Aviation, same as any other transport sector, is developing very fast and as well as in other sectors it is also needed to ensure safety in aviation. This safety is absolutely essential, but it probably cannot be ensured up to one hundred percent, so the view of the acceptable level of safety (ALoS) is used.

ALoS, however, can be ensured in two ways. The first way is to set complex rules that do not allow exceptions and ensures that nothing bad can happen when everybody comply. In this method it is still necessary to supplement the high penalties for infringements, which will further encourage compliance.

The second way is to set the regulatory basis to a reasonable level that it will allow exceptions documented by professionally drawn up safety studies showing acceptable level of safety. In this case, which is much better for the development of air transport, because it allows it, the support element in ensuring the safety is positive safety culture.

What is a safety culture and how it can be achieved in highly regulated aviation are extremely difficult question to answer. But safety culture in aviation differs in different parts of the world and therefore these questions are explained further.

II. SAFETY CULTURE

Safety culture is the way safety is perceived, evaluated and prioritized in the aviation organization. It also reflects a commitment to safety at all levels of the organization. Safety culture can be described as how an organization behaves when no one was watching. Alternatively, we can say that safety culture is what people think about the need for safety and this opinion is influenced by their co-workers, supervisors and managers.

It is important to note that unlike Safety Management, which is a manual for organization from the regulations point of view, safety culture is something that cannot be bought. Safety culture must be developed by the organization; it is a product of organizational and professional culture of the organization. In the case of a safety culture beyond the organization, which is the whole aviation safety culture in a State, it is possible to include also other types of cultures, e.g. national culture.

Safety culture can be positive, i.e. the correct perception of safety and behaving accordingly, neutral or negative.

The benefit of safety culture is a clearer and more comprehensive view of operational risk.

When is the safety culture viewed in terms of states, it is possible to detect its impact on aviation regulations. This effect can be observed on the strictness of the requirements for instrument runway.

III. ANALYSED COUNTRIES

An analysis of the EUROCONTROL States, Australia, New Zealand and Canada can draw certain conclusions concerning the level of safety culture.

These states were selected through comparison of "Europe" with other areas in the world in which general aviation is very developed. This condition satisfies both Canada and Australia with New Zealand because of the size of these countries, when the aircraft is in some cases the best and fastest mean of transport.

Comparison of EUROCONTROL States, which have almost the same rules because of the European integration, with the other three countries shows interesting results. The aerodromes with a maximum runway length of 1500 m, which had a straight-in instrument approach were analysed. This analysis evaluated these criteria:

- Runway length
- Runway width
- ATS presence
- Runway lights
- Approach lights
- Slope lights

- Surface on the Runway

Using this analysis, differences were found concerning deviations from ICAO regulations, where the European states have legislation set very strictly and each European CAA do not have jurisdiction or is not interested to secure an exemption, even in cases where it will be more than justified. An example might be the following table, where the interesting points for each State are mentioned, or Figure 1 and 2 with the number of approaches and runway infrastructure.

TABLE I. INTERESTING DATA ABOUT ANALYSED COUNTRIES

Country	min RWY length [m]	min RWY width [m]	the most interesting point
Australia	756	18	surface of some RWY is dirt
Croatia	1440	30	-
Denmark	1006	23	-
France	820	23	-
Germany	632	20	-
Greece	1461	30	-
Greenland	799	30	surface of some RWY is gravel
Hungary	1300	30	-
Iceland	885	23	-
Italy	1393	30	-
Canada	579	15	surface of most RWY is gravel
Netherlands	1199	23	-
New Zealand	791	9	railway across RWY
Norway	904	30	road across RWY
Portugal	800	20	-
Serbia and Montenegro	1000	25	-
Slovakia	1150	30	-
Slovenia	1200	30	-
Spain	938	30	-
Sweden	1150	30	-
Switzerland	1000	23	-
Ukraine	1200	42	surface of some RWY is grass
United Kingdom	289+236	18	the shortest RWY is combined asphalt + grass

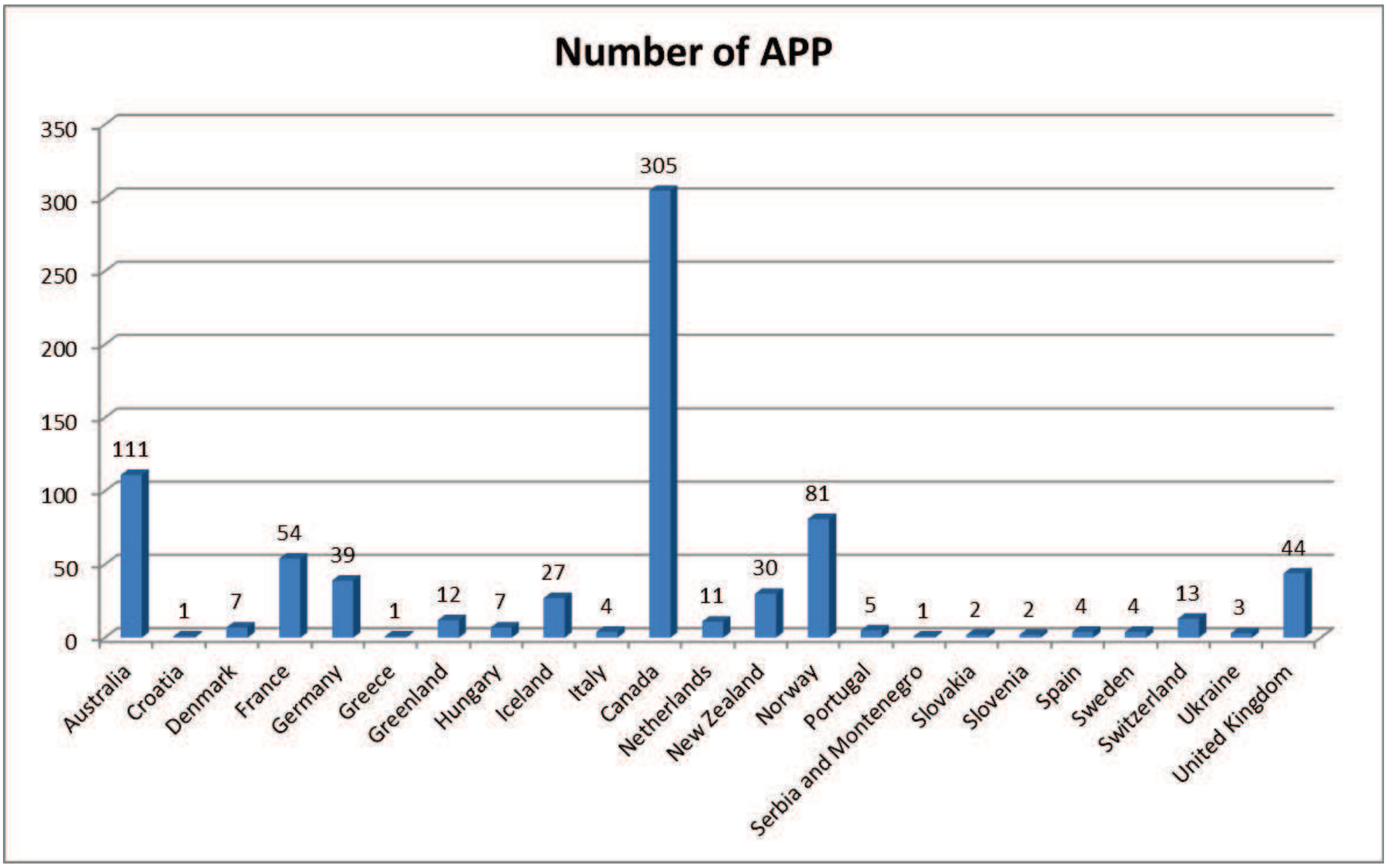

Figure 1. Number of instrument APCH by states

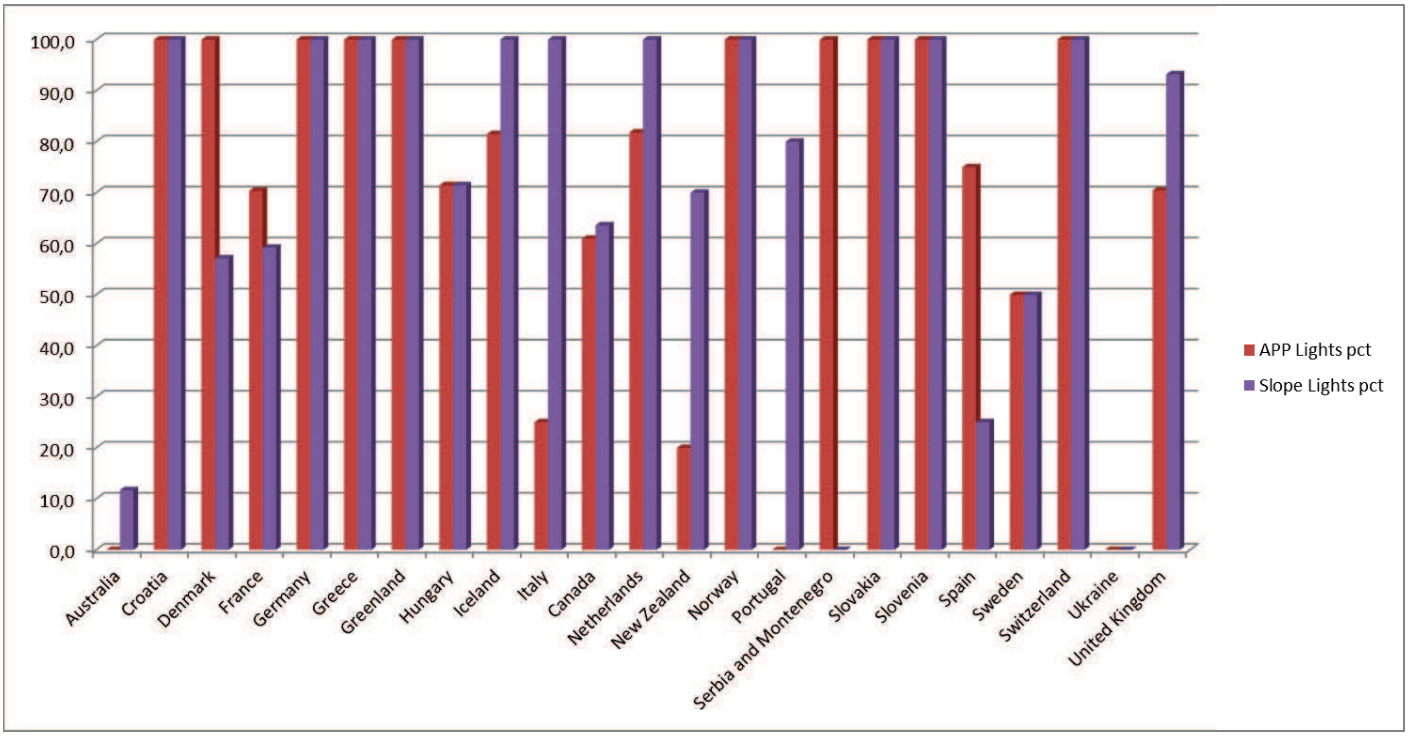

Figure 2. Percentage of approach lighting system and approach slope/path lighting system on the runways of analysed aerodromes by states

In some European countries it is possible to observe a deviation from the standard European view on the legislation. These states are:

- Ukraine - due to military origin of the aerodromes
- Greenland and Norway - large states similar to Canada
- United Kingdom – very good working CAA, which uses the safety studies for the introduction of changes, the reluctance to let Europe dictate the rules

By focusing on Figure 2, it is possible to reveal that although some of the "European" states deviate from the given strict rules, in the case of runway lighting equipment could not compete with Canada (60% runways has slope and approach lights), New Zealand (70% runways has slope lights, 20% runways has approach lights), and Australia (11% runways has slope lights). Alternatively, the possibility to include warning in the AIP, that there is railway across the runway and if the train is coming, red lights are flashing and you cannot therefore use the entire length of the runway, is absolutely unthinkable in Europe.

And exactly the case of the railway crossing the runway is clear case of immature safety culture in Europe, where it is not enough to announce a situation and inform users. In Europe, no CAA will be cleared of responsibility of possible collision between plane and train. But doing it this way may work in New Zealand.

IV. Conclusion

The analysis of aerodromes shows that the safety culture must be in states dependent on small aviation at a very high level, and that safety culture of Europe is at a very low level. This would confirm the possible deviations from the standard state, which is observed in the national runway equipment.

Increasing of safety culture is very long process and in the near future will not be seen its improvement, as representatives of various organizations in the Czech aviation always say in unofficial statements: "Regulation is one thing, but you know what reality is." Or that "pilots follow the rules when they are in the mood." Until there will be this comments, the safety will be in a negative perception and safety culture will be bad, which also means no exceptions and tough regulations. Change is, however, on airspace users.

V. Acknowledgements

This paper was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS14/212/OHK2/3T/16.

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Fuel throughput and implementation of hydrant refueling

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***Abstract* — The paper deals with airports' hydrant systems and their implementation at airports where the fuel is delivered by fuel trucks only. First off, term airport size is defined with respect to aircraft refueling problem. Necessary data collection was carried out. Based on collected dataset, model of hydrant system was created. Hence, the model was applied on four airport which differs in size. Based on the research result, recommendation from which airport size it may be efficient to implement hydrant fueling is drown.**

Keywords – airports; refuelling; hydrant system; fuel throughput

I. INTRODUCTION

Airport engineering covers wide range of systems as the airport environment provides the platform for a variety of interdisciplinary processes. One of them is aircraft refueling. It is one of the most complex processes of airports' everyday operations. Smaller airports use fuel trucks meanwhile medium-sized and big airports operate dedicated underground fuel hydrant system. Even though there are various studies covering the problem of hydrant systems, nowhere it is said from what airport size it is convenient to build the hydrant system. Especially at airports with density of operation around ten million passengers per annum, it is sometimes difficult to decide between fuel trucks and hydrant system.

II. THEORETHICAL BACKGROUND

As it was already said, there are basically two ways how to refuel aircraft at airports with significant portion of regular international traffic. First option is usage of fuel trucks which transfer fuel from their own tank into the aircraft which is connected with the fuel truck by the hose. The other option is utilization of dedicated underground piping system which delivers fuel from fuel storage (so called fuel farm) directly to the aircraft. Special vehicle called dispenser is used to connect aircraft tank inlets with underground piping system. One hose connects dispenser and aircraft tanks, the second connects dispenser with hydrant valve. This valve is buried in the apron pavement in special fiberglass pit. Scheme of airport hydrant system is shown at Figure 1. BAFS means Building of Aboveground Fuel Storage, ESD stands for Emergency Shut Down.

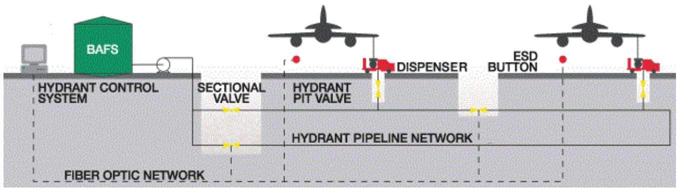

Figure 1. Airport hydrant system scheme

Main pipeline creates closed loop around terminal (or apron). This ensures circulation of the fuel within the system. Moreover, there are many lateral connections linking the main pipeline with hydrant pits. Pit scheme is shown on Figure 2.

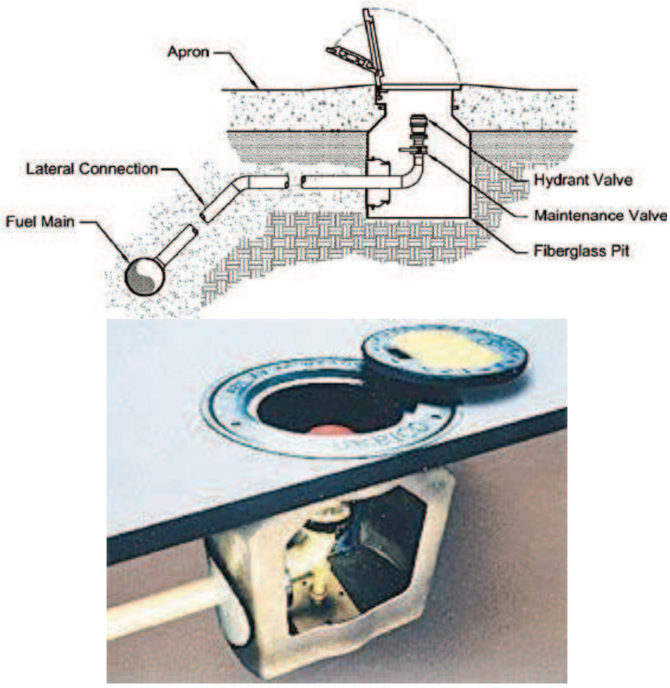

Figure 2. Hydrant pit [6] [1]

Hydrant systems are considered as an optimal fuelling method since they provide environmentally friendly, fast and reliable refueling method with overall positive impact on safety and efficiency of everyday airport operations [5].

III. Airport Size Definition

First of all, it is necessary to define the term *airport size* which is to be used within this paper from now on. Traditional figures for assessing the airport size are number of passengers handled and number of aircraft movements per year. The former is the most common variable to describe size of any airport with regular traffic however it has no direct relation to extent of fuelling operations at particular airport. On the other hand, the latter is focusing on density of operations at an airport so it is much more viable variable in terms of aircraft refueling problem. More movements means more fuelling operations and vice versa.

The term *airport size* often evokes the physical size of airport site. This has a little to do with fuelling operation even if distance between apron and fuel farms (or fuel truck filling station) has direct impact on operational costs of fuelling system (especially fuel trucks) and safety on airport service roads since traffic increases with the increase in distance between apron and fuel truck filling station. Another variable related to physical airport size is number of aircraft stands. It is generally believed the more stands, the bigger the airport is. This may be true but on the other hand, "smaller" airport can serve more flights a day and handle more passenger than its "bigger" competitor. Moreover, both stands number and station-apron distance directly influences hydrant system investment cost. This cost topic will be covered in one of the next sections.

On contrary, average aircraft size, its fuel consumption and flight structure (meaning average route distance) can have direct impact on the extent of fuelling operation. The bigger the aircraft is, the more fuel it needs. The higher the consumption is, the more fuel is needed. The longer the route distance is, the more fuel must be filled into the aircraft before take-off. However, these three variables has one common denominator which is the fuel throughput at an airport. This value covers average aircraft size, its average consumption and average route distance so it is the most comprehensive variable to describe airport size in terms of fuelling operations along with number of aircraft movements.

As for the relevant sources, [8] recommends that the type of system (hydrant or fuel trucks) used should be determined in relation to the expected rate of aircraft movements at the airport. According to [2], it depends on the amount of fuel that gets picked up at a particular airport. It is not so much the number of gates but rather the destination of the flights.

Discussion with experts within the course of this research confirmed the fact that most important value in terms of decision whether or not to implement hydrant refueling system (HRS) is fuel throughput (or fuel uplift) per year. Thus, referring to airport size from now on is related to volume of fuel uplifted at particular airport per year unless stated otherwise.

IV. Current Status and Initial Research

After defining the airport size, the next step is to examine what the current status is. That means to find out which airports (in terms of their size) uses hydrant systems.

A. *Fuel Uplift*

Thus, initial data collection took place since annual fuel throughput is not a figure which airports reports or has to report e.g. to international organizations, in their annual reports etc. Airports were addressed with short questionnaire in order to provide fuel throughput figures. Results can be found in Table I.

TABLE I. Fuel Uplift in Relation to the Hydrant System at Selected Airport

Airport	Fuel Uplift (mil. l)	Aircraft Movements	Fuel per Departure (l)	Passengers (mil.)	Hydrant system
San Francisco	**3 289,52**	424 566	15 496	44,48	yes
Miami	**3 123,00**	387 581	16 115	40,50	yes
Munich	**2 433,00**	387 983	12 542	38,36	yes
Delhi	**1 500,00**	280 713	10 687	34,37	yes
Madrid	**1 433,78**	373 185	7 684	45,20	yes
Milan Malpensa	**1 029,00**	174 892	11 767	18,54	yes
Oslo	**540,00**	239 357	4 512	22,96	yes
Geneva	**443,52**	192 944	4 597	13,90	yes
Athens	**425,00**	153 295	5 545	12,94	yes
Cape Town	**420,00**	91 486	9 182	8,51	yes
Hamburg	**340,00**	152 890	4 448	13,70	no
Prague	**330,00**	131 564	5 017	10,81	no
Bucharest	**259,24**	98 592	5 259	7,10	no
Stuttgart	**256,00**	131 524	3 893	9,72	no
Larnaka	**230,07**	50 329	9 143	5,17	yes
Porto	**189,00**	59 215	6 384	6,00	yes
Budapest	**179,00**	83 830	4 271	8,52	no
Charleroi	**157,34**	82 322	3 823	6,52	no
Fuerteventura	**144,68**	37 772	7 660	4,40	yes
Göteborg	**133,00**	63 253	4 205	5,00	no
Sofia	**99,00**	43 862	4 514	3,47	no
London City	**76,00**	68 000	2 235	3,39	no
Malmö	**50,19**	28 464	3 527	2,10	no
Gdansk	**42,00**	34 360	2 445	2,91	no

Table shows airports aligned as per fuel uplift. Traditional metrics as aircraft movements and passengers handled are included as well. Data are from 2012 except Munich, Budapest, Goteborg and London City which provided data from 2013. Variable *Fuel per Departure* is fuel uplift divided by half of aircraft movements (movements are sum of both take-offs and landings, but take-offs are refueled only). This value takes into account aircraft size, its consumption and route distance of flights operated from airport. The higher this value is, the longer the refueling takes.

Current status shows that hydrant systems exists at all selected airports with fuel throughput higher than 420 mil. l. On contrary, below 144 mil. l no airport has built hydrant system. In between those values, three of nine airports from selected statistical set uses hydrant system.

B. *Minimum Required Flow*

Crucial elements in airport hydrant system design are industry standards and technology requirements. As for the former, standardized diameters of pipeline are used in the engineering industry. This ranges from 6 to 24 inches [1]. As for the latter, the system should be designed to provide extended periods of fuel flow in the 1.8 m/s range in order to provide a sweeping or cleansing action within the piping system. Otherwise, at lower velocities, condensate water may collect in the piping and promote microbial growth [6]. Knowing the minimum pipeline diameter and minimum required flow velocity, minimum annual volume can be calculated using basic laws of fluid dynamics. Volumetric flow rate is defined as:

$$q = S \cdot v$$

where: q ... volumetric flow rate [m^3/s],

S ... surface of pipeline cross-section [m^2],

v ... fuel flow velocity [m/s].

Fuel flow velocity is known; surface of pipeline cross-section is defined as:

$$S = \pi \cdot r^2$$

where: r ... pipeline radius [m].

6 inches is equal to 0.1524 meters so radius is 0.0762 meters. Values are applied into the first equation:

$$q = \pi \cdot 0.0762^2 \cdot 1.8$$

$$q = 0.0328 \quad m^3/s$$

Minimum volumetric flow rate is 32.8 liters per second. Minimum annual volume to be circulated within the hydrant system can be computed from the equation:

$$V = q \cdot t$$

where V ... minimum fuel volume [m^3],

t ... operational period of hydrant system [s].

Operational period is not 24 hours a day since most airports have night curfew of 8 hours:

$$V = 0.0328 \cdot 365 \cdot (24 - 8) \cdot 60 \cdot 60$$

$$V = 689587.2 \quad m^3$$

From technological point of view, minimum volume to be circulated in the pipeline system per year is almost 690 million of liters.

However, based on the survey from previous subsection, hydrant systems can be operated even if this volume is lower than the one calculated above. The fuel can be circulated inside the pipelines also during the period when the system is not used for refueling. This measure ensures cleansing action within the piping system on one hand, but increase the operational costs on the other since pumping system must be in operation during periods when HRS is not making revenues. The dependence between annual fuel throughput and operational cost will be discussed in the next section.

It may be concluded that minimum technology volume is not a break-even point from which this system could be efficient to build.

V. DATA COLLECTION AND MODEL OF HYDRANT SYSTEM

With respect to the previous conclusion, it is necessary to research further in order to find a volume from which it may be efficient to build up hydrant system. Further research requires collection of data associated with hydrant systems already operated at airports. Since these data are sensitive, not many airports are willing to provide datasets for research purposes. Many airports were addressed with data collection form, but only five returned complete dataset. The paper refers to these five airports as Airport A, Airport B, Airport C, Airport D and Airport E due to data sensitivity. Moreover, airports provided data in different currencies so it was necessary to convert them into one common currency. Euro was chosen and average conversion rate for year of 2013 was used.

The model is called *technical and economical hydrant system model* as the inputs are technical data while outputs have economic nature. These outputs will be used for cost-benefit analysis of selected airports which differs in size.

A. Investment Costs

Results of data collection are show in Table II. Beside data from Airports A to E, Table 2 includes data available from the internet sources.

TABLE II. HYDRANT SYSTEM INVESTMENT COSTS AT SELECTED AIRPORTS

Airport	Aircraft Movements	Passengers (mil.)	Fuel Uplift (mil. l)	Fuel per Departure (l)	Investment Costs (mil. EUR)
Seattle	317 186	34,8	-	-	**24,849**
LaGuardia	371 565	26,7	-	-	**22,590**
Airport E	230 558	27,2			**15,000**
Airport C	174 892	18,5	1 029,0	11 767,3	**12,000**
Airport D	280 713	34,4	1 500,0	10 687,1	**11,295**
Tribhuvan	91 884	3,4	91,25	1 986,2	**6,416**
Airport B	192 944	13,9	443,5	4 597,4	**5,199**
Airport A	50 329	5,2	230,1	9 142,6	**5,000**
Vancouver	296 394	17,6			**4,895**
Winnipeg	137 974	3,4	-	-	**3,765**

No statistical method can be used to typify these type of costs. Hydrant system consists basically of three components; (1) pipelines, (2) hydrant pits and (3) pumping and control system. The costs of the first two components can be standardized and depend on either total length of pipelines *m* or number of pits *k*. Standardized prices are 370 EUR per meter of pipeline and 4344 EUR per one hydrant pit (SDRCAA, 2006). On the other hand, performance of pumping system and complexity of control system is directly proportional to size and robustness of particular hydrant system. To compare costs for pipelines and hydrant pits C_{mk} and total investment costs C_I, see Table III.

TABLE III. HYDRANT SYSTEM INVESTMENT COSTS CALCULATIONS

Airport	m [m]	m.370 [EUR]	k	k.4344 [EUR]	C_{mk} [mil. EUR]	C_I [mil. EUR]	C_{mk}/C_I
Airport E	25 000	9 250 000	340	1 476 960	10,727	15,000	0,715
Airport A	7 000	2 590 000	63	273 672	2,864	5,000	0,573
Airport B	8 000	2 960 000	98	425 712	3,386	5,199	0,651
Airport C	19 300	7 141 000	330	1 433 520	8,575	12,000	0,715
Airport D	18 000	6 660 000	221	960 024	7,620	11,295	0,675
Average							**0,666**

From the table above it can be concluded that costs of pipelines and hydrant pits represent two thirds of total costs in average, i.e. they must be raised by 50% to reach the level of total investment costs. The formula for investment costs is as follows:

$$C_I = (m \cdot 370 + k \cdot 4344) \cdot 1{,}5$$

where C_I … total investment costs [EUR],

m ... total length of pipeline [m],

k … number of hydrant pits.

B. Operational Costs

Results of data collection are shown in Table IV. These costs includes also maintenance costs.

TABLE IV. HYDRANT SYSTEM OPERATIONAL COSTS AT SELECTED AIRPORTS

Airport	Aircraft Movements	Passengers (mil.)	Fuel Uplift (mil. l)	Fuel per Departure (l)	Operational Costs (mil. EUR)
Airport A	50 329	5,2	230,1	9 142,6	**3,417**
Airport B	192 944	13,9	443,5	4 597,4	**2,518**
Airport C	174 892	18,5	1 029,0	11 767,3	**1,200**
Miami	387 581	40,5	3 123,0	16 115,3	**0,776**
Airport D	280 713	34,4	1 500,0	10 687,1	**0,464**

Costs differs in relation to the airport size but none of variables (aircraft movements, passengers handled, fuel uplift, fuel per departure) shows functional dependency on operational costs. Thus, it is necessary to create new variable. This variable is unit operational costs and is described as follows:

$$C_u = \frac{C_O}{V}$$

where C_u ... unit operational costs [EUR/mil. l],

C_O ... operational costs [EUR],

V … fuel uplift (volume) [mil. l].

Values of C_u are shown in Table V.

TABLE V. HYDRANT SYSTEM UNIT OPERATIONAL COSTS AT SELECTED AIRPORTS

Airport	Operational Costs [mil. EUR]	Fuel Uplift [mil. l]	Unit Operational Costs [EUR/mil. l]
Airport A	3,417	230,068	**14 853,01**
Airport B	2,518	443,521	**5 677,92**
Airport C	1,200	1 029,000	**1 166,18**
Airport D	0,464	1 500,000	**309,04**
Miami	0,776	3 123,000	**248,50**

Unit operational costs have functional dependency on fuel uplift at particular airport. This dependency is shown at Figure 3.

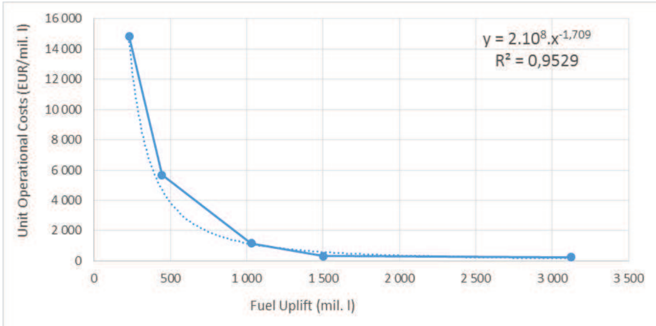

Figure 3. Unit operational costs as a function of fuel uplift

MS Excel is able to provide us with equation of trend line and its R^2 value which is 0.9529. That means the trend line copy the input values with accuracy of 95.29%. Knowing the value of annual fuel uplift, unit cost can be calculated:

$$C_u = 2 \cdot 10^8 V^{-1{,}709}$$

From unit costs, operational costs are calculated using following equation:

$$C_O = C_u \cdot V$$

C. Benefits

In the previous subsections, costs model related to hydrant systems was set up. For the cost-benefit analysis, benefits must be modeled as well.

There are various types of benefits related to implementation of hydrant system. First off, the total time of refueling is lower. Next, apron safety increases because of utilization of smaller and lighter dispensers which do not carry any flammable fuel. Also, environmental impacts are lower due to lower emissions. All these benefits are hard to quantify financially. Thus, only benefits associated with switching from fuel trucks to dispensers will be taken into account for the purposes of this hydrant model.

In order to do that, additional data must be collected. Beside airports operating hydrant systems, non-hydrant airports and fuelling companies were addressed with data collection questionnaire as well. Dataset includes characteristics of both fuel trucks and dispensers and provides acquisition cost, operational costs (including maintenance) and lifetime of vehicle. Data was acquired from three non-hydrant airport, four hydrant airports and one big international fuelling company operating more than 1 000 vehicles. Afterwards, mean values of all characteristics were calculated as a weighted average. Results are shown in Table VI, where:

C_A … average acquisition costs,

l … average lifetime of vehicle,

C_A/l … acquisition costs per year,

C_O … vehicle operational costs and

C_y … total vehicle costs per year.

TABLE VI. AVERAGE VEHICLE COSTS

Vehicle	C_A [EUR]	l [years]	C_A/l [EUR]	C_O [mil. EUR]	C_y [mil. EUR]
Fuel Truck (non-hydrant airport)	349 480	15	23 299	23 369	**46 668**
Fuel Truck (hydrant airport)	320 135	20	16 007	6 003	**22 010**
Dispenser	203 833	15	13 589	5 504	**19 093**

What is important to emphasis is the fact that after constructing and implementing hydrant refueling, airport will need less dispensers than fuel truck for the same extent of operation. Unlike fuel trucks, dispensers do not have to ride between truck filling station and the apron. Moreover, dispensers – as a smaller vehicles – can be parked in the vicinity of stands they are serving meanwhile big fuel trucks must be parked in remote areas due to their size. This two factors significantly influence fuel trucks' ridden distances which decreases their usable period of operation. According to discussion with experts, depending on the physical airport size, this can represent half to three quarters of total fuel truck operational period. With respect to that, number of dispensers needed at an airport after implementing the hydrant refueling will be as much as 80% of the total number of fuel trucks operated at an airport before construction of hydrant systems. E.g., if there are ten fuel trucks serving the airport at the moment, eight dispensers will be needed after hydrant system construction. However, implementation of hydrant refueling does not mean that airport can get rid of all fuel trucks. Few of them still must be present if there is a need for aircraft defueling or during the maintenance or failure of part of hydrant system. Thus, two more fuel trucks will be added to sufficient amount of dispensers for the model purposes. At Airport B, Airport C, Airport D and Airport E there are two back-up trucks as well.

As it can be seen from Table VI, fueling vehicles are divided into three categories; (1) fuel trucks serving non-hydrant airports, (2) back-up fuel trucks serving hydrant airport and (3) dispensers. Back-up fuel trucks have longer lifetime and lower operational costs because of their lower utilization.

Benefits are calculated as follows:

$$B = n \cdot 44668 - 0{,}8n \cdot 19093 - 2 \cdot 22010$$
$$B = n \cdot 44668 - 0{,}8n \cdot 19093 - 44020$$

where B …annual benefits of hydrant system implementation [EUR],

n … number of fuel trucks before system implementation,

$0{,}8n$ … number of dispensers after system implementation (round number).

Another benefits from hydrant system operation which can be expressed financially are revenues from fee for access to fuelling infrastructure. This fee may not be collected directly by an airport operator; airlines (final customers) usually pay to fuelling company (system users) which pay to hydrant operator (airport operator or dedicated company either dependent or independent on airport operator). Business relations can be even more complicated. Fee level for both trucks and hydrant fueling (1 cent = 0.01 EUR), fuel throughput and particular revenues at selected airports are shown in Table VII. Fee ranges from 0.31 to 1.81 cents per liter of aviation fuel.

TABLE VII. FEE FOR ACCESS TO THE FUELING INFRASTRUCTURE AT SELECTED AIRPORTS

Airport	Fuel Uplift [mil. l]	Fee (hydrant) [cents]	Fee (fuel trucks) [cents]	Revenues [mil. EUR]	Investment costs [mil. EUR]	Operational costs [mil. EUR]
Airport D	1 500	1,81	-	27,153	0,464	11,295
Airport A	230	1,04	-	2,393	3,417	5,000
Airport B	444	0,94	-	4,147	2,518	5,199
Miami	3 123	0,46	0,31	14,336	0,776	-
Orlando	-	0,69	0,50	-	-	-
San Francisco	3 290	0,46	-	15,050	-	-
Cape Town	420	1,06	-	4,436	-	-
Sofia	99	-	1,80	1,782	-	-
Budapest	179	-	0,75	1,335	-	-
Hamburg	340		0,52	1,768		

D. Model Assumption

Every airport is unique so is the design of their hydrant systems. Thus, no model can cover all the operational specifics of all airport. Therefore it is crucial to set few assumption which could generalize complexity of this system.

The first one is as follows. Fee for access to fueling infrastructure covers operational costs only. This is the very basic assumption. Equation is:

$$C_O = f \cdot V$$

where C_O ... annual operational costs [EUR],

f ... fee for access to fuelling infrastructure [EUR/l],

V … annual fuel uplift [l].

From the formula above, fee can be calculated as an operational costs divided by fuel throughput. This is the same as formula for unit operational costs, only difference is in units; fee is expressed in *cents per liter* meanwhile unit costs is in *EUR per mil. l*. E.g. if unit costs are as much as 2 000 EUR/mil. l, the fee must be 2 cents/l to cover the operational costs.

Thus, benefits from switching from fuel trucks to dispensers cover the initial investment costs. Assumption is described by equation:

$$C_I = p \cdot B$$

where C_I ... investment costs [EUR],

p ... payback period [years],

B … benefits [EUR].

Final equation of costs and benefits merges two previous equations and is as follows:

$$C_I + p \cdot C_O = p \cdot B + \sum_{i=1}^{p} f_i \cdot V_i$$

Please note this equation does not take into account time value of the money, i.e. discount rate is as much as 0%. For real investment appraisal, time value of money is always considered. More on this will be discussed in the next section.

Beside two main assumption there are more of them which complete model background. Model considers constructing hydrant system for all the stands except those for general aviation so hydrant operations could be as close as possible to 100% of total fueling operations. Next, business relation between stakeholders taking part on fueling operations are neglected. Finally, model considers such number of dispensers which is equal to 80% of fuel trucks currently operated at an airport plus two back-up fuel trucks.

E. Methodology

Finally, the methodology for assessing if building of hydrant system could be efficient or not is set:

Step	Inputs	Formula	Output
1.	Pipeline length m Number of hydrant pits k	$C_I = (m \cdot 370 + k \cdot 4344) \cdot 1{,}5$	Investment costs C_I
2.	Annual fuel throughput V	$C_u = 2 \cdot 10^8 V^{-1{,}709}$	Unit costs C_u
3.	Unit costs C_u Annual fuel throughput V	$C_O = C_u \cdot V$	Annual operational costs C_O
4.	Number of fuel trucks operated at an airport n	*0.8n*	Number of dispensers *0.8n* (round number)
5.	Number of fuel trucks operated at an airport n Number of dispensers *0.8n*	$B = n \cdot 44668 - 0{,}8n \cdot 19093 - 44020$	Annual benefits B
6.	Annual benefits B Investment costs C_I Discount rate	*Cost-benefit analysis*	Payback period p
7.	Payback period p System lifetime L	$p < L$ $p \geq L$	Build up hydrant system Do not build up hydrant system

VI. Model Application

Based on previously set methodology, any airport can roughly extrapolate its investment and operational costs and payback period for its hydrant system. However, in order to find out where is the line between efficient implementation of hydrant system in general, it is necessary to apply this model on several airports which differs in size. Selection of these airports is done based on data collection results presented in Table I. First airport to be selected is biggest airport without hydrant system within the Table I – Hamburg Airport with annual fuel uplift of 340 mil. l. If possible, other airport should be separated equally among each other. Table 1 enables to choose airports separated by as much as 80 – 81 mil. l of annual fuel throughput. Thus, other airport selected for model application are Bucharest, Budapest and Sofia with 259, 179 and 99 mil. l of fuel throughput respectively. Under 99 mil. l threshold, no airport has hydrant system implemented within the statistical set.

A. Methodology

With respect to model application on selected airports, it is necessary to gather required inputs. Annual fuel throughput is known so number of hydrant pits and pipeline length need to be accomplished. In order to do that, proposal of main pipeline loop must be designed as well as proposal of hydrant pits number for particular stands. List of stands and design of airport site can be found in Aeronautical Information Publication (AIP), Aerodrome Chart and Parking and Docking Chart in particular. Due to requirements for maximum article length, the list of stands with particular number of hydrant pits per each stand and chart of main hydrant pipeline loop tracing are not included.

Pipeline system includes also lateral connections which links the main pipeline with hydrant pit. For this lateral connection, the length of 35 m will be considered for each hydrant pit. It is an average length for the lateral connection based on the average dimensions of aircraft stands which enables hydrant pits to be located at required location within the particular stand so the refueling of all aircraft types using the stand is ensured.

Within the cost benefit analysis (CBA), method of net present value will be used so the next input is discount rate. Selected value of discount rate is 3% according to [3] which recommends this rate for the investments with lifetime above 30 years.

Final input for the model is lifetime of the system which is to be compared with calculated payback period. Data collection revealed that Airport A and Airport D have systems designed to be operated for 30 years, Airport B and Airport C for 50 years and Airport E for 40 years. Thus, mean value is as much as 40 years.

CBA covers all 40 years of investment. During this period, both benefits and operational costs will be subject to change as air transport grows approximately by 5% per year [5]. However, fuel consumption grows slower, from 2000 to 2010 at average rate 1.67% [4]. Thus, according to this rate, the growth of annual fuel uplift will be forecasted at selected airports. With the change in fuel uplift, both unit costs and operational costs will change as well. Also, number of fuelling vehicles must increase with raise in fuel uplift. Two more fuel trucks are considered for each additional 40 mil. l of fuel uplifted [4]. Again, due to length of this paper, this forecast is not included.

B. Hamburg Airport

Fuel farm and fuel trucks filling station is located right next to the main apron. Designed length of main fuel pipeline loop is 3 385 m. Number of hydrant pits is considered to be 97 on 39 stands. Thus, sum of lateral connection is 97 multiplied by 35 m which is equal to 3 395 m. Total pipeline length is 6 780 m. Investment costs are as follows:

$$C_I = (m \cdot 370 + k \cdot 4344) \cdot 1{,}5$$
$$C_I = (6780 \cdot 370 + 97 \cdot 4344) \cdot 1{,}5$$
$$C_I = 4{,}394702 \, mil.EUR$$

Unit costs for the volume of 340 mil. l are 7 050 mil EUR/l which means fee as high as 0.705 cents/l. Current fee at Hamburg airport is 0,52 cents/l so mild increase would be required. Operational costs are 2.396831 mil EUR per year.

As for benefits, there are 15 fuel trucks operated currently at an airport. That means 12 dispensers plus two back-up fuel trucks. Benefits are as follows:

$$B = n \cdot 44668 - 0{,}8n \cdot 19093 - 44020$$
$$B = 15 \cdot 44668 - 12 \cdot 19093 - 44020$$
$$B = 418864 EUR$$

Table VIII shows results of CBA for selected years. Payback is 11.98 years so CBA results are positive. Red numbers in brackets means negative values.

TABLE VIII. CBA OF HYDRANT SYSTEM AT HAMBURG AIRPORT

Benefits	Year 0	Year 1	...	Year 11	Year 12	...	Year 40
Benefits	€ -	€ 418 864	...	€ 470 014	€ 470 014	...	€ 834 193
Access Fee Revenues	€ -	€ 2 366 890	...	€ 2 087 299	€ 2 061 224	...	€ 1 449 651
Total Benefits	*€ -*	*€ 2 785 754*	...	*€ 2 557 313*	*€ 2 531 238*	...	*€ 2 283 844*
			...			...	
Costs	Year 0	Year 1	...	Year 11	Year 12	...	Year 40
Investment Costs	€ 4 394 702	€ -	...	€ -	€ -	...	€ -
Operational Costs	€ -	€ 2 366 890	...	€ 2 087 299	€ 2 061 224	...	€ 1 449 651
Total Costs	*€ 4 394 702*	*€ 2 366 890*	...	*€ 2 087 299*	*€ 2 061 224*	...	*€ 1 449 651*
			...			...	
Net Cash Flow	€ (4 394 702)	€ 418 864	...	€ 470 014	€ 470 014	...	€ 834 193
Cumulative Cash Flow	€ (4 394 702)	€ (3 975 838)	...	€ 468 552	€ 938 566	...	€ 19 740 315
			...			...	
Discount Rate 3%	*1,00000*	*0,97087*	...	*0,72242*	*0,70138*	...	*0,30656*
Net Present Value	€ (4 394 702)	€ 406 664	...	€ 339 548	€ 329 658	...	€ 255 728
Cumulative Net Present Value	**€ (4 394 702)**	**€ (3 988 038)**	**...**	**€ (322 928)**	**€ 6 730**	**...**	**€ 8 538 774**

C. Bucharest Airport

In this case, fuel farm and fuel truck filling station is located in the remote area within the airport. Moreover, main fuel pipeline loop has to reach Apron 1 and then Apron 2. This design gives the length of main loop as much as 5 948 m. 105 hydrant pits are considered at 45 stands which means sum of lateral connections of 3 675 m. Total pipeline length is 9 623 m. Investment costs are:

$$C_I = (m \cdot 370 + k \cdot 4344) \cdot 1{,}5$$
$$C_I = (9623 \cdot 370 + 105 \cdot 4344) \cdot 1{,}5$$
$$C_I = 6{,}024668 \, mil.EUR$$

Table IX shows CBA for selected year, the result is again positive with payback period of 17.48 years.

TABLE IX. CBA OF HYDRANT SYSTEM AT BUCHAREST AIRPORT

Benefits	Year 0	Year 1	...	Year 17	Year 18	...	Year 40
Benefits	€ -	€ 418 864	...	€ 540 257	€ 540 257	...	€ 763 950
Access Fee Revenues	€ -	€ 2 909 887	...	€ 2 379 723	€ 2 349 996	...	€ 1 782 220
Total Benefits	*€ -*	*€ 3 328 751*	...	*€ 2 919 980*	*€ 2 890 253*	...	*€ 2 546 170*
			...			...	
Costs	Year 0	Year 1	...	Year 17	Year 18	...	Year 40
Investment Costs	€ 6 024 668	€ -	...	€ -	€ -	...	€ -
Operational Costs	€ -	€ 2 909 887	...	€ 2 379 723	€ 2 349 996	...	€ 1 782 220
Total Costs	*€ 6 024 668*	*€ 2 909 887*	...	*€ 2 379 723*	*€ 2 349 996*	...	*€ 1 782 220*
			...			...	
Net Cash Flow	€ (6 024 668)	€ 418 864	...	€ 540 257	€ 540 257	...	€ 763 950
Cumulative Cash Flow	€ (6 024 668)	€ (5 605 804)	...	€ 1 626 614	€ 2 166 871	...	€ 16 052 798
			...			...	
Discount Rate 3%	*1,00000*	*0,97087*	...	*0,60502*	*0,58739*	...	*0,30656*
Net Present Value	€ (6 024 668)	€ 406 664	...	€ 326 864	€ 317 344	...	€ 234 194
Cumulative Net Present Value	**€ (6 024 668)**	**€ (5 618 003)**	**...**	**€ (152 967)**	**€ 164 378**	**...**	**€ 5 955 997**

As it can be seen from Table IX, operational costs are 2.946697. There are 15 truck at an airport so annual benefits in the first year will be the same as in the previous case (418 864 mil. EUR). Unit costs are 11 400 EUR/mil. l which means fee of 1.14 cents/l. Current value of the fee is not known.

D. **Budapest Airport**

Fuel farm and fuel trucks filling point are located further away from apron, in the vicinity of airport perimeter. There are two separated main loops, one connecting the fuel farms with Apron 1, the other with Apron 2, their combined length is 12 292 m. 130 hydrant pits are considered on 54 stands. Sum of lateral connections is 4 550 m which means total length of 16 842. Investment costs are equal:

$$C_I = (m \cdot 370 + k \cdot 4344) \cdot 1{,}5$$
$$C_I = (16842 \cdot 370 + 130 \cdot 4344) \cdot 1{,}5$$
$$C_I = 10{,}194113 \, mil.EUR$$

Operational costs are 3.9 mil. EUR per year in Year 1. Current fee is 0.75 while necessary level of fee is 2.18 cents/l which is three times higher. There are 11 fuel trucks which is equal to annual benefits:

$$B = n \cdot 44668 - 0{,}8n \cdot 19093 - 44020$$
$$B = 11 \cdot 44668 - 9 \cdot 19093 - 44020$$
$$B = 297471 EUR$$

CBA result are negative. Results can be found in Table X. Last column shows the year when the cumulative net present value is finally positive, this column is not part of CBA as its period is from Year 0 to Year 40. Payback would be eventually 52.54 years.

TABLE X. CBA OF HYDRANT SYSTEM AT BUDAPEST AIRPORT

Benefits	Year 0	Year 1	...	Year 40	...	Year 53
Benefits	€ -	€ 297 471	...	€540 257	...	€ 661 650
Access Fee Revenues	€ -	€ 3 851 724	...	€2 359 068	...	€ 2 003 405
Total Benefits	*€ -*	*€ 4 149 195*	...	*€2 899 325*	...	*€ 2 665 055*
			...		...	
Costs	**Year 0**	**Year 1**	...	**Year 40**	...	**Year 53**
Investment Costs	€ 10 194 113	€ -	...	€ -	...	€ -
Operational Costs	€ -	€ 3 851 724	...	€ 2 359 068	...	€ 2 001 449
Total Costs	*€ 10 194 113*	*€ 3 851 724*	...	*€ 2 359 068*	...	*€ 2 001 449*
			...		...	
Net Cash Flow	€ (10 194 113)	€ 297 471	...	€ 540 257	...	€ 663 606
Cumulative Cash Flow	€ (10 194 113)	€ (9 896 642)	...	€ 5 193 068	...	€ 12 769 362
			...		...	
Discount Rate 3%	*1,00000*	*0,97087*	...	*0,30656*	...	*0,20875*
Net Present Value	€ (10 194 113)	€ 288 807	...	€ 165 619	...	€ 138 528
Cumulative Net Present Value	**€ (10 194 113)**	**€ (9 905 306)**	...	**€ (1 823 527)**	...	**€ 63 236**

E. Sofia Airport

This airport has fuel farms and trucks filling point located close to one of the aprons. 93 pits are considered at 41 stands, the length of main loop is 5 084 m, length of lateral connections is 3 255 m, total length is 8 339 m so investment costs are equal:

$$C_I = (m \cdot 370 + k \cdot 4344) \cdot 1{,}5$$
$$C_I = (8339 \cdot 370 + 93 \cdot 4344) \cdot 1{,}5$$
$$C_I = 5{,}234133 mil.EUR$$

Operational costs are 6.114246 mil. EUR according to this model. Required fee would be 6.18 cents/l while its present value is 1.8 cents/l. Again, the fee would have to be increased eventually by more than three times. Seven trucks means benefits of:

$$B = n \cdot 44668 - 0{,}8n \cdot 19093 - 44020$$
$$B = 7 \cdot 44668 - 6 \cdot 19093 - 44020$$
$$B = 176078 EUR$$

Table XI shows negative results of CBA. Payback is 46.35 years. Last column is only illustrative and it is not part of CBA.

TABLE XI. CBA OF HYDRANT SYSTEM AT SOFIA AIRPORT

Benefits	Year 0	Year 1	...	Year 40	...	Year 47
Benefits	€ -	€ 176 078	...	€ 297 471	...	€ 297 471
Access Fee Revenues	€ -	€ 6 037 867	...	€ 3 698 016	...	€ 3 386 517
Total Benefits	*€ -*	*€ 6 213 945*	...	*€ 3 995 487*	...	€ 3 683 988
			...		...	
Costs	**Year 0**	**Year 1**	...	**Year 40**	...	**Year 47**
Investment Costs	€ 5 234 133	€ -	...	€ -	...	€ -
Operational Costs	€ -	€ 6 037 867	...	€ 3 698 016	...	€ 3 386 517
Total Costs	*€ 5 234 133*	*€ 6 037 867*	...	*€ 3 698 016*	...	€ 3 386 517
			...		...	
Net Cash Flow	€ (5 234 133)	€ 176 078	...	€ 297 471	...	€ 297 471
Cumulative Cash Flow	€ (5 234 133)	€ (5 058 055)	...	€ 3 418 447	...	€ 5 500 744
			...		...	
Discount Rate 3%	*1,00000*	*0,97087*	...	*0,30656*	...	*0,24926*
Net Present Value	€ (5 234 133)	€ 170 950	...	€ 91 192	...	€ 74 147
Cumulative Net Present Value	**€ (5 234 133)**	**€ (5 063 183)**	...	**€ (519 917)**	...	**€ 48 234**

VII. CONCLUSION

As for the results of CBAs in previous section, it can be concluded that volume from which it could be efficient to implement hydrant refueling is between 179 and 259 mil. l. However, another factor that must be taken into account is the level of access fee. Its present level is up to 1.81 cents/l which is able to cover operational costs for the fuel uplift of approximately 200 mil. l per year. With decrease in fuel uplift, the fee would raise exponentially, e.g. for uplift of 100 mil. l the required fee level is as much as 6.1 cents/l. High levels of fee may not be acceptable for final customers – airlines.

Based on results of this research, construction of hydrant system may be efficient with annual fuel throughput of 200 mil. l and more.

However, implementation of hydrant fueling is not always about economic benefits. There are many airports which operate hydrant systems even below 200 mil. l threshold. Usually, this system is implemented when the new terminal is build or under reconstruction or when the apron pavement is refurbished. Moreover, many airports are implementing this system even if the CBA is negative, the main reasons are environmental constrains, safety improvements or requirement on aircraft turnaround time. Thus, decision must be made with respect to local conditions as every airport is unique entity.

Acknowledgements: This paper is published as one of the scientific outputs of the project co-financed by EU*: IMPLEMENTATION OF SCIENCE-RESEARCH KNOWLEDGES TO THE AIR TRANSPORT* -ITMS 26220220010 and as a part of research project VEGA 1/0838/13- *THE BASIC RESEARCH OF CHARGES POLICY AT THE SPECIFIC MARKET OF AIRPORT SERVICES.*

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Fleet Assignment

Aircraft Cost Index

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Abstract — **This article is focused on the part of airline planning process – fleet assignment and explains the cost index. Fleet assignment problem is solved by graphical and mathematical method, considering various constraints. Cost index follows as the next step of flight optimization process and is used as the input to the flight manager computer.**

Keywords-airline; fleet; asignment; planning; cost index

I. INTRODUCTION

Airlines pay attention to their choice of aircraft. Aircraft should correspond with expected types of operations. Main parameters include seat-capacity and flight range. Then there are a number of other instances - for example regional operations may not have need for IRF aircraft equipment. For low cost airlines is typical to acquire one kind of aircraft. One kind of aircraft saves cost significantly: operational costs, easier crew training, variability of crew switching and unified aircraft maintenance. Maintenance crew needs to have license for one type of aircraft only. Conventional airlines usually operate more kinds of aircraft, sometimes even made by various manufacturers. At the end of 2013 fleet of Air France Group with its subsidiary company KLM Group contained 552 aircraft (See table 1). Aircraft manufacturers incorporated options to simplify crew training. For example pilots of Airbus A32X* can after shortened training switch to similar cockpit of A330. Cockpits B757 and B767 also fulfil requirements for shortened training. Implementation of such options by manufacturers allowed crew training costs cutting also for conventional airlines.

TABLE I. AIR FRANCE KLM FLEET OPERATED [1]

Fleet	*AIR FRANCE Group**	*KLM Group**	*TOTAL*
Long-haul	106	65	171
Medium-haul	139	77	216
Regional	101	50	151
Cargo	4	10	14
TOTAL	350	202	552
*Incl. Transavia and Martinair, excl. CityJet and VLM			

II. WHAT IS FLEET ASIGNMENT

Fleet assignment is essential part of Airline Planning Process as shown on Figure 1. First step is Fleet Planning, which have to be done at airline start-up point, in strategy changes periods or before old fleet disposal. Secondary decisions are highly dependent on first decision. When airline decides to purchase the aircraft, type (or types), amount, equipment and way of financing must be considered. In case when airline is not able to purchase aircraft with its own finances, operational and financial leasing or collateral loan can be used. Next step is Schedule Planning which contains Schedule Design and Fleet Assignment. Schedule Design includes Frequency Planning (determination of connection frequency) and Timetable Development. Frequency determination mostly complies with market where airline will be operating. Business travelers are more sensitive to time then price, thus in place where such travelers are in majority, there will be better to offer them more connections. Prevalent tourist passengers are more time flexible and less sensitive to connection frequency. This strategy can be used mostly on short-haul flights, because long-haul flights are limited with long distance - with time in the air. Decisions are also made based on flights frequency and time differences during days, weeks and months of the year. Main factor in decision making is market where flight is operated and time attractiveness to its passengers. Also airport's limitations must be considered. Airport assigns slots depending on actual capacities which constrain carrier's maximum aircraft at given time (typically in 1 hour) which can be used. Other constraints may be related to night traffic which is obliged to loudness. Other airport restrictions may include runway weight limitation or aircraft maintenance unavailability.

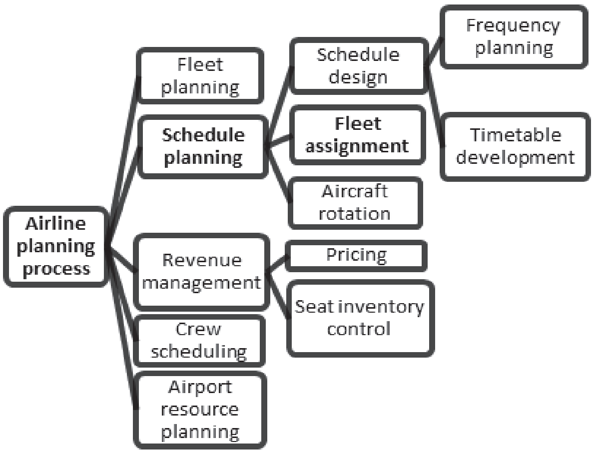

Figure 1. Airline Planning Process [2]

Fleet Assignment is aircraft allocation to each flight. Carrier fleet assigned to specific flight represents one kind of aircraft and similar types of aircraft with homologous operational and economical characteristics, which includes seat-capacity, flight range and loudness or navigation equipment. Other characteristics include passengers load factor (LF) and cargo LF, maintenance costs, fuel consumption, etc. Fleet assignment is used for operations optimization and together with others airline planning tools helps to reduce costs and maximize revenues on each flight. In order to resolve fleet assignment problem we need to have properly and correctly defined inputs:

- Flight plans
- Aircraft types
- Quantity of each aircraft type
- Nods - airports
- Quantity of stops in each nod within 24 hours
- Costs and potential revenues

III. Fleet Assignment Models

A. *Example of Graphical Representations*

Main inputs to problem resolution are airline flight plans. Each flight is determined by departure airport, arrival location and scheduled departure time. Prerequisite of graphical solution is knowledge of demand and each aircraft characteristics. Principal of graphical representation is aircraft assignment to each flight in flight schedule - Time-staged Flight Network [3]. Each flight is represented by diagonal line between two airports. Beginning of diagonal line represents departure time and end of line represents arrival time of given flight. Vertical lines belongs to airports and shows the time flow (from up to down). Figure 2 shows flights, aircraft ground handling and overnight stay at the airport.

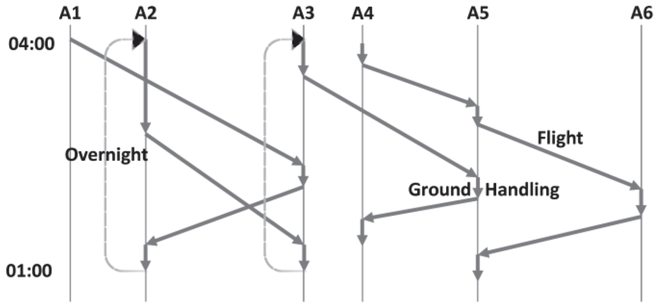

Figure 2. Time-staged Flight Network (A – Airport)

B. *Example of Mathematical Formulation*

For each flight *f* is possible to assign aircraft type *e.*

$$x_{fe} = \begin{cases} 1 \\ 0 \end{cases} \quad (1)$$

$$C = Minimize \sum_{f \in F_e \in E(f)} \quad \sum \quad c_{fe} x_{fe} \quad (2)$$

Where
$f \in F$ flight belonged to set of flights F
$e \in E(f)$ aircraft e from fleet E (f), which flight can be operated with
c_{fe} costs, which arise from occupation of flight f by aircraft e
x_{fe} coverage constraints

Constraints may include:

- Coverage constraints – to each type of flight one type of aircraft must be assigned
- Size constraints – maximum amount of used aircraft of any type can not overpass maximum available aircrafts of this type
- Trough-flight constraints – requirement of trought-flights in the schedule must be considered
- Maintanace constraints – place and time of maintanance
- Crew constraints – home base of crew is typically selfsame as hub, types of qualifications for specific types of planes, minimum number of flying hours (specified in crew contract)
- Continuity constraints – inbound flights into node should be equal to the total number of aircraft out from the node

IV. Cost Index

Cost Indexing is the practice of evaluating the effect of one cost factor in order to minimize the sum of those factors. Many jet aircraft are equipped with various performance computers for the purpose of determining the best speed at which to travel (i.e. the economy speed) in order to minimize the total operating cost of the flight. To do this the FMC (Flight Management Computer) needs information about time-related costs and fuel cost. Fuel costs are based on the price and amount of fuel needed to complete the flight (legally, with reserves etc.). Rather than enter all of these individual factors into the onboard FMC, most airlines use a ratio of the two costs to determine the economy speed for a given flight on a given day. This ratio is called the Cost Index and it determines the economy speed for a flight by minimizing the total cost of operation.

$$CI = \frac{\text{Cost of Time}}{\text{Cost of Fuel}} \quad (3)$$

Cost Index (CI) is the relationship or ratio between time and the cost of fuel. It is based on a balance. At a higher Mach number, the fuel cost will be greater, but it will be balanced out by the fact that the time factor is lower, and vice-versa. Flight Management Systems are able to come up with the Mach number and altitude to balance the time cost with the fuel cost, therefore establishing a CI. Each aircraft type and each airline will have unique values for this index.

Time related costs (TRC) are basically the costs you can save by saving one hour of flight time. When determining the type related costs for a trip, you must take into account every cost you pay by time. Such costs are leasing, maintenance, engines, auxiliary power units and all other items you replace by the hours. Also some companies pay their crew by the hour, or provide a bonus by the hours. If this is the case, those expenses should be included in the CI. The leasing of the airplane can be paid by the actual flight time or by fixed period of years. In first case leasing is directly included in TRC, in second case more complex calculation based on lease period is required to determine how it affects the TRC during the lease period. When the lease is paid, this cost can be removed from the formula. The hourly price of leasing can be determined by dividing the lease price by the flown hours. Maintenance price is the price paid for every scheduled maintenance of the aircraft and its items. This price can be easily evaluated as most maintenance is hourly scheduled. When there are cycle based maintenance it doesn‘t add value to the TRC as it doesn't change with changing the flight time between two cycles.

Fuel costs are the prices of fuel which aircraft consumes by the hour during flight. It looks straight forward but in fact these costs are subject for complex calculation. The varying fuel price, fuel tankering and fuel hedging can make a lot of difference when calculating the fuel costs.

Airplane lease 10 000 000 € planned to be paid in 10 000 hours equals 1000 €/h

Calculated maintenance 50€/h

Resource limited items (such as engines APU etc.) = 100 €/h

TRC= 1150 €/h

Average consumption = 1000 kg/h

Fuel price 1 € per 1 kg

Fuel Cost Per Hour = 1000 €

This means that if you can save one hour by flying faster and burning 1000 kg more you will save 150 €

The number of the cost index varies with each manufacturer and a way to determine it is provided in the manuals. Once calculated it can be inserted into the FMC and the computer will do the complex calculation and give you the optimum speeds and performance in order to get most of the airplane resources. CI changes all the time and modifications should be made with each change in costs.

V. Conclusions

Important part of airline planning is fleet assignment, which is allocation of each type of aircraft to each flight. In this process it is necessary to consider various factors, which includes inputs and several constrains. Because nowadays flying efficiently is very important, part of the article describes cost index. CI is significant ratio of direct operation costs for each flight. It can provide cost reduction by flying mode optimization. Based on CI value flight management computer generates optimal flying parameters – takeoff speed, speed of flight and landing speed.

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Integrated Management System in civil aviation

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Abstract—**Almost in every organization we can meet with department of quality management, environmental or safety. Each department has an important and irreplaceable function within the organization. They use same or similar inputs in their work process, but output is different product. In view of the fact that the perfect cooperation of these departments requires high level of communication, paper work and other related tasks, the managers are beginning to look for new more effective model of organization structure. Solution could be model called Integrated Management System - IMS.***)*

Keywords - Quality, enviromental, safety, Deming cycle, integrated management system, ISO 9000, ISO 14001, OHSAS 18000.

I. Introduction

Although it may seem that the quality and quality management are new disciplines in management system, the truth is that the first mentions of ways how to improve processes goes back to the Roman times. For significant progress could be considered creation of the Deming cycle (also called PDCA circle) - Figure 1. Another milestone in the field of quality management was the year 1968, when NATO adopted AQAP (Allied Quality Assurance Procedures) and especially year 1987, when ISO 9000:1987, ISO 9001:1987, ISO 9002:1987 (now invalid standard) and ISO 9003:1987 were issued. In these documents were set out standards for individual industry (automobile industry, food industry, etc.).

In contrast to the Quality management, Environmental management system is a relatively young discipline. The starter of awareness of this sector were environmental events and disasters especially: 1952 - smog in London, 1960 - mercury poisoning in Japan, 1976 - poisoning by dioxin in Seveso (Italy), 1984 - dioxin poisoning in Bhopal (India) and also the year 1986 and radioactivity disaster in Chernobyl (Ukraine). The result of increasing pressure by community to companies was in year 1991 the birth of Business Charter for Sustainable Development. Within this charter the largest polluters were committed to do ecologic steps, unfortunately due to the lack of appropriate processes they did not know how to do it. In 1993, the European Union issued EMAS (Eco-Management and Audit Scheme), but due to status of "voluntary" EMAS did not cause major changes (improvement brought EMAS II in 2001 and EMAS III in 2009). Finally in 1996 was issued standard ISO 14001:1997, which gives organizations the tools to improve their ecological situation.

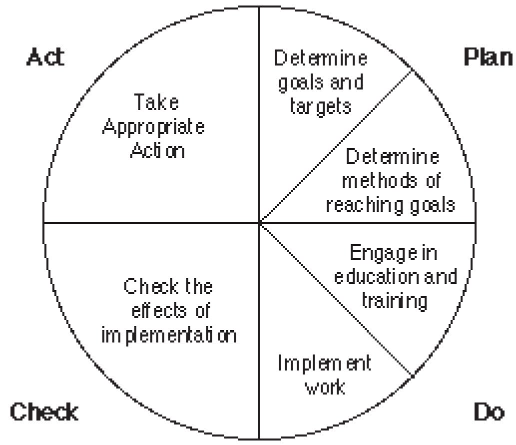

Figure 1 - Deming Cycle

Health and safety at work is the youngest discipline. And in contrast to quality management and environmental management system it is not yet issued like ISO standard. At present, the British Standard BS OHSAS 18001 is used. First standard was published in 1999.

II. ISO 9000 - Quality management system - QMS

The ISO 9000 family addresses various aspects of quality management and contains some of ISO's best known standards. The standards provide guidance and tools for companies and organizations who want to ensure that their products and services consistently meet customer's requirements, and that quality is consistently improved.

Standards in the ISO 9000 family include:

- ISO 9001:2008 - sets out the requirements of a quality management system
- ISO 9000:2005 - covers the basic concepts and language
- ISO 9004:2009 - focuses on how to make a quality management system more efficient and effective
- ISO 19011:2011 - sets out guidance on internal and external audits of quality management systems.

ISO 9001:2008 sets out the criteria for a quality management system and is the only standard in the family that can be certified to (although this is not a requirement). It can be used by any organization, large or small, regardless of its field of activity. In fact ISO 9001:2008 is implemented by over one million companies and organizations in over 170 countries.

This standard is based on a number of quality management principles including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement. Quality Management Principles. Using ISO 9001:2008 helps ensure that customers get consistent, good quality products and services, which in turn brings many business benefits.

III. ISO 14001:2004 - Enviromental management system - EMS

ISO 14001:2004 specifies requirements for an environmental management system to enable an organization to develop and implement a policy and objectives which take into account legal requirements and other requirements to which the organization subscribes, and information about significant environmental aspects. It applies to those environmental aspects that the organization identifies as those which it can control and those which it can influence. It does not itself state specific environmental performance criteria.

ISO 14001:2004 is applicable to any organization that wishes to establish, implement, maintain and improve an environmental management system, to assure itself of conformity with its stated environmental policy, and to demonstrate conformity with ISO 14001:2004 by

a) making a self-determination and self-declaration, or

b) seeking confirmation of its conformance by parties having an interest in the organization, such as customers, or

c) seeking confirmation of its self-declaration by a party external to the organization, or

d) seeking certification/registration of its environmental management system by an external organization.

All the requirements in ISO 14001:2004 are intended to be incorporated into any environmental management system. The extent of the application will depend on factors such as the environmental policy of the organization, the nature of its activities, products and services and the location where and the conditions in which it functions.

In 2011 was from these standard removed the system energy management, which was issued in a single standard ISO 50001:2012.

IV. OHSAS 18000 - International occupational health and safety assesment series

OHSAS 18000 is an international occupational health and safety management system specification. It comprises two parts, 18001 and 18002 and embraces a number of other publications.

OHSAS 18001 is an Occupation Health and Safety Assessment Series for health and safety management systems. It is intended to help an organizations to control occupational health and safety risks. It was developed in response to widespread demand for a recognized standard against which to be certified and assessed.

The OHSAS specification is applicable to any organization that wishes to:

- Establish an OH&S management system to eliminate or minimize risk to employees and other interested parties who may be exposed to OH&S risks associated with its activities
- Assure itself of its conformance with its stated OH&S policy
- Demonstrate such conformance to others
- Implement, maintain and continually improve an OH&S management system
- Make a self-determination and declaration of conformance with this OHSAS specification.
- Seek certification/registration of its OH&S management system by an external organization

Essentially, OHSAS helps in a variety of respects. it helps: minimize risk to employees/etc; improve an existing OH&S management system; demonstrate diligence; gain assurance; etc. The benefits can be substantial.

V. Integrated management System

Integrating of management system into one sophisticated system is possible only, if we know, how these various systems work and what is the input and the output of their processes. This process is shown in Figure 2. From there, it can be seen that quality management is focused on product effectiveness and the achievement of the final product. Environmental management systems, on the contrary, do not care about the quality of the final product, but is interested in the environmental aspects and impacts caused by the activities in the manufacture of the product. The OHSAS monitors and minimizes hazards and risks that may arise in the workplace.

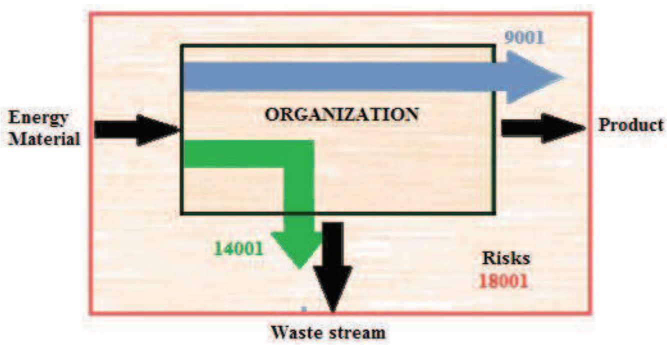

Figure 2 - Integration of QMS-EMS-OHSAS

It is also seen that each management system have different target:

QMS => Customers

EMS => Environment / all of us

OHSAS => Employees

The principle and the basic idea of an integrated management process is thus merging of individual management systems into one unit for the purpose of removing duplicate processes, improving control systems and providing more effective management system. (Figure - 3)

Figure 3 - Basic idea of IMS

VI. Present vs. Future

A. The present and upcoming changes

At present, the quality management can rely on the standard ISO 9001:2008, Environmental management on the standard ISO 14001:2004 and Safety management on the standard OHSAS 18001. Each of these standards has a different structure. In order to implementation of integrated management systems it will first need to change these structures. Therefore, in the near future going to these changes:

- ISO 9001:2008 => ISO 9001:2015
- ISO 14001:2004 => ISO 14001:2015
- OHSAS 18001:2007 => ISO 45001:2016

All new standards for management systems will have a unified framework. Thanks to this, standards will mutually consistent and compliant.

B. A new form of standards and significant differences

As mentioned earlier the most important thing about new standards is that it will have uniform structure that will looks like this:

- Scope
- Normative reference
- Terms and definitions
- Context of organization
- Leadership and People Management
- Planning
- Support
- Operation
- Evaluation of performance
- Improving

Major changes of ISO 9001:2015:

- the introduction of the principle of risk management into the quality management system (missing in the current version)
- Thorough identification of all stakeholders and their contribution to the management of quality control
- requirements for preventative measures will be covered by risk management plans

Major changes of ISO 14001:2015:

- Subject of EMS will be extended by external influences of organization on the environment
- Inclusion of "life cycle perspective" to the assessment of environmental aspects (ie the assessment of the environmental impact of a product throughout life)
- New requirements to ensure the control and influence of input and output processes related to important aspects
- Strengthening the importance of assessing compliance

VII. IMS IN CIVIL AVIATION

All three management systems are designed so that they can be effectively implemented in organizations of any size or orientation. However unlike other sectors, Air transport has stricter or more detailed instructions as to the quality and environment, as well as in security. Nevertheless, nowadays is the trend to implement ISO 9001 and take them as complementary to the regulation of European Commission. Likewise, many companies are establishing SQMS - Safety & Quality Management System. The main reason for these implementations is again reduction of duplicate operations, better control and financial benefits in cases where the merger leads to a reduction in the number of employees.

VIII. CONSLUSION

Regardless of the newly prepared standards can be stated that the current management system standards often have the same or similar requirements. For example:

- Establish policy and objectives
- Control of documents
- Control of records
- Internal audits
- Management of non-conformities
- Monitoring and measuring of performance
- Management review
- Determination and compliance of external requirements

These similarities allow the integration of management systems and many advanced organizations have undergone a process of integration. in the future this step will be much easier thanks to the new standards.

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Methods of Forecasting to be Used in the Process of Air Transportation Demand Planning

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***Abstract*— The aim of the article is point out the potentials for use of the methods of forecasting methods to calculate the forecasts in terms of the number of air travelers for a certain period of time. The methods can also be used to calculate the forecasts for the rush hours of the day, week or year. The methodology is based on the estimation and adjustment of the demand in the logistical processes in terms of the future development of sales and offer of products and services in the air transportation market. When calculating the forecasts on the future number of air travelers, the article is dealing with the possible fluctuations in air transportation caused by political, social, economical, weather and other unforeseeable factors.**

Keywords- logistics, air transportation process, weighted moving average, seasonality, estimation of accuracy, absolute error, squared error forecasting

I. INTRODUCTION

Successful airlines are those capable of meeting the requirements and needs of their potential customers in time and with maximal efficiency. The same applies to airports and airport companies, which are capable of matching quickly the needs of airlines when arranging for the optimal conditions to provide air travelers airport support and high quality of services.

Quality of logistical services in air transportation are prerequisites of development, competitiveness, increase in efficiency and level of safety, economy of financial assets and profitability throughout the process of air transportation. It is substantially assisted by forecasting the future demand for air transportation, thus forming the basis for strategic, tactical and operative decisions and the measures to be adopted. Planning for new flight lines and destinations, forecasting the number of potentially transported travelers (tones of cargo), filling in the seat capacity and increasing the quality of the logistical-operational processes, are essential to the development of a real forecasting plan of the airline and airport development.

Tools that can be used in the planning process of the future forecasting demand, distribution and sales of in the air transportation (passenger and cargo) can involve some of the methods of forecasting, which enable us to perform an integrated forecasting of demand for air transportation for several years (certain period of time) ahead.

II. METHOD OF SIMPLE MOVING AVERAGE

It is a relatively simple method that can be used to forecast the number of air travelers over a certain period of time, or to forecast the number of travelers (tons of cargo) for a given flight, or seat capacity (load factor) of an aircraft.

The expression to estimate the forecast on demand on air transportation on the part of the passengers (cargo or seat capacity of the route and the flight line) for a t+1 period of time $P_{t,t+1}$ for the t-th period is written as:

$$\boldsymbol{P_{t,t+1}} = \frac{\sum_{i=0}^{n-1} S_{t-i}}{n} \qquad (1)$$

where $\boldsymbol{S_{t-i}}$ are the numbers of transported passengers (or tons of air cargo, seat occupancy, load factor of the flight) over the past $\boldsymbol{n}$ periods of time.

However, this method is difficult to apply in calculating the forecast in case of seasonal fluctuations in air transportation, e.g. during the year, week. The forecast calculated by the method of Simple Moving Average, however, does not vary from the overall average for a longer period of time (e.g. for 5 or more years). [1]

III. WEIGHTED MOVING AVERAGE

The principle of the method consists in calculating the average values of the investigated variable of a certain (selected) number of empirical values of the time series. The calculated average value is assigned to the medium period of the so-called moving part of the time series.

When calculating the estimated (forecast) number of the air travelers (tons of cargo) the basis considered is the weighted true requirements/demand on transporting passengers in real time and the number of transported passengers for a certain period of time in the past.

We proceed from the expression

$$S_{t+1-n} = P_{t,t+1} \quad (2)$$

following substitution

$$P_{t+1,t+2} = P_{t,t+1} + \frac{1}{n}(S_{t+1} - S_{t+1-n}) \quad (3)$$

it then holds that

$$P_{t+1,t+2} = P_{t,t+1} + \frac{S_{t+1} - P_{t,t+1}}{n} \quad (4)$$

By substituting $\frac{1}{n} = \alpha$ into the expression, we obtain

$$P_{t+1,t+2} = (1 - \alpha)P_{t,t+1} + \alpha S_{t+1} \quad (5)$$

whereas it holds that coefficient $\alpha = \frac{1}{n}$, where n is the number of the periods of time.[5]

The method of Weighted Moving Average is suitable for programme-based processing, too. In such case, the problem factor remaining is however in the correction factor, i.e. the values, which are to be added or distracted so as to obtain the relevant results. It holds that if the correlation factor is equal to 1, i.e. our estimate of the forecast in the number of air travelers for the forthcoming periods of time is based on the true number of passengers transported over the latest (actual) period of time. The lower the value of the correction factor, lower than the value of 1, the more it will be approaching the Simple Moving Average and will be less sensitive to the actual changes in the number of transported passengers in the nearest (future) period of time to come.

By properly choosing the coefficient α we are solving the compromise between the elimination of random deviations and matching with the actual status in the forecast of the transported passengers, whereas coefficient α is not to be constant. Methods, which can help us determine the correction factor α are also termed as adaptive methods.

IV. Combination of Weighted Averages and Seasonability

To improve forecasting of potential (future)numbers of air travelers over a certain period of time, the forecast estimates) should be corrected by seasonal fluctuations in demand for air transportation. The analyses are unambiguously proving that the density of air transportation and the number of the transported passengers on the individual lines is higher in summer months compared to those in winter. The reasons of the fact are unambiguous. It is caused first of all as a result of the unfavorable winter weather and the summer holiday season, tourism and relaxation. Performance (seasonal) variations in air transportations are evident even during the summer rush hours during a day or week.

Procedure of calculating the weighted averages and seasonability includes calculation by means of the:

1. method of moving averages, whereas we cover the overall trend of the investigated time series,
2. seasonal indices calculated on the basis of moving averages with the help of which we are able to quantify the above mentioned seasonal variation by expression:

$$I_s = \frac{S_t}{\overline{S_t}}, \quad (6)$$

where $\overline{S_t}$ is a moving average for the t-th period of time.

Correction of the forecast on the seasonal variations in air transportation during the year (week, day) is then

$$P_{t,t+1} = I.\, \overline{S_{t+1}} \quad (7)$$

V. Exponential Smoothing

It involves application of the method of the Weighted Moving Average. When forecasting the potentially transported (handled) air travelers in the airport information system, by using the smoothing, the coefficients $\alpha \in \langle 0,1 \rangle$ are assigned, the values of which are derived from the exponential distribution. Greater importance is here attributed to the latest statistical data on the number of passengers transported (handled) during the certain period of time.[3]

It is important to mention the expression for the calculation of the forecast from n historical data using the basic formula for the weighted average, which for the exponential smoothing takes the form:

$$P_{t+1} = \alpha S_t + \alpha(1-\alpha)S_{t-1} + \alpha(1-\alpha)^2 S_{t-2} + \dots + \alpha(1-\alpha)^{t-n+1} S_{t-n+1} \quad (8)$$

or

$$P_{t+1} = \alpha S_t + (1-\alpha)[\alpha S_{t-1} + \alpha(1-\alpha)S_{t-2} + \dots + \alpha(1-\alpha)^{t-n+2} S_{t-n+1}] \quad (9)$$

Within the exponential smoothing, we are knowledgeable of the Holt´ s method, which can be applied if the demand for air transportation reaches certain level and a trend component. This method, however, has no component of seasonability.

Methodology of calculation:[4]

1. smoothing the series of known values from the third period of time
2. the first value for the second period of time is $P'_{2,1} = S_2$
3. the first difference will $d'_1 = S_2 - S_1$
4. smoothed value for the third period of time is then equal to:

$$P'_{3,2} = (1 - \alpha)(P'_{2,1} + d'_1) + \alpha S_3 \quad (10)$$

$$d'_2 = (1 - \beta)d_1 + \beta(P'_{3,2} - P'_{2,1}) \quad (11)$$

For the adjustment of the series with the seasonal fluctuations in air transportation the Holt-Winters´ method can be used, which must be so long as to capture the given seasonability. At that, this method makes use of the time indices calculated as follows:

$$I_t = \frac{S_r}{\sum_{i-1}^{s} S_i / S} \quad (12)$$

where s is the length of the season series. The time series is the smoothed one including the differences and time indices in line with expressions:

$$P'_{T+1,T} = (1-\alpha)(P'_{T,T-1} + d'_{T-1}) + \alpha \frac{S_t}{I_{T-s}} \quad (13)$$

$$d' = (1-\beta)\, d'_{T-1} + \beta\, (P'_{T+1,T} - P'_{T-1,T}) \quad (14)$$

$$I_{T+1} = \gamma \frac{S_T}{P'_{T+1,T}} + (1-\gamma) I_{T-s} \quad (15)$$

5. Forecast for the k-th period of time is then:

$$P_{T+i} = (P'_{T-1,T-2} + i d'_{T-1}) I_{T-s} \quad (16)$$

The methodology is as follows:

a) Calculating the seasonal indeces in each season series and their average for each period of time,
b) Estimating the first difference as the difference of average consumptions for the last of the two seasons divided by the length of the season,
c) Estimating the smoothed centered moving average for the last period of time for the last season as an average for the last season, plus the multiple of the estimated average difference,
d) Calculating the smoothed moving averages and then the forecast for the next season.

VI. Models of decomposing the time series

These models are important among the prognostic models. Apart from smoothing by the average, they make use of the analysis, which enables determining the trend or the seasonal fluctuations.

It is about the models identifying the three components of time series:

1. trend component,
2. seasonal component,
3. random component.

The aim of decomposing the time series is to quantify their trend and seasonal components. It is the process of quantifying these components termed as the decomposition of the time series.

Models of decomposition are divided into:

1. additive
2. multiplicative.

For the additive decomposition it holds that:

$$\boldsymbol{D = T + S + E} \quad (17)$$

For the multiplicative decomposition it holds that:

$$\boldsymbol{D = T \,.\, S \,.\, E} \quad (18)$$

where

D = time series (historical data),
T = trend component,
S = seasonal component,
E = random component.[1]

The additive model is applied in case when the behavior of the demand trend is relatively stable. If the trend is substantially increasing or decreasing, it is suitable to make use of the multiplicative model. The information obtained by way of the decomposition can be used for evaluating the development of demand so far and forecasting its future behavior. In order to quantify the trend and seasonal components of the time series, it is necessary to apply the moving averages to determine the trend and then make use of the knowledge of the trend for the seasonal factors.

Decomposition of time series involves the following steps:

1. looking for the trend, which represents the main tendency of a relatively long period of the analyzed demand, and which consists in the technique known as the trend centering (average of two moving averages),
2. finding the seasonal component by means of the above mentioned expression, for the additive decomposition, where the random (unpredictable) component is neglected: $\boldsymbol{S = D - T}$,
3. setting up the time series cleared of the seasonal effects. The results are the trend components comprising only the random components. Id est $\boldsymbol{D - S = T + E}$, where the left side represents the seasonally cleared series.

The task can be considered as finished only when it is reasonably assumed that the seasonal is not going to change, so the forecast is determined by the trend. If this is not the case, the causal models are applied. One of the models can be represented by a simple linear regression, which expresses the relation between the two variables taking the general form y = f(x), where y is the dependent variable and x the independent variable.

The precision of the regression analysis depends to much extent on the selection of the right data, which are then used in the regression analysis. In cases when there are several explanatory variables, the multiple regression is applied.

VII. Evaluating the precision of the forecasting

For the purpose of evaluating the precision, one can make use of the methodology of calculating of the Mean Absolute Deviation, Mean Absolute Error. The Mean Absolute Deviation is the basis way of measuring the error made by the forecasting model in relation to the historical data of the time series.

The formula for calculation is expressed as:

$$\boldsymbol{MAD} = \frac{\sum_{t=1}^{n} |D_t - F_t|}{n}, \quad (19)$$

where,

D_t = true demand in the time period of t,
F_t = forecast of the demand in the time period of t,
n = umber of time periods used .

The absolute value is necessary to ignore the direction of the deviation. This characteristics is used when we want to express the error of forecasting in the very same units, which are peculiar to the values of the original statistical series.[3]

A. Mean Square Error

For calculation it makes use of the same variables as the MAD. This characteristics penalizes large deviations in the forecast, as the error is squared. On the basis of the Mean Square Error, preference is given to the model, which demonstrates moderate values of errors in the forecast to such ones, which reveal very low values of error and one extreme value of the forecast error. [2]

It is given by the relation:

$$MSE = \frac{\sum_{t=1}^{n} \left| D_t - F_t \right|^2}{n} \quad (20)$$

B. 6.2 Mean Forecast Error

It is rare when the prognosed value and the true demand are equal. However, the difference between the average forecast value (aspect of several time intervals) and the average of values of true demand should be as low as possible. To assess this requirement, it is suitable to calculate the mean forecast error using expression:

$$MFE = \frac{\sum_{t=1}^{n} \left| D_t - F_t \right|}{n} \quad (21)$$

Mean Absolute Percentage Error

The last of the important characteristics is an addition to the expressive power in evaluating the precision of the forecasts. Despite carrying the word absolute, it expresses the relative error. While using the same variables as in the previous equations, the expression for calculation is as follows:

$$MAPE = \frac{100}{n} \sum_{t=1}^{n} \left| \frac{D_t - F_t}{D_t} \right| \quad (22)$$

CONCLUSION

Forecasting demand in air transportation belongs to the basic input logistical information in the process of planning flights, designing air transportation, financial planning, organizational, operational and personnel support with its importance ever increasing. In general, forecasting air transportation is a combination of analyzing air transportation of the past, intuition, analysts´ experiences, and forecasts of airlines and airports.

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Problems of implementation of EU legislation in the non-membership states on the example of a type certification.

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Abstract — **This article focuses on a problems of implementation of EU legislation in the non-membership states. Validation process of type certificate is using like an example.**

Keywords — ***type certification, validation, imlementation of EU legislation.***

I. Introduction

The article covers the history, current state and development of type certification in Russia, difference in the procedures from the same carried out in EU and possible ways and obstacles arising during the implementation of EU legislation in the Russian Federation (RF).

Differences between national and international certification systems slow down possible exports of aircrafts, especially since the growth of international trade is 3-4 times higher than the rate of growth of national economies.

Thus, speaking of the implementation of EU legislation in the Russian Federation refers to the process of adaptation of the national aviation legislation to the norms of European law. This article examines the procedure of type certification.

II. Airworthiness and flight safety of civil aviation in Russia

The purpose of the type certification of the aircraft is to ensure safety of flight. Safety is a property of the air transport system to operate flights without endangering of human life and health.

Currently in Russia exist two independent systems of certification in the field of civil aviation, which guarantee aviation safety:

- System of certification aircrafts and objects of civil aviation (система сертификации авиационной техники и объектов гражданской авиации – ССАТиОГА) headed by the Interstate Aviation Committee (IAC);

- System of certification of objects of air transport (система сертификации объектов воздушного транспорта – ССВТ) headed by civil aviation government department of Ministry of transport RF.

The first system in accordance with the law of the Russian Federation "On certification of products and services" is registered in the State Register. It is a system of certification of designer and manufacturer of aviation equipment. In accordance with it the following objects of civil aviation are subjected to mandatory certification: aircrafts, aircraft engines, propellers, components, international airports and general aviation aerodromes, aerodromes equipment, designers of aircrafts, production of aviation equipment.

Aviation rules AP-25 (авиационные правила-АП) AP-25 for aircrafts and AP-29 for helicopters are currently adopted in that system for airworthiness.

The second system is a system of operator. This one is also required and registered by the Gosstandart (Russian state standard organization) in the State Register. Within the framework of this system of certification takes place the evaluation of the aircraft, i.e. its compliance with the standard design. The compliance is checked according to the requirements of the Federal Aviation Regulations "The example of aircraft. Requirements and process of certification".

These systems are independent and have nothing in common, which leads to the fact that the system solution of the problem of ensuring and saving airworthiness of aircraft does not exist.

III. Difficulties in the process of validation of type certificate

The first question, which the applicant has in the case of validation, is: what system of certification cover the particular document. In our case, we are talking about type certification, which means certification of designer of aviation equipment. The applicant should contact the IAC for validation of type certificate.

All further steps are carried out in accordance with The European Aviation Safety Agency (EASA) Regulation № 1592/2002 od 15.07.2002 „Working arrangement on airworthiness between the European Aviation Safety Agency and the International Aviation Committee“.

This Arrangement applies to:

a. The acceptance by the importing party of the design approval, including alterations or modifications to a design, environmental approval, and the finding of compliance made by the exporting party with the importing party's design related operational requirements, for civil aeronautical products, parts and appliances for which the exporting party is the type certificating authority;

b. The acceptance by the importing party of the airworthiness certification of civil aeronautical products, parts and appliances that may be exported from each Contracting Party;

In practice, until now only one certificate was validated for passenger aircraft and it is certificate for Sukhoi Superjet 100 (SSJ 100). This EASA certificate recognizes that Sukhoi Civil Aircraft Company (SCAC) has demonstrated compliance for this aircraft with the EASA Type Certification Basis with applicable airworthiness and environmental requirements. It allows the European airlines as well as those airlines operating in countries which use EASA regulations as a reference to operate the SSJ100 aircraft.

The EASA Type Certificate was officially handed over to SCAC on 24 February 2012 at IAC AR Headquarters in Moscow.

What obstacles arise in the realization of the process of implementation EU legislation in the Russian Federation?

A. In the IAC does not exist specific support procedure for validation of type certificates.

Specific support procedure for validation of type certificates exist in EASA document № E.P010-01 «Certification Support for Validation (CSV)». The IAC does not have analogous procedure.

Application procedures for registration of a type certificate for aircraft is described in the internal documents of the IAC, but the procedures of an application and an interaction designers with IAC during the validation is not specified.

That means that the designer if necessary is not able to apply directly to the department engaged in this process. It is necessary to apply to the IAC, where is further developed the appropriate course of action for the applicant. In each case this course of action is individual, which means that the applicant does not know what documents are necessary for the validation.

B. Standards EASA and IAC are not fully harmonized.

System of standards for air transport is underdeveloped in RF. No work on the development (reprocessing) of the existing industry standards to the national standards or rules is carried out. Recommended practices of ICAO are not fully applied in civil aviation legislation in Russia.

Despite the fact that the requirements of AP and CS / FAR are based on the requirements of Annex 8, they are not identical, and that has negative effect on the certification basis (CB - full list of requirements for airworthiness compliance which is a necessary and sufficient condition for obtaining the type certificate for particular aircraft).

For example during the validation of SSJ 100 certificate considered special specifications of designer and special specifications of CS (EASA-form, certification specifications) was different in 68 points.

In some of these point was only slight difference, but some points are completely changed. Differences in sections as follows:

- Section B (Flight) - 18 points;
- Section C (Strength) - 8 points;
- Section D (Design and Construction) - 11 points;
- Section E (Power plant) - 9 points;
- Section F (Equipment) - 22 points;
- Appendix H - 2 points;
- Appendix I - 7 points (i.e. all).

This means that the process of obtaining EASA certificate is not «automatic», it is necessary to include additional points not considered by the designer. It is necessary to carry out further tests, which are based on those points.

C. Differences in the methods of certification tests.

In developing the flight tests from the designer side in Russia are used parameters which are tested during the flight tests. These parameters are designed by the designer organization and meet Annex 8 requirements, but not the CB requirements. There are added into the testing process only after first results are known. This is based on the historical process of tests preparations.

The problem is that EASA develops flight test program on the basis of the CB requirements. This means that CB requirements is compiled in both cases (EU-based test result and RF-based test results), but the approach to testing is opposite. This obstacle could be solved by using the test program requirements of EASA.

In addition, some best practices of certification testing do not exist in IAC practice. This can cause additional complications.

D. Differences in certification of software.

Due to the difference in the historical development, there are significant differences in the requirements for developing and testing procedures for components (systems, units, assemblies) and especially software.

Software installed on modern aircrafts, developed in Russia, is considerably inferior compared to software produced in Europe.

The opportunity to prepare more modern equipment is available, but to fulfil European standards requirements is very time-consuming and costly process.

During the validation of type certificate for SSJ 100 all issues were resolved by using the easiest way. Manufacturer selected foreign component suppliers who already have EASA certificates for this equipment.

E. Interaction of experts.

As in any process in aviation, the human factor and its influence on the validation process must be taken into account.

During the work with Russian experts, not only in the aviation but in any field, personal contact has important meaning. When in Europe, most communication is done via e-mail or an appropriate exchange of documents. During work with the Russian side it is often necessary to establish closer personal contact, which simplifies the further conduct of validation procedures.

Significant factor is also language barrier arising in communication. In the EASA all communications are carried out in English, not only at the level of communication between the organizations, but also on the internal level.

In IAC all communication is in Russian, aviation experts often cannot interact in English, which requires the services of translator. In addition, all official documents on the territory of the Russian Federation must be mandatory duplicated in Russian, which can cause extra obstacles in the implementation of the validation process.

IV. CONCLUSION

This article describes the process of implementation of the European legislation on the example of the type certificate validation. Currently, procedure of validation of type certificates is not sufficiently developed and methodology has to be written directly for each aircraft type.

Despite this, there are problems which are common to all types of aircrafts:

1. There is no general validation procedure.
2. System of standards for air transport in Russia is underdeveloped and often do not use existing international practice in standardization, which leads to further complication of the procedure of validation.
3. For validation of certificate is often required additional testing because of differences in methodology.
4. Manufacturers of Russian aircraft prefer not to use components of the foreign producers, thereby reducing their competitiveness.

Historically, the development of standardization and certification of aircrafts was independent from the other countries, therefore for many designers the usage of foreign practices is a new experience. However, this is currently not only a useful experience, but also necessary step for the active development and competitiveness of the companies.

Exchange of experiences for both sides will increase the level of safety of aircrafts.

V. ACKNOWLEDGEMENT

This paper was supported by the grant agency of the Czech Technical University in Prague, grant No. SGS14/164/OHK2/2T/16.

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Passenger Differentiation as a Tool for Increasing the Efficiency of Airport Security Checkpoints

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***Abstract*: The current airport security model will sooner or later come under strain. The effective way how to solve this problem could be targeting airport security checks on the basis of risk. The aim of this paper is to summarize the future trends of airport security check, as well as to draft a model, which could be useful for airports nowadays, when the topic is still under discussion and which could be used as a transitional stage while the passenger and flight data risk assessment with international cooperation has not been already fully implemented.**

Keywords: airport security; passenger profilling, security checkpoint

I. INTRODUCTION

In the statistical point of view, the security threat posed to aviation remains relatively small. Aviation symbolizes freedom and international trade. However the public is creating a climate of fear of the terrorism. The goal of a potential attack may be not only loss of life but also disruption of international business. Current assessments confirm that attack methods evolve, as well as the confidence in the threat and risk methodology grows. The common terrorist paths are shown in the Figure 1.

Sooner or later our current security model, accumulating many controls at high costs and passenger inconvenience but still not effective, will have to be changed. The effective solution seems to be targeting controls on the basis of risk.

II. THE FUTURE OF AIRPORT SECURITY CHECKPOINTS

Experts from around Europe, ICAO and partner countries gathered in Brussels on 27 September 2011 and discussed how to develop aviation security policy further. As a result of this conference they agreed that, ten years on from 9/11, civil aviation is protected by a robust security regime and that the extensive controls in place combined with continued strong intelligence attention have been instrumental in foiling attempts at unlawful interference. [1]

One of the conclusions and recommendations which were discussed and agreed is that security measures can and should relate to the risk they intend to mitigate. If a high quality risk assessment is available, security resources can be targeted to where the risk and threat is higher. [1]

There should be common EU risk assessment developed. The measures require data on passenger travelling and information sharing from international and local authorities and from industry. The aim is to propose EU Passenger Name Record (PNR), which could gather the passenger data for securing flights fully respecting fundamental rights and freedoms.

Besides that, new technological facilities have also potential to transform security system for the benefit of passengers. For example, security scanners, liquid explosives detection systems and other technologies such as biometric identification will help to implement more differentiated controls in the future. The European Commission was invited to coordinate the development of the future security model, involving regulators and stakeholders.

For 2020 the passenger and flight data risk assessments with international cooperation is planned. The unpredictable alternative measures will be used to deter and detect. In the field of behavior analysis, the automated real-time update of the risk score will be the part of passenger pre-screening. The automated biometric gates, automated operator assists and the real time risk score update and level of screening decision will enhance the technology of security screening. Operation smoothness will be guaranteed by the greater use of automation processes, dynamic passenger guidance of screening process, way-finding at entry and in checkpoints, queue management program and improving staff allocation. The planned "Known Traveler" program could allow government agencies to perform detailed background checks for travelers who voluntarily enroll in. [2]

In summary, the following areas might be included in the scope of the future checkpoint;

- passenger differentiation,
- "Known Traveler" program,
- data integration ,
- new checkpoint configuration,
- technology and detection standards,
- randomness,
- passenger experience and throughput increasing,
- biometrics and identity management and
- passenger behavioral analysis.

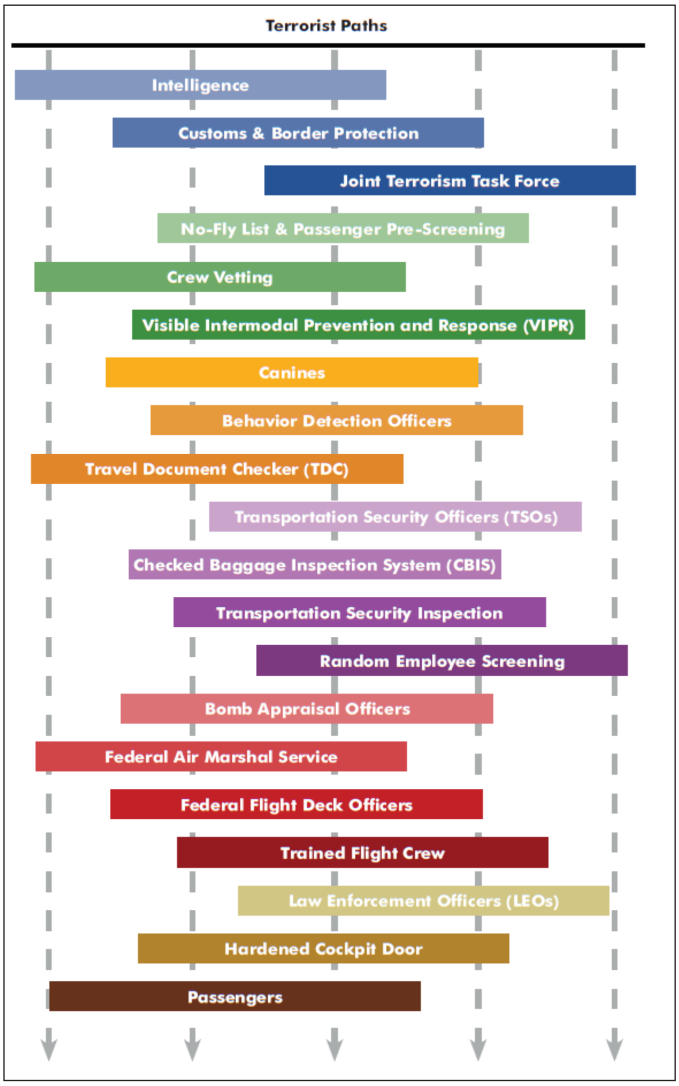

Figure 1. Twenty Layers of Security. [4]

Risk based screening is based on the premises that the majority of airline passengers present a low risk to aviation, some assessment may be made using travel data and further assessment can be made through passengers voluntarily. The behavior detection and interviewing techniques are the additional measures to assess risk. Security can be increased by focusing on unknowns. [3]

III. Passenger Differentatation

On arrival at an airport, a traveler would be directed to one of following lanes;

- Known Traveler,
- Normal or
- Enhanced Security.

Passenger differentiation does not mean screening based on controversial aspects, such as race, gender or religious beliefs. It means screening different passengers in different ways. The influence of randomness would be involved. It would be also considered the differentiation of an entire flight or specific time period, not just individual traveler. Contributing factors to risk assessment might include some or all of:

- flight – route or type (business, tourism),
- traveler type (such as crew, staff, military personnel),
- passenger data,
- watch-list check from match with travel document information,
- rules based analysis of reservations and check-in data,
- membership of a known traveler scheme subject to,
- background checks,
- current and valid membership,
- presence on Interpol Lost and Stolen Passports database,
- checks against other Government databases,
- associated passengers on the same flight,
- behavior analysis,
- alternative measures such as random selection for enhanced screening, trace detection and explosive detection dogs. [3]

IV. Simple Passenger Segmentation Model Draft

Currently the passenger and flight data risk assessment with international cooperation is still under discussion, it has not been already implemented. Airports are awaiting the final model which (as it was already mentioned) will sooner or later come into reality. However, the need for improving efficiency of airport security check-points is a current topic. For this reason, author suggests a model proposal using the passenger differentiation based on just several criteria, which are currently and easily available.

Proposed model consists of passenger segmentation according to:

- flight type (business, tourism),
- traveler type (such as crew, staff, military personnel),
- age of passenger (small children, elderly people),
- passenger cultural type according to the Lewis Model (Linear-active, Reactive and Multi-active),
- gender,
- frequency of travelling by the air and familiarity with airport security,
- aspect of passenger grouping (e.g. family) and
- number of baggage.

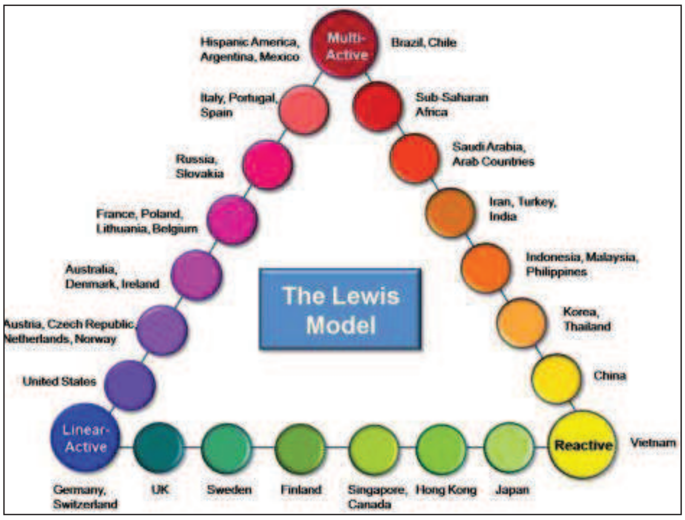

Figure 2. The Lewis Model [5]

Observing the security check operation, the influence of mentioned aspects on the airport security effectiveness could be measured.

For instance, for families with small children there are often special so called "family lines", because they usually need more assistance while passing through the security check. Different example is business passenger, who is used to travel a lot and mostly familiar with all the security requirements.

Regarding gender, there is a higher percentage of women alarming when they pass the detecting frame (the main reason is the higher number of fashion accessories).

It is known that different cultures behave different way. The Lewis Model in Figure 2 shows the distribution of nations according to the way of communication, which could be connected to the behavior habits, such as talkativeness, willingness to lean cooperation or e.g. body contacts and personal space issues.

The idea is to find out, whether there are any dependencies between mentioned passenger features and time they spend on the security checkpoint in average. If so, the impact of relevant features on the security check efficiency will be quantified. Using this proof, passengers could be divided in several classes according to the time they probably will spend on the security check and according to the level of assistance they need. The staff allocation would be tailored to this demand.

V. Conclusion

In this paper, the future direction of the airport security development is described and summarized. Besides that, the proposal of simple passenger selecting model is sketched. Implementing proposed passenger selecting into real, passengers could get used to kind of differentiation and profiling while managers could effectively control the security check operation. The model, based on mentioned ideas, could be easily adapted to the future passenger differentiation requirements.

Acknowledgment

This paper has been supported by the project "CZ.1.07/2.4.00/17.0107 Support of Short Term Attachments and Skilful Activities for Innovation of Tertiary Education at the Jan Perner Transport Faculty and Faculty of Electrical Engineering and Informatics – University of Pardubice" and "Student Grant Competition SG540001/20/51030" on Jan Perner Transport Faculty, University of Pardubice, Czech Republic.

european social fund in the czech republic · EUROPEAN UNION · MINISTRY OF EDUCATION, YOUTH AND SPORTS · OP Education for Competitiveness · University of Pardubice

INVESTMENTS IN EDUCATION DEVELOPMENT

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Design of Novel Software for Supporting CAA's Oversight Activities

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Abstract — **This paper presents the research and development project which depicts and focuses on the issue of Design of Software for Supporting Czech CAA's Oversight Activities within organizations approved for maintenance, production and design of aviation equipment (AMO, CAMO, POA and DOA organizations). The paper makes the reader acquainted with the whole process of developing the work, used resources, methods and used software. Last but not least, it encompasses results, as well as it provides the options for improvement and streamlining the system and possible future development of the proposed software.**

Keywords - Civil aviation authority, oversight activities, software, Software Requirements Specifications

I. Introduction

Complex fields, to which aviation undoubtedly belongs, require constant supervision and regulation by determined authorities. However, this high level of regulation contributes to the fact that aviation has become one of the crowning creations of the mankind and ranks among the safest means of transport that the current world knows.

Civil aviation has undergone a spectacular development in the last 60 years and all indicators show that even the following years won't be different. In order to maintain and increase the high level of safety, it is necessary to foster all parts of the aviation sector, including the regulatory system. This should not, however, be realized by creating new rules, regulations or stricter regulation. Instead of that, current conditions (i.e. regulation) should be harmonized and streamlined. Balance between quality and quantity should be found and better conditions should be ensured by authorities as well as by airline operators.

Currently, there is a large number of organizations and agencies, whether national or international, which are involved in safety oversight and the regulation of civil aviation. In the imaginary pyramid of national safety oversight, Civil Aviation Authority is on top and represents the last and the most important segment. Its function directly affects air traffic operations and development in the Czech Republic. Therefore, it is necessary to ensure that the institution meets the highest requirements.

The aim of the project, as the name suggests, is to introduce a theoretical design of software, which should serve as a template for future development and implementation of software for supporting CAA's oversight activities. This draft consist mainly in valorizing of the current status of oversight activities, evaluation of technical feasibility and the summary of functional and non-functional requirements for a software that will reflect the needs of the Civil Aviation Authority. The effort of the authors was to simultaneously give the reader a comprehensive view on the issues of Czech CAA's Oversight Activities within the organizations approved for maintenance, production and design of aviation equipment.

For more details about the project, please refer to [19]. The document includes general, but often very detailed information about the issue supported by image attachment that facilitates the readers understanding of the provided information.

II. Research method

The entire process of elaboration of project included two main phases (research and development) which are further composed of four steps (Mapping the current status, Creating the structure of oversight activities, Analytical design of software, Draft of improvement measures and future potential) in sequence as shown in the Fig. 1. The research phase contained first two steps (Mapping the current status and Creating the structure of oversight activities), whilst development phase consisted of following two (Analytical design of software and Draft of improvement measures and future potential). The following text will describe in detail these phases.

Research phase

The first objective of the project was mapping and description of the CAA's oversight activities. The process itself is very complex and involves a large number of sub-processes. Elaboration of this part required access to core information – that information was provided by staff of the Department of organizations approval in the form of consultations. The subsequent step was to create the structure

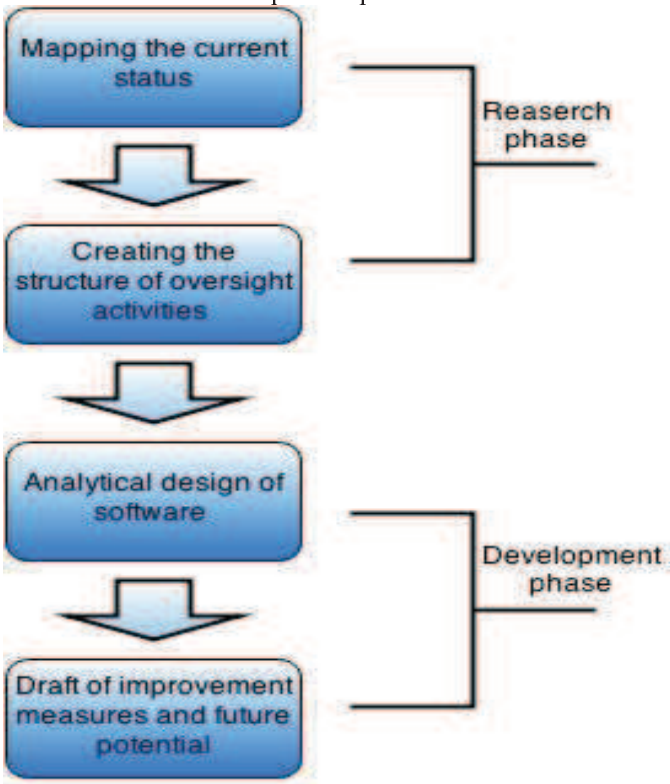

Figure 1. Process of elaboration

of audit activity, with all its specifics in the form of a mind maps. For this purpose, Mindjet's Mind Manager software was used. This software allows visualization of mind maps and creating structures of individual processes. The structure itself, however, cannot capture all relationships, connections and time frame between individual processes, which is naturally essential for software development. Therefore, as a third step it was necessary to proceed to Gantt diagrams using Microsoft Office Project software. Gantt charts represent graphical representation of planned sequence of activities in time and create relationships between these activities. During the whole process, it was also necessary not to forget inputs and outputs from the process, which are primarily represented by official forms and documents. Functions and relationships of these documents throughout the process were described by RACI matrices and also incorporated into the Gantt charts.

Development phase

After successful completion of the previous steps, analytical software concept had to be made. This concept should have analyzed entire process of oversight activities and subsequently decompose this process into component parts and determine basic software function. Design of new features that should improve, simplify and streamline the entire process was also included in this phase.

The objective was to provide a detailed description of the requirements and features for audit software that will be used by the CAA. This description should serve to software development team as well as a feedback for Czech CAA. In order to meet the first requirement (determining basic software functions), it was necessary to determine the appropriate structure, that would closely corresponds with the requirements of the development team, and which could be used without significant changes as a basis for design and subsequent implementation of the software. For this purpose, decision was to use the method of software requirements specifications (SRS). This method is commonly used by software analytics and designers and allows identifying a set of requirements and functions that are essential for the entire software design. Properly drafted SRS should meet four basic objectives which were followed:

- It provides feedback to the customer
- It decomposes the problem into component parts. .
- It serves as an input to the design specification.
- It serves for testing and evaluation

For this purpose, a generic template for developing SRS draft was used. The template was developed by IEEE's working group. The template itself is very detailed and far exceeds a content of the project. For this reason, decision was to focus only on the most essential parts, particularly on initial description and identification of functional and non-functional requirements.

The last step was to propose improvement measures throughout the process, because the purpose of novel software for supporting CAA's oversight activities is to bring a change. The change should be focused on improving, simplifying and increasing the efficiency and transparency of the entire process. Simultaneously it should allow all employees to facilitate their work and increase their effectiveness. Finally, it is necessary to state that the given change will also affect audited organizations, for which the entire process of obtaining certification and following audits should be easier and quicker. These functional requirements are not derived from the current state of CAA's oversight activities, but they represent new features and functions. For identifying these new functions, the entire process of oversight activities was assessed by the author and discussed with senior management of the Department of organizations approval. During a joint discussion, the main requirements and improvement measures were identified. Simultaneously with this process, other CAA's programs were assessed to identify possible future development of the proposed software.

III. Results and Discussion

The entire system of the oversight activities is made up of many partial processes that create a complex unit. Nevertheless, it is necessary to state that the system of the oversight supervision is accurately adjusted from the legislative as well as from the functional point of view. The main disadvantage of the whole process thus remains its "paper form" and with it associated low efficiency. Moreover, the present condition does not really allow the monitoring of the modern trends in the regulation supervision. At the same time, the system as it is set, does not permit an efficient information gathering that would allow a deduction of the structured safety data that consent the actual view on safety and also a prediction of the safety risks, i.e. the predictive safety indicators. It is necessary to realize that the regulation organs, of which the CAA is no doubt a part, create an essential part of the safety system that surrounds the entire aviation branch. The correctly set and functional regulation system is thus one of the requirements for a constant growth of safety in the framework of commercial aviation. Therefore, for us to be able to maintain the safety of civil aviation together with its constant development, it is required that the regulatory organs and its supervision of this branch continue in its growth. One of the options on how to achieve this is the mentioned software, which just as everything else has to go through a certain development. The following figure (Fig. 2) demonstrates generic SW development process.

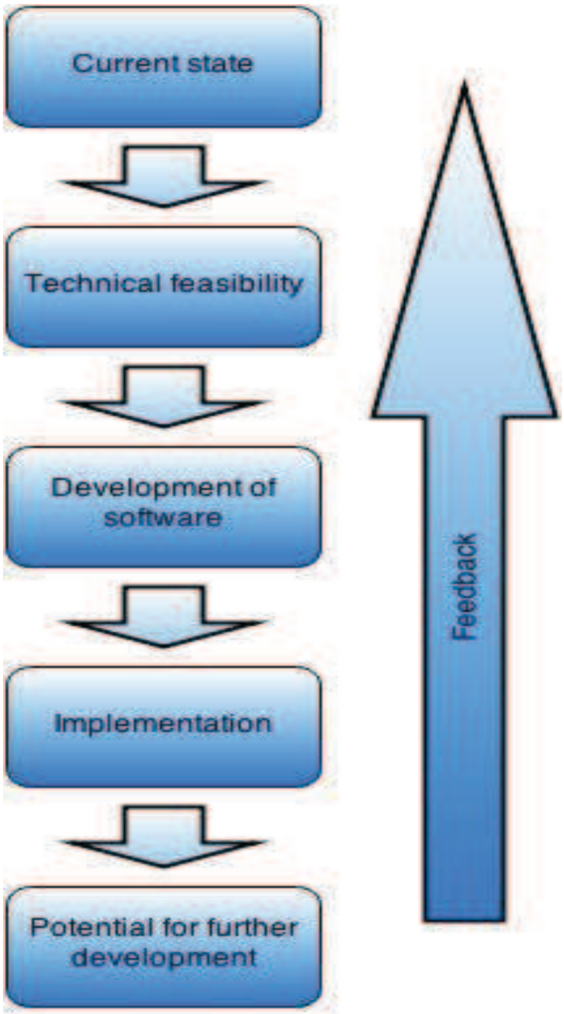

Figure 2. Generic SW development process.

First of all, it is essential to efficiently map the current state of the system, as it is set. This is followed by the evaluation of the technical feasibility. Particularly in a way, that the creation of software, that would precisely correspond to the specific requirements and demands of the CAA, would be possible. These two above mentioned points create the main outcome of proposed work. A successful development will be followed by an implementation of this software into the process of the oversight activities. The implementation should be accompanied by the exposure of possible imperfections of the software and their correction. After the process of a complete transfer of the existing activity into the electronic form and if the software is able to achieve its functions so that it does not decrease the quality of the present system, the software will show an enormous potential for further development, efficiency improvement and increase of the regulation supervision safety, in the framework of the civil aviation.

Foreign "best practice" integration

Potential and perhaps some improvements can be found primarily in programs that are used by foreign civil aviation authorities. The Canadian system, which was introduced on a 2012 EASA conference in Cologne, Germany, is one of those programs. This conference focused mainly on Civil Aviation Authorities, their supervision and new methods of managing and creating regulations in aviation. One of the presented programs was a Canadian system, which as one of a few presented at the time was a fully functional and real program introduced by the Canadian civil aviation authority. This program created a great reception especially for its ability to identify the safety indicators and for the standardized evaluation of the risks across civil aviation. It represents a complex, realistic and a very precise tool for the supervision and its planning over organizations that play active role in civil aviation. The entire system is very flexible and enables fast adaptation to a wide spectrum of requirements. At the same time, it allows a prediction of the development of the given system and the optimal division of sources. The program is presented mostly as a possible future development of the software for the Civil Aviation Authority, after its basic implementation. A detailed characterization part of the project discusses the functional and non-functional requirements, which could be used in a further development of the potential software for the supporting of CAA's oversight activities. In other words, in order to maintain and increase the safety of civil aviation with its constant expansion and evolution, it is also necessary to develop the process of regulatory system, specifically the systems that are used by the given regulatory organs. It is essential that after the introduction of the software for Czech CAA the system is constantly improved and expanded and the Canadian program is one of the possible methods of achieving this.

The following scheme (Fig. 3) illustrates the attempt to utilize and integrate the best practice from Canadian system into the already implemented proposed software for supporting CAA's oversight activities.

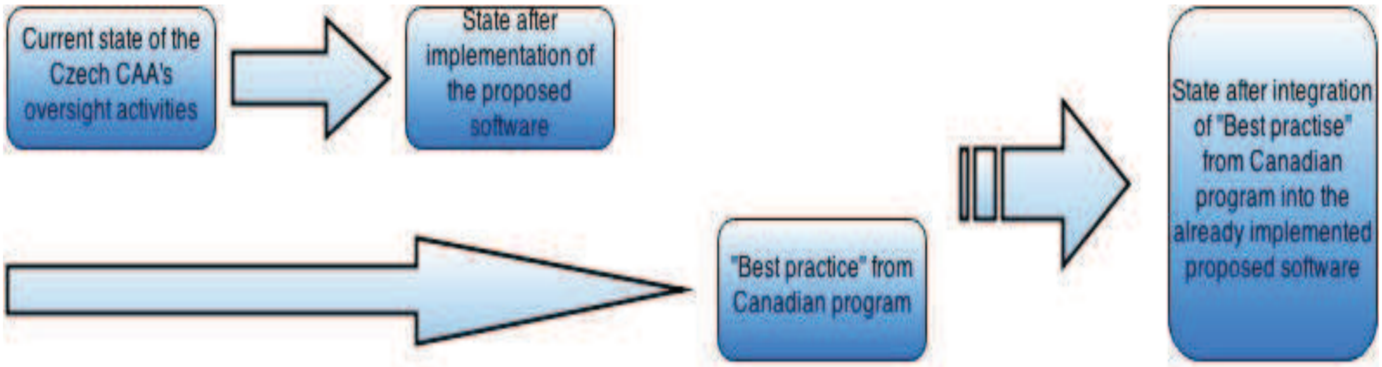

Figure 3. Utilizing and integrating the best practice from Canadian system into the already implemented proposed software for supporting CAA's oversight activities

IV. CONCLUSION

The requirement for a sustainable development and growth of commercial aviation is to lay high demands and constant perfecting of all its components from the technical to the legislative level. Regulatory supervision is an inevitable part of the aviation field and it is necessary to maintain its standards equally with the development of the whole branch. This can be achieved by a constant effort for higher efficiency, harmonization, cooperation and increase of the safety level. The work has clearly underlined the possibilities of the technical feasibility of introducing the software for the supporting of CAA's oversight activities and the increase of the level and efficiency of the whole process including the possibilities of its future development. Project outcomes should be used as a feedback for the Civil aviation authority and at the mean time as a concept, which can be used during the development of the given software and which will allow the designers of the software to comprehend the issue of the oversight activities and speed up the process of the entire development.

ACKNOWLEDGMENT

This paper was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS14/167/OHK2/2T/16.

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CURRENT SCIENTIFIC AND RESEARCH ACTIVITIES AT THE FACULTY OF AERONAUTICS TECHNICAL UNIVERSITY OF KOŠICE

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Abstract—**Among the main activities of the Faculty of Aeronautics Technical University in Košice, Slovakia, in addition to provide the university education with a focus on the avionics, are included activities of particular departments in the field of aviation research and development. The paper processes the current overview of this issue at the particular departments, indicating the offer of cooperation within the built experimental laboratories.**

Keywords-aviation reserch; university; education

I. INTRODUCTION

The Faculty of Aeronautics of the Technical University in Košice was established on 1 February 2005. Despite the short period of its existence it has a long experience in training pilots and aviation experts. The Faculty of Aeronautics is a successor of the Air Force Academy of Gen. Milan Rastislav Štefánik in Košice, which was a prestigious educational institution in Europe and in the world providing university education for pilots and air operating personnel since 1973.

The main mission of the Faculty of Aeronautics is to perform tasks of the Technical University, especially in the area of air technologies, aeronautics and astronautics – to provide, organize and ensure higher level education, life-time education as well as facilitate creative academic research in the fields of aeronautics, aviation equipment, aerospace and related issues.

The accredited study programs are focused on the areas such as air traffic control and management (with pilots and ATC-staff included), aviation mechanical engineering, electrical engineering and avionics, aircraft design, aviation equipment repair and operation.

II. THE FACULTY OF AERONAUTICS ACCREDITED STUDY PROGRAMMES

Studying at Faculty of Aeronautics takes place in response to the activities in the field of science and research, in line with the current state of development of these areas. The Faculty of Aeronautics provides university education at three study fields 5.2.59 Traffic, 5.2.4 Motor vehicles, rail vehicles, ships and airplanes and 5.2.13 Electronic, at all three university degrees.

TABLE I. STUDY PROGRAMME

Level	STUDY FIELDS
1.	Air Transport Management
	Professional pilot
	Air traffic controller
	Airport operation
	Aircraft operation
	Avionics systems
	Sensorics
2.	Air Transport Management
	Aircraft operation
	Sensorics and avionics systems
3.	Air Transport Management
	Aircraft operation
	Aviation and industrial electronic systems

III. FOCUS ON THE SCIENTIFIC AND RESEARCH ACTIVITIES OF ACADEMIC DEPARTMENTS

The scientific and teaching staff of the Faculty of Aeronautics, Technical University in Košice includes six departments with specialized focus in different areas of aviation issues.

- Department of Aerodynamics and Simulations: aerodynamics, informatics, computer technology programming applied to mathematical analyses, mathematics, physics
- Department of Avionics: avionics, airborne instruments, electrical systems of aircraft, airborne radio and radio-technical systems and special systems of aircraft
- Department of Aviation Technical Studies: aviation engineering, aviation and industrial sensorics and

magnetometrics, aviation mechanics and material, aviation electrotechnics, electronics and cybernetics

- Department of Flight Training: preparation of the flying staff, personnel of air traffic control, simulator training of crews and air traffic controllers
- Department of Aviation Engineering: preparation of ground and flying staff in theory of aircraft design, aeronautical engines, ground servicing and airfield operation
- Department of Air Traffic Management: focused mainly on the area of management, organization and supervision of air traffic operations and airport

A. Department of Aviation Engineering

The department provides scientific and research activities mainly in the areas: aircraft design and aeronautical engines, maintenance and repair of aircraft and aviation engines, ground servicing and airfield operation and Airfield technical and operational support. Science and Research:

1. Development of control systems for small turbo-shaft jet engines with experimental validation in the laboratory of small jet engines.

2. Research conducted for the effects of alternative aviation fuel on rubber materials.

3. Building material basis for practical training of maintenance staff to international regulations (Part 66 and Part 147 for the categories of B1.1, B1.3 and B3).

Cooperation offered for partners:

- Laboratory of intelligent control systems of aviation engines - research focused modern methods of modelling, control and diagnostics of complex systems using approaches based on artificial intelligence,

- Methods applied to objects such as small aviation jet engines MPM-20, TJ-100 and Saphir 5.

B. Department of Aviation Technical Studies

The department is responsible for the research, which is conducted in selected areas of electrotechnics and mechanical engineering in aviation, particularly, applied magnetometry, diagnosting and material engineering. Science and Research:

1. Research, development and application of sensors based on magnetic microwires.

2. Applicational vector magnetometry.

3. Influence of new ways of treating sintered materials on their tribological characteristics.

4. Basis for research, development, design, testing and applications of unmanned aerial vehicles.

Cooperation offered to partners:

- Research and development of contactless submerged sensors of stress and temperature,

- Research of special sensors and electronic units to customer requirements,

- Testing characteristics of magnetic materials and sintered steels,

- Magnetic measurements, mapping and analyses of stationary and lf magnetic fields,

- Cooperation in the development of intelligent multi-sensor systems,

- Testing accelerometers, gyroscopes and magnetometers for flying vehicles and praxis,

- Stabilization and navigation of objects based on physical fields,

- Manufacturing, testing and optimization of supporting frames of above standard modularity,

- Design and production of forms for spare parts from plastic materials,

- Developing CAD/CAM models of a real spare part; manufacturing real models using 3D printing from models delivered in CAD/CAM form

- Realization of engineering computational tasks using CAE,

- Testing metallic materials featuring various surface treatments for contact fatigue; analyses of surface layer damages of metallic materials subjected to contact fatigue testing,

- Basic metallographic analyses of metallic materials following tribological testing,

- Measuring vibration on traction mechanism and follow-up analyses of vibrational spectra.

Places of work for science and research:

Laboratory of Sensorics- research profile: sensors based on magnetic microwires equipped with it own contact-less sensors for monitoring of the status of the so called „smart“ materials (objects).

Laboratory of applied magnetometrics- research profile: vectormagnetometrics - industrial and laboratory systems with original sensors, methods of measurement, intelligent processing and signal visualization.

Laboratory for diagnostics- research profile: testing resistance of materials to contact fatigue equipped with AXMAT and R-MAT instrumentation enabling testing materials for contact fatigue in axial and radial directions.

Unmanned aerial systems- research profile: testing sensorics of unmanned vehicles equipped with instrumentation for testing MEMS accelerometers, gyroscopes and magnetometers.

C. Department of Avionics

The scientific, research and development activities of the department is specialized basically in avionics, airborne instruments, electrical systems of aircraft, airborne radio and radio-technical systems and special systems of aircraft. Research and development are conducted in selected areas:

- to increase the share of international unification and certification of aviation training
- to modernize education and training techniques and technologies in aviation
- mathematical modelling and characteristics of aircraft cabin electronic systems
- to use the aeronautical radio altimeters to improve the safety of flight
- EMC on board of the aircraft
- an integration of satellite and inertial navigation systems, multi-sensory objects
- thermodynamic control of complex processes under the action of high pressures and temperatures

Science and Research:

- aircraft antenna systems
- intelligent cybernetic systems of aircraft
- improving precision of navigational parameters
- multidimensional systems featuring robust regulation units
- efficiency and economy of simulation models of complex avionics systems,
- research in intelligent algorithms of controlling and modelling complex aviation systems, electromagnetic compatibility on board of an aircraft,
- dependence on altitude of airborne aircraft systems ,
- solving problems related to controlling thermodynamical processes in aviation engines and their transfer into industrial fields of application,
- classical airborne navigation systems applied in other transport systems,
- anti-collision warning systems for small aircraft and helicopters,
- developing and analyzing radiation patterns of airborne antennas carried on aircraft and helicopters.

Cooperation offered for partners:

Laboratory of airborne antenna equipment

Compact attenuation chamber with instrumentation enabling measurement of antenna parameters up to 10GHz,

Specific equipment facilitating measurement and evaluation of the radiation pattern of antennas located on models of aircraft, helicopter or other means of transport

State-of-the-art SW enabling for the radiation pattern characteristic, measured and processed by the program, to be visualized and mutually compared.

D. Department of Flight Training

The department of flight training has currently two specialized departments. It is a simulator workplace for practical training of air traffic controllers LETVIS and advanced pilot trainer for the single light aircraft (Cessna 172). LETVIS is the simulator, which implements research on human factors in the air traffic control environment.

Science and research:

- research conducted in the field of designing and optimization of final approach routes with different navigation infrastructure.
- research in the field of implementing new technologies, work procedures and safety measures that follow from the European project, the Single European Sky (SESAR)" in the air traffic control environment.
- research in the field of air transport safety.

Cooperation offered to partners of the trade:
- Research in the field of designing and optimizing the routes of final approach at airports with different navigation infrastructures,
- Research in the field of implementing new technologies, work procedures and safety measures that flow from the Pan-European project of the „Single European Sky (SESAR)„in the air traffic control environment
- Research in the field of air transport safety.

Places of work for science and research:

Flight simulator room

Equipped with two types of flight simulators:
1. Single-engine light training aircraft (Cessna - 172)
2. Two-engine propeller aircraft with onboard instrument flying outfit

Flight simulators to be used for research in the field of air traffic safety when approaching and landing on airports not equipped with powerful ground navigation aids.

Virtual simulation environment for the air traffic controller

Optimization of flight routes, modelling the air traffic flow, research runway and sector capacity,

Airport management area, ATC staff to-Technology Interface.

E. *Department of Aerodynamics And Simulations*

The department is focused on modelling and simulation in aviation, together with the use of panel methods for optimizing the design process of aircraft and propellers. Applications of operations research in aviation are aimed at creating mathematical models and optimization problems of aviation and numerical methods in aerodynamics with emphasis on the development of e-learning in selected types of study programmes. Another part of the department staff in training work investigates the magnetic properties of amorphous and nano-crystalline materials (microwires) and basic physical properties of systems containing magnetic nanoparticles (magnetic fluid and ferronematics) and their application possibilities.

Science and Research:

- modelling and simulations in aviation using panel-based methods when optimizing the design process of aircraft and propeller
- developing mathematical models and optimization problems of air transportation and numerical methods inaerodynamic with emphasis on electronic education in selected study programmes
- physical properties of systems containing magnetic nano-particles and their applicationalpotentionals
- magnetic properties of amorphous and nano-crystalline materials (microwires)

Cooperation offered for partners:

Solving problems related to the use of linear programming, computational methods when digitizing airflow and methods of research aircraft performance and aircraft flight characteristics,

Research conducted the properties of amorphous and nano-crystalline materials giving us the possibility of offering our applications in civil engineering, mechanical engineering linked with the use of various sensors for sensing temperature, pressure, magnetic coding, strength and elasticity of structures,

Solving problems using software (ANSYS, FLUENT) CFD simulation of the external aerodynamics in 3D , aerodynamic design of aircraft, unmanned aerial vehicles and flying models,

Making use of magnetic fluids as insulating and cooling media in power transformers.

Places of employment for science and research:

Aerodynamic laboratory – prototype shops - research and expert opinions on order.

Laboratory of hydromechanics and thermomechanics - scanning and evaluation of measurements and evaluation of the basic properties of fluids and gases.

Airport – simulation centre - solving problems related to 3D modelling and simulation of airport processes.

F. *Department f Air Traffic Management*

The department is responsible for teaching subjects focused mainly on the area of management, organization and supervision of air traffic operations, economics and the rights of airline management specializations with emphasis on: management and marketing of airlines, economic problems of airlines, problems of organizing activities of airports, and economic activities of airports

Science and Research and cooperation offered partners of the trade

1. Analysing and modelling of aviation activities.
2. Analysing capacity issues of air transportation.
3. Analysing of the efficiency of aviation equipment operation.
4. Developing functional models of aviation companies.
5. Prognosing the development of airlines and airports.
6. Optimization of the organizational structures of airlines and airports.
7. Research in the aspects of safety within the air training of student pilots.
8. Research in the field of practical preparation of air traffic controller students with focus on air traffic safety.

IV. Conclusion

One of the elements of quality and inclusion of the educational institutions in the system of university ranking is also a systematic development of science and research and the transfer of knowledge into the learning process. Development cooperation in the listed areas of individual departments and lecturers will not only create conditions for the development of high quality material base, but also for scientific growth, motivation and systematic training of young scientists and educators.

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Requirements affecting decision on aircraft selection for an airline fleet

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Abstract— **The contribution is emphasizing the need to perform an analysis as part of selecting aviation equipment. More exactly, it is pointing out the need to analyse aircraft in terms of airline planning, economics and finance. The issue of selection and renewing airline fleet is of high importance, consequently detailed approach is to be adopted in the process of planning for**

Keywords- aviation equipment; aircraft selection;analysis aircraft; fleet airline planning

I. INTRODUCTION

These days, air transportation belongs to the most regulated branch of industry. It is common knowledge that the selection of an aircraft mostly depends on traffic requirements for over a period of time, its cargo carrying capacity and flight range. However, success in the current competitive business environment is no longer guaranteed by selecting aircraft fleet solely on the basis of operational requirements. At that a great amount of factors such as market requirements, political situation, company strategy, purchasing power of the population, the existing fleet structure etc are to be taken into consideration. It being a rather complex process, one has to assess all the criteria of airline fleet procurement, which in the future might affect the operation of an airline company. Consequently, planning and analysing the process of the fleet selection remains a must.

II. PHASES OF FLEET PLANNING

As it is a rather complex process, one has to bear in mind all the criteria and attributes of aviation equipment procurement, which could in the future affect operation of an airline company. Planning in itself, as by Deloitte, can be divided into three phases namely into strategic planning, assessing implementation and negotiation.[1]

A. Strategic alignments

What is our total fleet requirement (number and type of aircraft)?

- forecast demand (passenger/freight),
- forecast supply-demand balance,
- target operating model.

Should we maintain upgrade or replace our existing fleet?

Strategic drivers:

- competitive pressures,
- target network strategy,
- future passenger traffic on routes.

Market drivers:

- fuel cost and fuel cost volatility,
- carbon cost and carbon cost uncertainty,
- lease length.

Which aircraft frames and engines should web e considering?

- range of available frame and engine options,
- optimisation of fleet portfolio with respect to network strategy and cost considerations,
- evaluation of options that offer flexibility.

B. Implementation considerations

How do we optimise the phasing of introducing new aircrafts?

- bridging requirements between current and future fleet,
- uncertainties in delivery timetables,
- leasing constraints,
- implementation considerations.

How do we minimise implementation costs?

- MRO set-up and contract,
- retraining crew,
- reconfiguring ground services.

How do we finance our aircraft?

- proportion of aircraft purchased versus leased,
- any residual value from disposal of existing aircraft,
- impact of the phasing of aircraft on financing.

C. Negotiation support

How do we compare between different manufacturer packages?

- evaluation of non-comparable offers,
- evaluation of negotiable trade-offs e.g. between cost of aircraft and MRO contract or extended warranties.

How do we maximise value in our negotiations with manufacturers?

- granularity to model cost and benefits of different components of packages,
- flexibility to turn model around quickly during negotiations.[1]

III. AVIATION EQUIPMENT IN USE

In order to ensure transfer of cargo and passengers, airlines makes use of a wide range of aviation equipment. To this end, they can choose from among small, regional turbo-prop aircraft to wide-body, long-haul aircrafts. The best known manufacturers are the European Airbus Industries and the Boeing Company form the USA, each of them having its own philosophy, vision for the future and marketing strategy. Every year the media is full of reports on the rival fighting between them in terms of the aircraft numbers ordered and delivered. As for the order, the year of 2012 was not in favour of the European manufacturer. As reported by the SME daily as of 5th October2012, the Airbus obtained half of the orders as did its rival the Boeing Company. Of the published data it follows that the Airbus Industries has sold between January and September as much as 437 aircraft, whereas the Boeing Company has managed to sell 962 for the same period of time, with the cancelled orders excluded. Figure 1 is a survey of orders placed with both of the top manufacturers.[2]

Slovak operators preferred Boeing and since 1991 the Aircraft register of the Slovak Civil Authorities has recorded 70 transport aircraft of which 71% came from the same manufacturer. The one-time biggest operator in Slovakia, the SkyEurope Airlines operated as much as 24 aircraft made by Boeing, making up 34% of the total number of airliners.

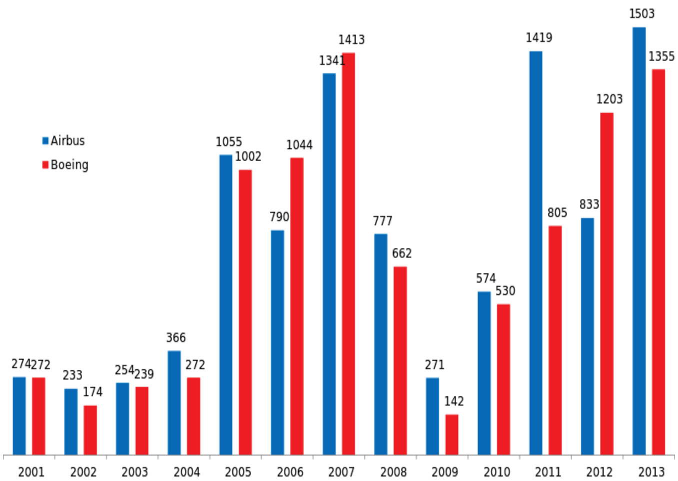

Figure 1. Airbus, Boeing net orders[5]

IV. EVALUATION AND SELECTION OF THE AVIATION EQUIPMENT

Economy, reliability and safety of operation are the requirements established by airline companies so as to ensure the highest possible level of and quality of aircraft while achieving maximum profitability, coverage of flights within the technical capabilities of the types selected. At that they must offer potential for reducing the market area of the competitors, continuous and seamless introduction of new technologies and innovations and raise the professional level of the airline staff.

In practical life, airline companies are often facing the dilemma of renewing or extending their fleet. Evaluation and the subsequently selection of aircraft might seriously affect the existence of the company itself. Therefore, managers must perform and evaluate several analyses so as to acquire the most precise data for decision making on aircraft selection. That is why it is important to follow a process of aviation equipment selection based on the analyses as follows:

- Aircraft analysis,
- Planning analysis,
- Economic analysis,
- Financial analysis.[3]

A. Aircraft analysis

Operating costs are directly influenced by lots of technological aspects, consequently, an aircraft analysis should involve:

- performance analysis oriented on evaluating

aircraft capabilities along specific routes as part of a network of flights of the operator governed by the operational conditions of the separate stages. Output parameters are payload, fuel consumption and duration of flight. When assessing the different types, it is important to consider not only the aircraft characteristics and performances but also those of the corresponding airports, which often appear as factors limiting the operation of some types of aircraft. Here, parameters such as length of runway, elevation, reference temperature are to be considered as well,

- comparison of aircraft involves mutual evaluation

of performance characteristics of the selected types and those, which are successful in meeting the requirements established for the routes, to be further investigated, i.e. by reducing the analysis on aircraft on a shortlist, mostly involving comparison of technical and economic aspects of operation.

B. Planning analysis

Already the very first flights required the aviation equipment to be evaluated on the basis of repeated operation while respecting passenger demand and the sufficient level of care for flight crew and the equipment used. It resulted in the need to generate a harmonic programme to form the basis of an air carrier, a document otherwise termed as the flight schedule.

In order for the flight schedule to be feasible in terms of operation and market attractiveness, its development is a rather difficult task. The team or originators are required to set up an operationally viable plan, which minimizes the effect of necessary compromises. A flight schedule plan should:

- meet the requirements of the seasonal demand while enabling optimal load factor of the aircraft capacity and taking into account the continuous transition from /to rush hours of operation,
- enable changing aircraft depending on the capacity without changing the flight schedule,
- facilitate transfer of cargo in via a network of flights,
- respect the seasonal nature of transportation.

Optimization of the flight schedule is the basic aim of every airline company and should deserve maximum attention. It is determined by the conditions under which operation is performed, the market at which the passengers are oriented. Optimization of the flight schedule should involve commercial, technical and operational aspects.

C. Economic analysis

Economic evaluation of the renewal or development of the aircraft fleet are the crucial tasks of determining functional dependence on costs. Assigning cost items is seldom unambiguous and some of them could be attributed to several areas. Most of the accounting systems used by the airline companies are designed for budgeting and reporting purposes, neither for selecting aircraft nor for development of the airline fleet.

Economic evaluation of the aviation equipment selection is to be focused on direct costs of operation., which vary with the types and also affected by aircraft design, mass, price and other technical parameters. To this end direct operating costs are to be divided into fix (independent of aircraft operation) and those variable ones (dependent on the use of aircraft). Included among the direct operational costs are salaries and costs of the pilots, aircrew, fuel, airport charges, navigation and route charges, aircraft maintenance, depreciation and insurance of the aircraft.

D. Financial analysis

These days, airline companies face several financial issues, which in the strong competitive environment gain on importance when compared to a regulated market where even performance aspects are given less consideration. The problems usually involve:

- profitability – capability of the company in terms of generating profit,
- financial strength – capability of the company to raise capital thus meeting management objectives,
- flexibility – capability of the company to react and act in response to the changing conditions of operation,
- market share or the market presence – capability of the company to successfully compete at specific markets.

In view of the airline company, aviation equipment is representing its long term assets, often used over 15 or 20 years, thus being of high financial impact. For this reason, it is advisable to develop several financial plans (projects), which will represent some kind of aircraft types. Should the airline company feel ready to go for one of the types, then the projects will be involve ways of acquiring the new aviation equipment (by way of purchasing or leasing). Following a thorough evaluation of the separate variants, the managers of the airline company will decide in favour of the most advantageous way of acquiring the equipment.[3]

V. Environmental limits

Aircraft noise is the most significant cause of adverse community reaction related to the operation and expansion of airports both in developed and developing countries. Aircraft coming off the production line today are about 70% quieter than they were 50 years ago and the aircraft manufacturers are working to reduce this even more. The noise generated by aircraft creates problems in making decisions regarding airport layout and capacity. The correct assessment of future noise patterns, to minimize the effect on surrounding communities, is essential to the optimal layout of the runways.

Annex 16 issued by the ICAO is providing a maximum allowable level of noise. Contained in the material are five noise categories covered by Chapters I.-V. The maximum allowable level of noise depends on their MTOW. Aircraft listed under Chapter I. are the noisiest ones, deprived of landing rights or offered limited access to a great number of airports. Chapter I. and II. involve aircraft made by former Soviet and Russian manufacturers. Chapter III. corresponds to European and World-wide standards.

Aircrafts' noise emissions have local and regional impacts, especially areas close to airports. The Advisory Council for Aviation Research and Innovation in Europe (ACARE) defined long term goals for the European aviation sector. The ACARE objectives and a related vision "Flight path 2050 Europe's Vision for Aviation" aim besides improved safety, reduced emissions and energy consumption also for reduced aircraft noise. A short to medium term goal by 2020 is a 10 dB noise reduction per movement and a maximum noise level of 65 dB at the outer limits of an airport. The long term goal is a 15 dB noise reduction per movement by 2050 (ACARE, 2012). The Fig. 2 below shows of aircraft types operating in Europe, aircrafts' capacities also shows ACARE's aircraft noise reduction goals for 2020 and 2050 for the different aircrafts (ACARE, 2012). [4] [6]

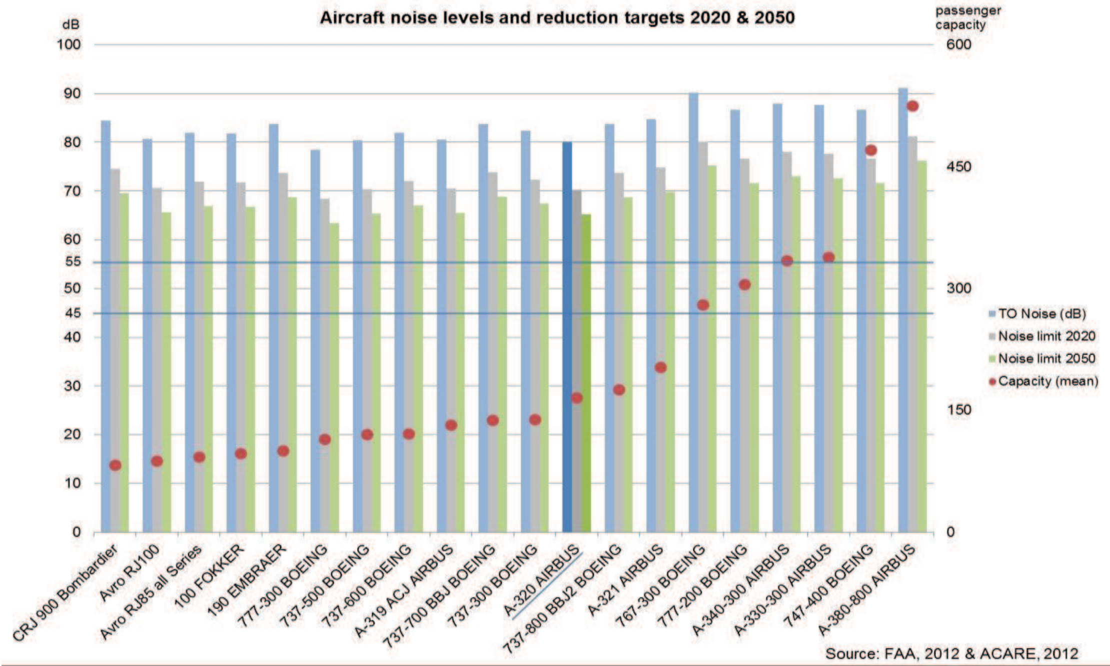

Figure 2. aircraft types operating in Europe, aircrafts' capacities and current take-off noise levels[6]

VI. CONCLUSION

Issues related to the selection and renewal of the aircraft fleet are high on the agenda. Airline companies evaluate its quality using various criteria such as the average age of the aircraft fleet, looking of the aircraft, maintenance, cockpit outfit and technical aspects as well.

Modernization of the airline fleet forms inevitable part of the drive for higher quality in providing passenger services, operational safety and competitiveness in the air transportation market, of course. The advantages of new generation aircraft are in higher payload, a source of higher revenues, as well as higher speed and flight range with potentials for further extension of the network of flight lines. Another advantage is in ecologically „cleaner" operation meeting the strictest ICAO requirements established for noise and emissions. At that, they offer higher standard of the cockpit, wider spectrum of on-board services and improved operational safety as a matter of fact.

Aircraft characteristics significantly affect airport layout factors, including the number, orientation, and configuration of runways, the types and strengths of pavements, the dimensions of parking aprons, taxiways, holding bays, and so forth and the design of passenger and cargo terminal areas.

The aim of the article was to offer the reader a closer view onto the need for planning and performing analysis in the process of selecting a suitable aviation equipment. It is a long and complex process, during which considerations should involve not only the parameters of the given aircraft types and the operational costs but also the passengers to be carried. Proper selection of the aviation equipment and planning of flights will eventually result in higher financial returns and customer satisfaction.

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Information Basis of Operational Reglations in Civil Aviation and its Practical Application

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The text contains an overview of a project of Ministry of Transport of Czech Republic for creating Information Basis of Operational Regulations in Civil Aviation. Following paragraphs provide information about whole concept and show key ideas necessary for understanding such software.

Second part of this text will discuss possible usage at Air Navigation Services of Czech Republic.

K e y w o r d s: civil aviation, division of regulations, electronic regulations, information basis, operational regulations, pdf file

I. INTRODUCTION

Information Basis of Operating Regulations in Civil Aviation (IBORCA) is a grant research project of Ministry of Transport of Czech Republic.

This projects primary goal is to develop specialised software - IBORCA, which is going to contain possibly the most complex database of regulations, directives, conventions etc. Secondary goal is to create methodology for developing and operating such software.

Due to large number of regulations and other normative acts in civil aviation exists a demand for a software tool which allows its users to search and find relevant information above all possible documents. This software shall be quick, easy-to-use and reliable source of information about current (up-to-date) regulatory framework in civil aviation.

It is believed that this software is going to find its users among institutions such as CAA CR, Civil Aviation Department of Ministry of Transport CR etc. Other possible users are universities focused on civil aviation. Further development of this software promisses opening this software to public use.

Ministry of Transport recognise the potential of this software as a tool to improve quality of education of aviation personnel.

Project IBORCA has 3 partial goals:

- system analysis and creating system architecture
- creating methodology for developing and operating a software such as IBORCA
- coding and testing IBORCA and deploying final version

Solving team is created by 3 subjects:

- Faculty of Transport Czech Technical University Prague
- Faculty of Mechanical Engineering Brno University of Technology
- Sting Academy – Private university Brno

It is necessary to define term “operating regulations”. There is no official definition of this concept. For the purpose of project IBORCA this definition will be used: “Operating regulation is any regulation which has direct application on subjects participating in every-day operation of civil aviation”. This broad definition allows authors to integrate specific documents according to presumed needs of users. It also allows extending the database by new regulations.

II. DIVISON OF REGULATIONS

In respect of large number of regulatory documents in civil aviation it is considered to be necessary to divide all documents into categories which will be representing interests of potential users. Due to their different needs authors have chosen three ways of division of operating regulations in civil aviation:

- according to Area of Operation
- according to Act on Civil Aviation
- according to Series of Regulations

These three ways create representative division which respects the structure of civil aviation and also allows easy orientation for users.

<u>Division according to Area of Operation</u>

This division is based on projects assignment.

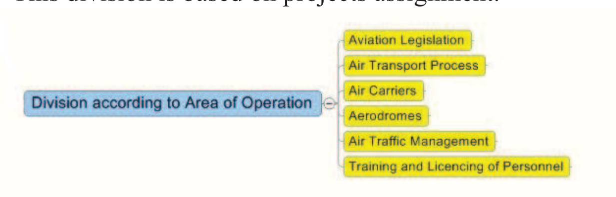


Figure 1 – Division according to Area of Operation

Division according to Act on Civil Aviation

Act on Civil Aviation is a basis of second division which is supplemented by Europian Community Law and small number of other topics.

Figure 2 – Division according to Act of Civil Aviation

Division according to Series of Regulations

This division is based on existing database systems (e.g. lis.rlp.cz). It is probably the easiest and most comfortable (well-known) division.

Figure 3 – Division according to Series of Regulations

Division according to Series of Regulations is considered to be basic division in IBORCA. However user will have the opportunity to switch among them. Divisions overlap - every document in IBORCA shall belong in every division in at least one category. For example document L 4444:

Division	Category
Area of Operation	Air Traffic Management
Act on Civil Aviation	Utilization of Czech Airspace and Air Services
Series of Regulations	L - Serie

Table 1 – Categorization of L 4444 document

These 3 divisions will be the only divisions in IBORCA, however it is possible to change categories (add, rename, delete) in every division.

Due to IBORCAs primary goal as a research project we are unable to include paid documents and documents with restricted access. This leaves IBORCA as a database of open public documents (free documents). These documents we are able to maintain up-to-date without additional payments.

Based on described limitations authors decided to include documents from these sources:

- AIS CR
- Ministry of Transport CR
- Czech Aviation Authority
- EASA
- EUR-Lex – Official Journal

In respect of development of IBORCA it was decided to include only the most representative documents in each category. The system will be then supplemented with new documents according to feedback from its users.

III. DESCRIPTION OF A SYSTEM

Basic requirements were specified in the assignment of project IBORCA:

- search for a word (combination of words) with the possibility of a search with further criteria
- search above a group of documents
- search with lemmatization
- automatic search of a term in Czech and English language
- library of favourite documents for every user
- implementation of further documents

These basic ideas were (in analytic phase of project) transformed into document of requirements which specifies exactly what a system shall do.

IBORCA is considered to be a free access database. It is being designed as an information system with central data storage with internet access and web graphical user interface.

This creates a set of requirements on system itself which is being designed as a Document Management System (DMS).

Analysis of similar projects

A lot of states allow access to their legal documents through web interface, however search functions are limited. Typically it is not possible to search above all documents in a database. Also published documents correspond to area of responsibility of its operator (e.g. AIS CR or Ministry of Transport CR). So it is up to its users to find other relevant documents on its own.

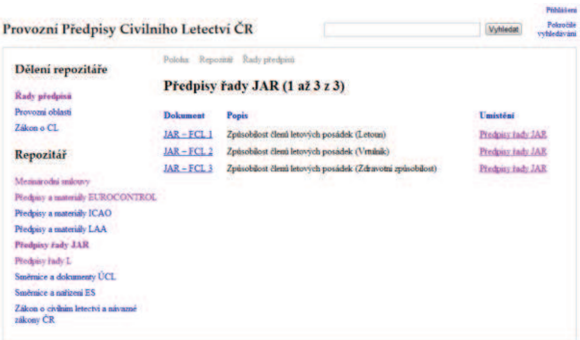
More advanced is EUR-Lex system which contains legal documents of EU. It allows search above selected group of documents, but is not user-friendly. There is also experimental system N-Lex which contains national legal documents of EU members. Due to its experimental status it is still under development and does not contain all relevant documents.

Commercial products are representing another solution. Well-known software is ASA Flight Library. It contains a large amount of publications, pictures and videos. Distribution is on a DVD with on-line updates. It contains only American legislation, but as a part of it are other studying materials. This is very good product in respect of user-friendly environment and its containt.

User interface

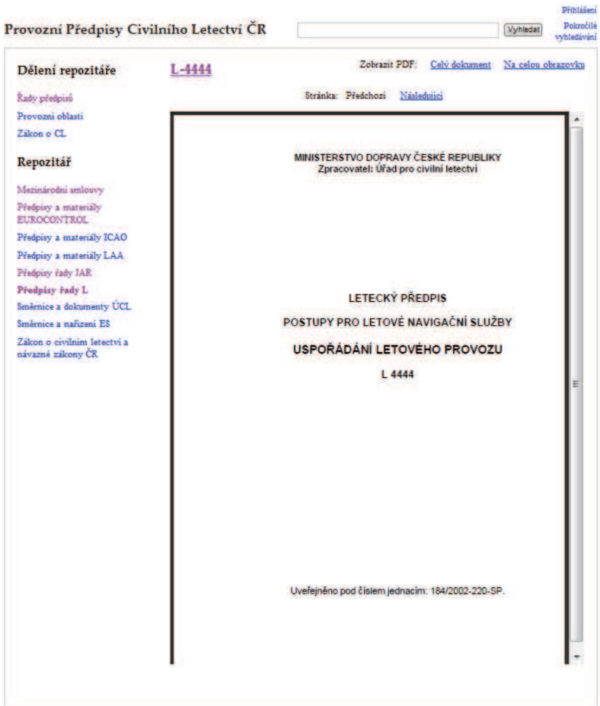
User interface allows users to find a specific document and list it through. Division of regulations discussed in previous chapter is a key to enable this function to users.

Other function of user interface is to enable search above documents and work with the results. There are few pictures showing user interface of this system:



Picture 4 - Selection of specific document

Picture 5 - Information about specific document



Picture 6 - Listing through specific document

Data format and search engine

Authors chose PDF file as a form of document in IBORCA. These files can be easily full-text searched. It is also easily displayed in web-browser. Most of the legal documents are distributed in pdf files, so they can be easily inserted into database without any additional conversion.

Very important role of IBORCA is to find specific word or combination of words in given regulations. For this purpose IBORCA is going to use full text search engine Sphinx. Other key part of this process is lemmatisation. This requires a creation of a lexicon of words from dictionary of common Czech words.

Metadata and key words

Metadata are used for increasing acurancy of searching process. For every document in IBORCA was created its own set of metadata. These are derived from Dublin Core Standard.

Every document has also its own set of key words and they are derived into 4 groups – Czech key words, English key words, Czech abbreviations and English abbreviations. Key words are also increasing accurancy of search process.

Key words were chosen from every documents set of definitions. Other possibility is to read every document and based on that choose adequate key words. This was not done due to limited timetable of this project.

IV. Practical Aplication

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

V. CONCLUSION

This article was to inform readers about project of Ministry of Transport of Czech Republic for creating Information Basis of Operational Regulations in Civil Aviation. Emphasis was given to key aspects of the project.

IBORCA is now fully operational but is not yet available for public use.

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Completion of Civil-Military Integration in the Czech Republic

Operation of OAT Flight Udner Control of Civilian Air Traffic Controller

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***Abstract*—Quite long process of civil – military integration was completed on the 1st May 2014 in the Czech Republic. The concept was several times changed as well as the date of its realization. Finally it has been done. To meet all requirements of the concept, to train up and exercise all the personnel providing air traffic services ATS to follow correctly legislations and regulations was the task for the realization team for the last 3 years. Now, the main idea "one airspace with one controller" is in operation as well as the principles of flexible use of airspace. The new way of provision of ATS to the Czech OAT military aircraft by civilian controller and the new division of airspace among ATS units has been reached.**

Keywords-civil-military integration, OAT (Operation Air traffic) Fligts, A-scramble, Air Traffic Controller, MACC, Air Traffic Services Provision, Super Low Sectors, Air Policing

Source: [6]

I. Introduction

Process of civil – military integration was established almost in each European country and is being processed in many variations. Also in the Czech Republic were decided about civ – mil integration already in 1993 (The brief history of project is described in section II.). The main ideas of the Czech way of integration were based on the Flexible Use of Airspace Concept (FUA) and the idea "one controller providing ATS in one airspace[1]".

The basis for the concept of is that airspace should no longer be designated as either military or civil airspace but should be considered as one continuum and used flexibly on a day-to-day basis. Consequently, any necessary airspace segregation should be only of a temporary nature.

The FUA Concept is based on three levels of ASM which have been identified in the Airspace Management Handbook (see [5]) as:

- Strategic ASM - Level 1 - Establishment of national airspace policy and structures,
- Pre-Tactical ASM - Level 2 - Day-to-day allocation of airspace and
- Tactical ASM - Level 3 - Real-time use of airspace.

For military IFR flights in Europe there exists a wide variety of national military ATM arrangements. Furthermore, the responsibilities for ATS to OAT-IFR flights are organized differently in every nation, ranging from fully integrated civil-military entities to separation between civil and military authorities with only limited co-ordination.

It is therefore important to ensure that whatever the organizations and the procedures are, the same level of service will be provided to OAT flights. These differences should be of no concern for the military airspace user as long as appropriately qualified personnel and suitable equipment is utilized for competent handling. [3]

The final product of civil – military integration in the Czech Republic is to move part of responsibility of Military ACC (MACC) to ACC situated in IATCC (Integrated Air Traffie Control Center) and to other military units such as CRC (Control and Reporting Center). In other words, it means to abandon MACC. All air traffic services shall be provided by civilian ACC (area control center) - not only to general air traffic (GAT) but also to operational air traffic (OAT). In the following sections are described the way and the operational use of new concept which has started on 1st May 2014.

II. Brief History of Integration

The process of civil-military integration was started in 1993 but all the time it was only about the collocation military ATCOs to the same control center together with civilian

[1] Before completion of civil-military integration, there were all the time civilian and military controllers both providing ATS in one shared airspace.

ATCOs. This aspiration was accomplished to construction of Integrated Air Traffic Control Center (IATCC) which was built and started operations in 2007 in Jeneč. According to contemporary plans, the IATCC should be integrated control center for civilian and military flights as well. Such kind of integration, which was planned in 2007, seemed to be more likely as collocation than integration because there were two ATCOs (civilian and military) providing air traffic services in one airpsace. Integration consists only in collocation all controllers to united center.

Although everything was prepared to start operation together in 2007 (civil and military ATCOs under one roof) the reality was different. From IATCC has been provided air traffic services by civilian ATCOs only. Military ATCOs were still located in own military units (MACC – Prague airport and military basis located at airports LKCV, LKPD, LKNA, LKNA and today already closed LKPO).

Finally in year 2011 was signed agreement between Ministry of Transport (file number: 574/2011-220-SP/2) and Ministry of Defense (file number: 1802/2011-5888) about the realization of integration of providing air traffic services. Based on that document shall be ATS provided by civilian controller not only to GAT flights but also to OAT – C[2] flights.

The realization team had to prepare complete operational procedures, training for each unit and publications related to the civil – military integration. The whole process of integration should finish in March 2013. By supplement number 1 was prolonged the term of realization to 31st March 2014. Finally the process was finished one month later on the 1st May 2014. How? See below.

III. Military Statistics

Before describing own process of integration, it should be also mentioned what is the amount of military traffic which is subject of integration. All military traffic flying as GAT flight type is also under control of civilian ATS units. In global rate there is minimum of military GAT traffic around the European countries in comparison with civilian commercial GAT traffic (data from year 2013). See table and graph below.

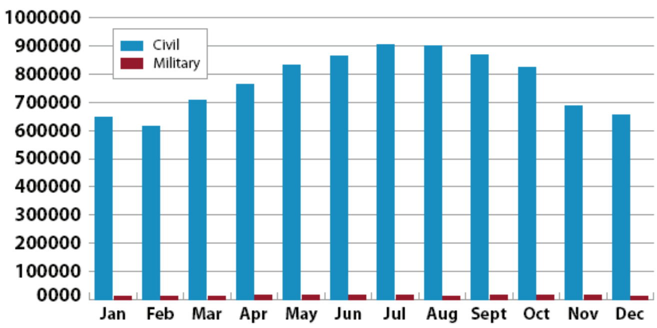


Figure 1. Civil and Military GAT in ECAC [3]Airspace

[2] OAT – C = operation air traffic - compatible
[3] ECAC = European Civil Aviation Conference

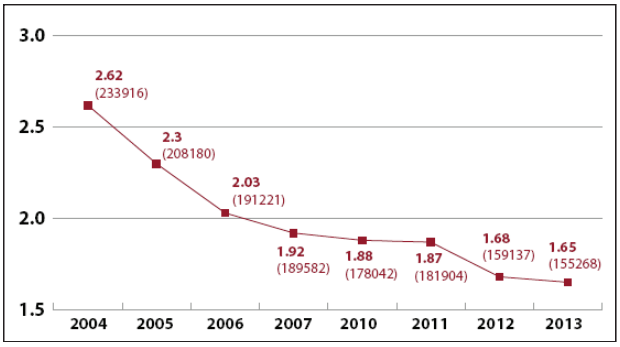


Figure 2. Military GAT as Percentage of Total Number of Flight (total number of GAT flights between brackets)

In the following table can be seen the number of Military GAT flights (per year 2013 and 2012) in the Czech Republic and its neighbour countries.

TABLE I. MILITARY GAT BY EUROCONTROL MEMBER STATE

Country	2013		2012	
	Flights	%	Flights	%
Czech Republic	1 110	0,94	1 341	1,12
Slovak Republic	140	0,12	157	0,13
Austria	2 525	2,14	2 347	1,96
Germany	2 995	2,54	3 618	3,02
Poland	6 995	5,89	5 601	4,68

Source: [1], [2]

In the table below, there are shown numbers of OAT flight in some European countries (the Czech Republic included). These flights are operated as OAT – S (special) flights in restricted areas (ATS provided by military unit) and as OAT – C (compatible) flight for the part of flight route from the basis to restricted areas (ATS provided by civilian ATS unit for such part). Terms OAT – C and OAT – S are explained in the following section describing OAT flights.

TABLE II. STATE AIRCRAFT FLYING OAT

Country	Total Number of OAT flight	Comparison with OAT flights in 2012	OAT as percentage of total military flight
Czech Republic	23 282	- 15 %	95,44 %
Germany	26 641	- 20 %	89,88 %
Sweden	24 500	- 9 %	97,45 %
UK	50 206	-7,14%	87,41 %
Croatia	Not provided	Not provided	93 %

When providing some statistics about total number of flights it should be also mentioned what types of aircraft are delegated.

TABLE III. EUROPEAN MILITARY AIR FLEET (CZECH REPUBLIC AND ITS NEIGHBOUR) – SEE NEXT PAGE

State	Combat Aircraft (fighters)	Transport Aircraft	Light Aircraft	Helicopt.	Total Count
CR	**32** (SB39, L159)	**17** (C295, L410, YK40, CL60, A319)	**4** (L39)	**52** (Mi8, Mi24/35, Mi17/171, W3A)	**105**
AU	**37** (Eurofight., Saab 105)	**3** (C130)	**20** (PCT, PC7)	**67** (Blackhawk, AB212, Alouette III, OH58)	**127**
GER	**212** (Eurofight. Tornado)	**83** (P3C C160, A310, A340, Global500)	**39 + 155** (T38, para mil)	**360** (CH53, Bo105, Tiger, UH1D, EC135)	**849**
SK	**12** (Mig29)	**2** (An26)	**9** (L39)	**19** Mi2/8/17)	**50***
POL	**128** (F16, Mig29, Su22)	**53** (C130, C295, An28)	**70** (PZL130ú	**248** (Mi2/17/24, W3A, SW4, SH2G)	**499**

*(in order 2 C295)

CR – the Czech Republic, AU – Austria,
GER – Germany, SK – the Slovak Republic, POL - Poland

IV. OAT Flights and Their Rules

In the following lines are listed rules and conditions for OAT flights. There were defined two groups of OAT flights. The first group are OAT – C flights and the other OAT –S flights (C = compatible, S = Special). See the definitions below:

- OAT – C (compatible) - is military flight (or its part) which doesn´t require segregation from other air traffic. It can be operated only within FIR Praha. Messages (FPL and related msgs.) are not sent to IFPS.
- OAT – S (special) - is military flight which needs segregation from other air traffic or special handling. Such flight is controlled by military air traffic services providers.

A. Basic characteristics of OAT flights and its definitions

TABLE IV. Comparison of OAT – C and OAT – S Flights

OAT – C	OAT – S
ATS are provided by civilian controller.	ATS are provided entirely by military controller.
FPL has to be filled for IFR and VFR flights.	FPL is not filled.
FPL is not sent to CFMU (is never subject of flow management).	Provided only in special segregated area (TRA, R, TSA).
Flight profile very similar to GAT flights – they are provided the "common sense" way to GAT flights.	Flight profile and characteristics are out of range for common GAT flights.
Provided only inside FIR Praha (never outside of the Czech republic)	

B. OAT – C flights identifications

Each OAT – C flight has specific identification (field 7 in FPL) which is related to aircraft type and mission of the planned flight. In the table 2 below can be found complete list of identification for OAT – C flights from military basis[4] in the Czech Republic.

TABLE V. List of OAT – C Flight Identifications

Military Basis	A/C type (ICAO code)	Identification (FPL)	RTF Callsign
24. zDL LKKB (Kbely)	A – 319	DPHIN	DOLPHIN
	CL 60	TSHRT	TSHIRT
	YK 40	JKIL	JACKIL
	C - 295	SMGLR	SMUGGLER
	L - 410	CABBY	CABBY
		GRZL	GRIZLY
		FOTO	FOTO
		CLBRA	CALIBRA
	Mi - 17	GASTN	GASTON
	Mi - 8	SALON	SALOON
	W3A	HANDY	HANDY
		HLPR	HELPER
21.zTL LKCV (Čáslav)	SB 39	CF	CHARLIEFOXTROT
		MDEN	MAIDEN
		SILVO	SILVO
		SPRHD	SPEARHEAD
		LION	LION
	L - 159	BUTCH	BUTCHER
		PLUTO	PLUTO
		GOLEM	GOLEM
		PEGAS	PEGAS
		ROBOT	ROBOT
22. zL LKNA (Náměšť nad Oslavou)	Mi - 24/35	GPRD	GEPARD
		WOLF	WOLF
		PERUN	PERUN
	L - 39	PRCHR	PREACHER
		SHPRD	SHEPERD
		CBID	CARBIDE
		SNAKE	SNAKE
	Mi-17/171	HIPPO	HIPPO
LKPD (Pardubice)	EV-97	CANDY	CANDY
	Z-142	BASIC	BASIC
		BABY	BABY
		BCOTT	BOYCOTT
	L-39	HONEY	HONEY
		BTLE	BEETLE
		DAISY	DAISY
	Mi-2	HPER	HOPPER
		PENNY	PENNY
		GOBI	GOBI
	Mi-17	GMLT	GIMLET
		SHKR	SHAKER
		DSTER	DUSTER
	L-410	CTTG	COTTAGE
		BUDDY	BUDDY

[4] There are several military basis in the Czech Republic: LKCV, LKPD, LKNA, LKKB

C. FPL for OAT flights

As it was already mentioned, for each OAT – C flight must be filled FPL. But each OAT – C flight can also contain OAT – S part (ATS provided by military unit for such part of the flight). OAT-S part of flight is in FPL unambiguously defined by STAY indicator (as it is defined in Doc 4444).

For OAT flights it can be used in field 15 of FPL (flight route) also identifier DCT (direct) between significant points. Flight plan route can consist of coordinates too. All these specific elements are not allowed for GAT FPL in the Czech Republic. In the table below can be found examples of FPLs for OAT – C flights which include OAT – S parts.

TABLE VI. EXAPLES OF IFR OAT – C FLIGHT PLANS (FPL)

```
(FPL-CF01-IF
-2SB39/M-SDIRUY/C
-LKCV0000
-N0510F150 VLM DCT NELPA DCT KARE STAY1/0005
   KATO/N0490F240 DCT
493922N0150257E/N0500F360 DCT DONAD DCT DIVUK
   STAY2/0005 NEVUS
-LKCV0046 LKPD LKKB
-OPR/21 PBN/B5 STAYINFO1/FLIGHT THROUGH TRA
   77,78,79,80 STAYINFO2/ACTIVITY IN TRA70
   DOF/140416 RMK/TEST OF CIVMIL INTEGRATION CS
   CF02 A2455 REG/9240 9241
-P/001)
```

```
(FPL-TSHIRT02-IF
-CL60/M-SDIRUYW/S
-LKKB0000
-N0250F090 EKROT DCT GOLIN DCT ORLIX DCT TBV DCT
   HLUB STAY1/0003 DOMA/N0250F110 DCT BAXEV DCT
   4944N01759E DCT HLV DCT BNO/N0250F090 DCT RADKA
   DCT JAROM DCT 4904N01518E DCT MLAK STAY2/0007
   CIME DCT 4948N01251E 5005N01246E DCT DIKVA DCT
   KARO STAY3/0002 PRUN DCT RAK DCT EKROT
-LKKB0240 LKCV
-STAYINFO1/FLIGHT THROUGH LKR3 STAYINFO2/FLIGHT
   THROUGH TRA77,78, 79 STAYINFO3/FLIGHT THROUGH
   LKR4 PBN/B5 OPR/21 DOF/140423 RMK/TEST OF CIVMIL
   INTEGRATION COOP GCI
-P/002)
```

The example of FPL above (in table III.) there are all aspects of OAT – C flights (including OAT-S parts defined by STAY indicators).

To recognize that the FPL is for OAT flight, it is defined by specific letter "F" in filed 8 of FPL (flight type). It is also obvious that in flight plan route there are not so common fix names as published in AIP CR (4 letters codes in filed 15 such as PRUN, KARE, KARO, KATO). These names are published only in military aeronautical information publication (MIL AIP, ENR 4). They serve as entry and exit fixes to/from restricted areas which are allocated for OAT activity of OAT flights (OAT – S parts). In the figure 3, there are depicted in the map these points (green colored fixes/points on the boundary of temporary restricted areas). List of these points is in table IV. with its coordinates. When focus more precise for the name of 4-letter points, it can be recognized that the name is abbreviation of geographical location (name of the closest town or village as it can be seen in table)

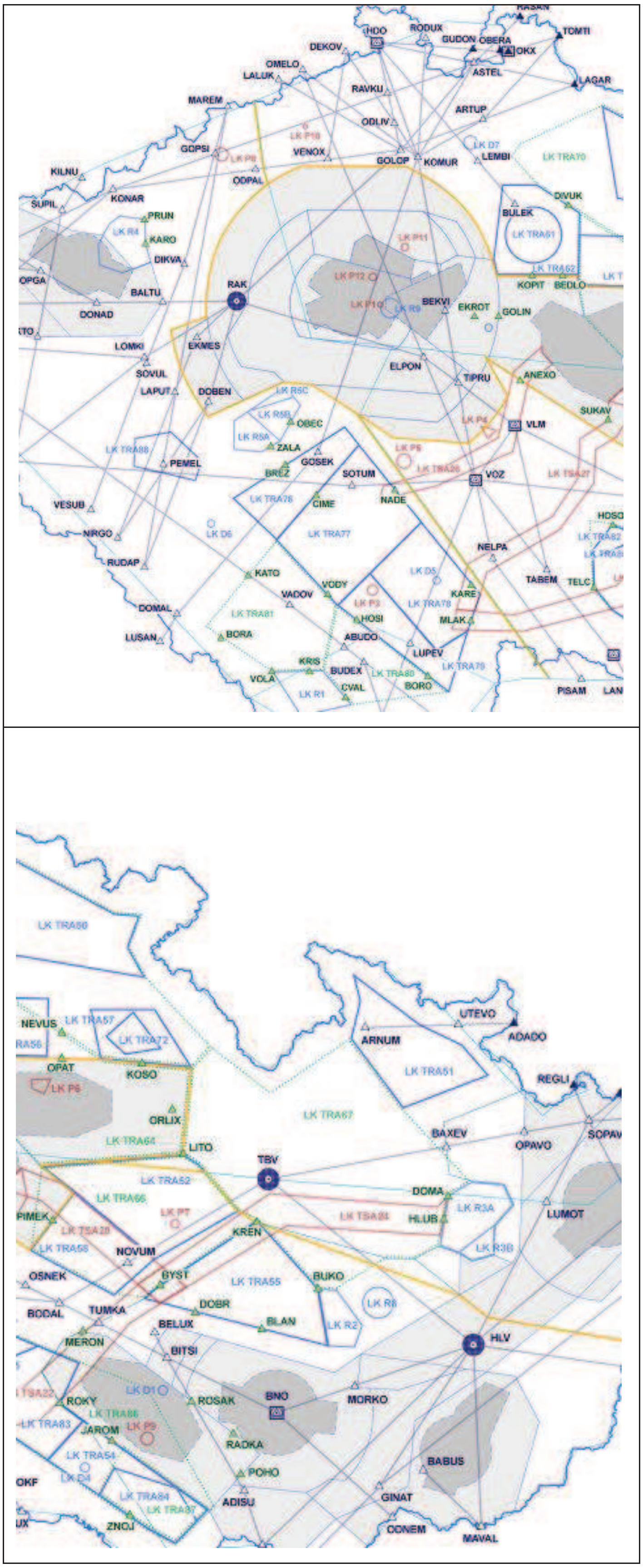


Figure 3. Entry/exit points to restricted areas allocated for OAT activity

TABLE VII. ENTRY/EXIT FIXES TO/FROM RESTRICTED AREAS FOR OAT FLIGHTS ACTIVITY

Point name	Geographical location	Restricted area (LK…)
KARO	Kadaňský Rohozec	R 4
PRUN	Pruněřov	
CVAL	Chvaletice	R 1
KRIS	Křišťanov	
VOLA	Volary	
BORA	Borová Lada	TRA 81
CIME	Čimelice	TRA 76 / TRA 77
BREZ	Březnice	TRA 76
NADE	Nadějkov	TRA 77
KARE	Kardašova Řečice	TRA 78
MLAK	Mláka	
BLAN	Blansko	TRA 55
DOBR	Doubravník	
BYST	Bystřice nad Peršt.	
BUKO	Buková	R 2 / TRA 55
HLUB	Hlubočky	R 3
DOMA	Domašov	R 3 / TRA 67
HOSO	Hošovice	TRA82 / TRA85 / TRA86
TELC	Telč	TRA 85
ZNOJ	Znojmo	TRA54 / TRA84 / TRA87
OBEC	Obecnice	R 5 B
ZALA	Zalány	R 5 A
LITO	Litomyšl	LKPD
KOSO	Kostelec nad Orlicí	LKPD
OPAT	Opatovice nad Labem	LKPD/LKCV
KATO	Kašperské hory	TRA 81
POHO	Pohořelice	LKNA
ROKY	Rokytnice nad Rokyt.	LKNA
VODY	Vodňany	TRA 81
HOSI	Hosín	TRA 80
BORO	Borovany	TRA 80
KREN	Křenov	TRA 55, 66, 67
PROS	Prostějov	R 6

Note: these points are published only in MIL AIP and they are known only for pilots of OAT flights and for controllers providing ATS. These points are not available for GAT flights.

V. AIR POLICING, ALPHA – SCRAMBLE FLIGHTS

Almost each country (member of NATO) secures its airspace by own facility. Only 7 countries don´t have own hypersonic combat flights (Albania, Estonia, Iceland, Latvia, Lithuania, Luxembourg and Slovenia) and air policing is provided by neighbor countries which are NATO member.

If there is threat of attack at peace times, RENEGATE concept is activated (for example in case of unauthorized entry to FIR Praha – without clearance or with no radio communication). This is time for QRA – Quick Reaction Alert aircraft. This is notation for the group of combat flights (in our case the group of two Saab JAS-39 Gripen (see figure 4) which has to in very short time take off f due to air policing.

Figure 4. Saab JAS-39 Gripen (ICAO code SB39), QRA flights

The activity of these flights can be clarified in general as follows:

- Alpha Scramble – flight for air defense to unknown aircraft in our airspace
- Tango Scramble – training flight

In case of non standard situation in our airspace, there is rendered a decision to QRA for immediate take off to identify litigious target. QRA and other military flights in our airspace were controlled by MACC and civilian controllers have to follow airways strictly in case of air policing so far (before 1st May 2014), no directs were allowed and every discrepancy and deviation from flight plan route had to be coordinated between civilian ATS center with military one(MACC).

After 1st May 2014, MACC is no more on duty therefore there was created new concept of air policing based on precise cooperation between ACC and other civilian ATS units with Control and Reporting Center (CRC) which is responsible for provision of ATS to QRA (A- scramble) currently.

To protect and separate other civilian GAT flights from QRA flights proceeding via the shortest way to intruder, there are created areas with special status and operation modes. These areas are created around the intruder and around the QRA. (see paragraph A and B for explanation)

A. Area of Active Coordination

This area is created around QRA flights (group of two SB39 squawking SSR code in mode A 1311 and 1312) and it has radius of 20 nautical miles (NM) around the QRA and vertically it is defined the height 5000 feet above and below QRA (see figure 5).

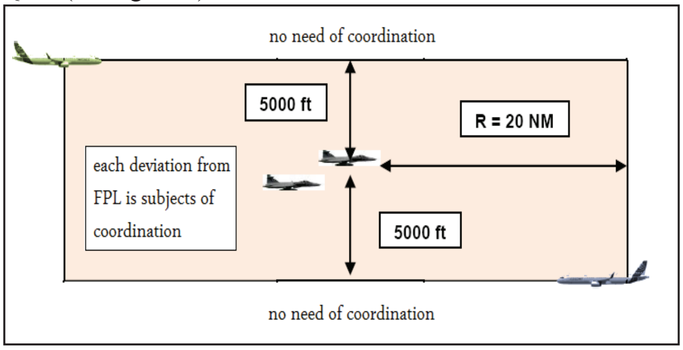


Figure 5. Area of Active Coordination

Because QRA are under control of military controller (intercept controller in CRC) and the rest (all other traffic) is under control of civilian ATS unit, each aircraft flying in area of active coordination is subject of coordination between civilian and military controller. The traffic outside area of active coordination flying through FIR Praha there is no need coordination between civilian and military controller and directs and other shortcuts are allowed. This concept is much easier for user than it was before 1st May.

Figure 6. Area of Active Coordination – ATCO´s surveillance screen **(SVR740 – subject of intervention, 1311 and 1312 – QRA = Air Policing)**

Civilian controller at each working position has visualization of this area in surveillance screen around QRA targets squawking A1311 and A1312 to identify special area of active coordination (see figure 6). Complete list of the SSR codes which initiate depiction of area of active coordination in the surveillance screen for controllers is in the following table.

TABLE VIII. SSR CODES FOR QRA AIRCRAFT

SSR codes (mode A) of QRA (A/T-scramble)	
QRA aircraft of the Czech Republic	**1311** **1312**
QRA aircraft of the Czech Republic – training of intervention	**2456** **2457**
QRA of Germany	**1305** **1306** **1323** **1324**
QRA of Poland	**1317** **1320**
QRA of the Slovak Republic	**1326** **1327**

B. Area of Intercepetion

Area of interception is defined as no fly zone around the intruder. It is defined as space horizontally radius 10 NM around the intruder and vertically 4000 feet below and above the intruder (see figure 7). This area is also depicted (dashed line) in the figure 6 (around SVR740 flight).

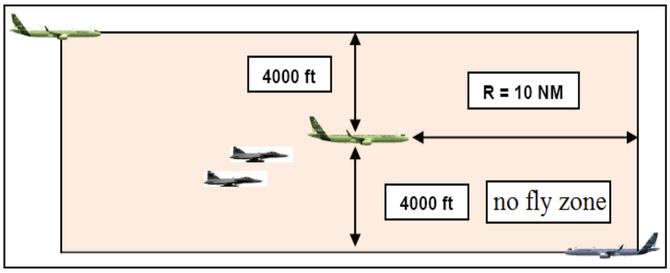


Figure 7. Area for Interception

In the figure 7 it can be seen the interception of QRA (2x SB39 to intruder and area which is blocked as no fly zone for intervention of quick reaction alert aircraft.

Figure 8. Ilustration of QRA intervention

Identify applicable sponsor/s here. *(sponsors)*

VI. Airspace Changes – Super Low Sectors

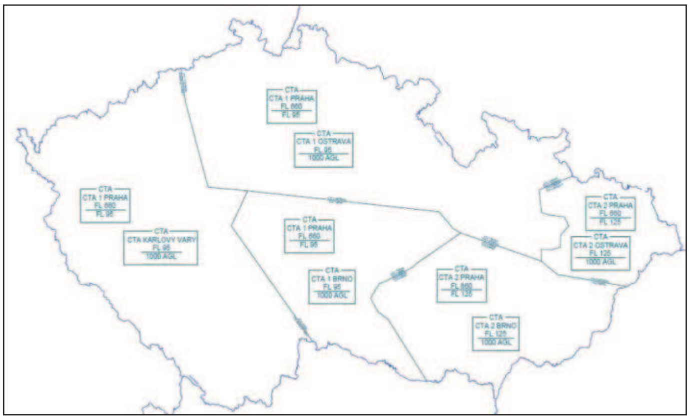
In the section IV it is mentioned that FPL for OAT - C flights are not distributed to IFPS. In other words it means that OAT – C flights are never subject of flow control. It can very easily happen (especially during plentiful military activity) that some sectors of ACC or other ATS unit can be suddenly overloaded without warning and chance to avoid such situation. CFMU (Central Flow Management Unit) in its slot and CTOT (Calculated Take Off Time) calculations takes in account only IFR GAT flights, not OAT – C/IFR or VFR flights. That´s why there were created so called super low sectors (SLS) vertically defined from 1000 feet above ground level up to flight level (FL) 95 or 125 (in some parts of FIR Praha). In the future it is expected to redefine SLS up to FL125 or FL145 within whole FIR Praha airspace.

Air traffic services are provided in SLS by regional approach (APP) units located at the airport Karlovy Vary (LKKV), Ostrava Mošnov (LKMT) and Brno Tuřany (LKTB).

The major military traffic is expected just up to FL 150 for overflights from military basis (LKCV, LKPD, LKNA and LKKB) to temporary restricted areas for OAT activity (these areas are published in AIP CR). The traffic capacity of the regional airports (APP units) was not spent recently anytime. Therefore there were not created new sectors (for provision services to OAT flights in ACC unit) but current areas of responsibility (AoR) of regional airports (APP units) were markedly enlarged by this purpose (to provide ATS to the military OAT flights).

Since 1st May 2014, it has been AoR of APP Karlovy Vary CTA[5] Karlovy Vary. AoR of APP Brno has been CTA 1 and 2 Brno and finally AoR of APP Ostrava has been CTA 1 and 2 Ostrava. AoR of ACC Praha has been CTA 1 and 2 Praha. See graphical scheme below.

Figure 9. CTAs in FIR Praha – new airspace division after 1st May 2014



VII. Verification Mode

To be sure that all procedures, all technical support and all personnel is ready for such big change there were organized two training change over to new procedures during April 2014.

The results were reported to CAA because it was one of the required conditions to start operation of this "change of functional system" (as it is called by CAA). During the test change over in April were identified some problems but all of them were clarified as not block for real change over.

In the night from the 30th April to 1st May was realized real change over and new concept became the reality. It was followed by several testing flight (each per day from the 1st to 4th May). Also during test period were identified some mistake but it was proofed that all discrepancy is based on human factor. System wise were identified some errors in off-line parameters settings but overall it was and it is capable of operation with no restrictions.

VIII. Conclusion

The aim of civil-military integration was based on the decision from the year 1995 and FUA concept and the main goal is to provide air traffic service more efficient, increase safety, increase capacity and last but not least to save money from public sector and public budget.

By integration were reached the basic principle of one controller providing service in one airspace, civilian and military ATM systems were integrated (they cooperate together), military restricted areas are used flexible, fighting power of Czech army is assured and finally everything was done according to European Commission and project SESAR.

Before realization of integration, there were 2 air traffic control centers for one airspace (ACC Praha and MACC Praha). There two completely independent ATM systems (it means twice costs for maintenance and further development and expansion), there was more complicated coordination between civilian and military units.

Now, after integration (as it is mentioned in the text above several times), there are obtained many benefits (more flexible use of airspace, increased safety in general, operational savings up to 20 000 thousand Kč every year and investment and technological saving several tens of millions per year).

By realization of civil – military integration occupies the Czech Republic primacy in the Europe when talking about civil and military cooperation. The process was not easy but it has been successfully done.

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Figure 10. Ilustration of Combat Aircraft (Air Policing / Defense) (right)

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Fuels in Air Transport

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***Abstract*-Fuel in general is required to meet standards governing its density, acidity, point of ignition and crystallization and other properties.**

Fuel must comply with all applicable standards to ensure safe supply from the fuel tanks to the engine even in extreme conditions, to efficiently use and maximize its energy content and to minimize its impact not only on the fuel system but also on the environment.

Keywords: aviation fuel, Jet A-1, kerosene, AVGAS.

In these days, the substitution of conventional fuels with alternative fuels is largely considered. It is caused not only by their negative impact on the environment but also by the world-wide trend in the use of ecological fuel.

Car manufactures try and compete in producing the most ecological vehicle with low consumption and low emissions.

Emissions are currently one of the most popular words. Manufacturing plants try to reduce the content of sulphur in their exhausts, the green tax on vehicles according to their EURO category has been increased.

When using motorways and A-roads, trucks are subject to toll calculated according to the number of axles as well as the EURO category. This trend is supposed to gently force operators and owners of older vehicles to change them for more modern types, which are more environmentally friendly.

Emissions are getting ever increasing attention even in air transport. Although air transport is less common than road transport, aircraft engine manufacturers and aircraft prodcers do not fall behind and keep reducing emissions and fuel consumption. Low-friction painting is used (easyJet), the weight of aircraft is decreased and some companies already use fuel produced from renewable resources. One of the most famous carriers is Lufthansa, which operated its Frankfurt – Hamburg service with airplanes powered by a mixture of 50% of jet fuel and 50% of biofuel. Other operators that have followed are KLM, Finnair, AeroMexico and others.

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Fuels in Air Transport

The most commonly used fuel in air transport is jet fuel. It is commonly known as JET A-1 (AVTUR – Aviation Turbine Fuel) according to AFQRJOS (Avitation Fuel Quality Requirements for Jointly Operated Systems). The most commonly used fuel in general aviation is aviation gasoline (AVGAS), used for piston engines.

There are a range of aviation fuel grades and specifications and it would take tens of pages to list them all. This text focuses on JET A-1 jet fuel and the most commonly used aviation gasoline in the Czech Republic, fuel 100 LL. [1] [2]

Jet Fuel

Jet fuel is used to power jet (turbofan) engines, which currently dominate the industry.

Fuel Requirements

As this fuel is used in commercial air transport, the requirements are strict and it has to meet a large number of conditions given, as any other matters in aviation, by applicable regulations to prevent fatal consequences caused by low quality. Table 1 provides an overview of requirements on the properties of JET A-1.

Table 1: Required properties of JET A-1 aviation fuel.

Property	**Units**	**JET A-1**
Density at 15 °C	kg/m^3	775-840
Acidity	mg KOH/g, max.	0.015
Sootless flame height	mm, min.	25
Aromatic hydrocarbons	% vol., max.	25
Alkenes	% vol., max.	25
Sulphur, total	% mass, max.	0.3
Sulphur in mercaptans	% mass, max.	0.003
Distillation test:		
10% vol. distilled under	°C, max.	205
End of distillation	°C, max.	300
Point of ignition	°C, min.	38
Point of crystallization	°C, max.	-47
Viscosity at -20 °C	mm2/s, max.	8
Calorific value	MJ/kg, min.	42.8
Resinous products	mg/100cm^3, max.	7

Source: **BLAŽEK, Josef a Vratislav RÁBL.** *Základy zpracování a využití ropy*. 2. edition. Praha: VŠCHT, 2006, 254 s. ISBN 80-708-0619-2. Retrieved from http://skripta.kachitta.net/download/isbn-80-7080-619-2.pdf

The producer must issue a certificate for every single delivered batch of jet fuel. In order to improve its in-service properties, the fuel is refined adding selected antistatic, lubrication, biocide and anti-freezing additives and additives to prevent oxidizing reactions of unstable fuel components catalysed by certain metals, which may be added to the fuel during production, storage or transport. The content of aromatic hydrocarbons must be kept to minimum as it increases the amount of soot when being burnt and soot causes erosion of the turbine at high speeds.

Properties of Jet Fuel

Viscosity

Viscosity is an important property of fuel to ensure reliable operation of fuel nozzles at low temperatures.

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Lubricity

Lubricity is the measure of the ability of fuel to provide lubrication between two surfaces and to reduce friction and therefore wear.

Point of Crystallization

This point is the temperature at which the last hydrocarbon crystal melts when heating crystallized fuel. It means that the point or temperature of crystallization is higher than the temperature at which fuel solidifies, i.e. changes from liquid to solid.

Volatility

Volatility is the ability to evaporate. It is a very important value in fuels. Its nature can be described using vapour pressure, which is the pressure of vapour above the liquid surface, and its distillation curve. High values lead to unnecessary losses of fuel and blocking of the fuel system, so called vapour cushions.

Point of Ignition

It can be described as the lowest temperature at which vapour above the surface of flammable liquid tends to ignite in the presence of a flame source.

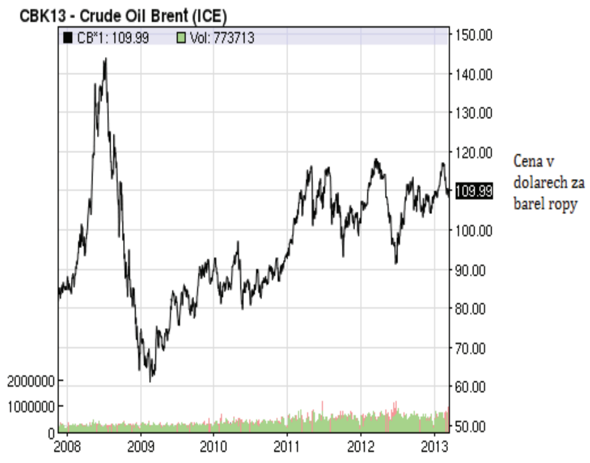
Corrosivity

It results in damage to metal parts of the fuel system and its degradation.

Price

The whole aviation industry, its growth and decline depend on the price of crude oil. It is very difficult to predict the trend development and the only certainty is that the price will not decrease. Year 2008 was an exception to the rule, as the price of crude oil reached an all-time high and in 2009, it was possible to buy a barrel for $60, which was nearly $100 less than the year before. The end user could hardly notice this rapid change because the price of kerosene and gasoline increases proportionally to the price of crude oil but decreases only at a slow rate irrespective of the change even by $100. The average price per 1 tonne of jet fuel paid by Lufthansa in 2013 was $721, which was $160 more compared to 2009. [3]

Figure 1: Stock market changes in price of crude oil



Source: Latest Price & Chart for Crude Oil Brent. NASDAQ [online].© 2013 Barchart.com, Inc. [Citace: 1. 4. 2013.]. Retrieved from http://www.nasdaq.com/markets/crude-oil-brent.aspx

The stock exchange trades in dollars per barrel. This unit is equivalent to 42 US gallons or 158.97 litres. One would have to pay CZK2200 to buy a barrel of crude oil at an exchange rate of CZK19.80 per 1 USD.

The price prognosis of this liquid is not favourable because the whole world depends on it. Natural gas and crude oil account for 54% of energy used on Earth and one can hardly realize that it is used for drug production, cosmetics or plastic materials. Approximately 90 million barrels of crude oil are used every day. As the large exploitation sites are located in places of unstable political environment, the future price is unsure as well as the fate of those countries. Large drilling sites may be found in Venezuela, Iraq, Iran, the United Arab Emirates and Kuwait, the biggest one being on the seabed where exploitation is not economical. The price will certainly depend on future research of oil substitutes. [4]

Aviation Gasoline

Aviation gasoline is used in aircraft with spark-ignition engines so it cannot be used in aircraft with jet engines. Compared to automobile petrol, aviation gasoline is made of compounds with more isoalkanes and less aromatic hydrocarbons. A high calorific value per unit of mass is an important factor.

Aircraft fuelled with aviation gasoline usually fly at altitudes where the outside air temperature drops below the freezing point. Therefore a maximum prescribed point of crystallization is required. The calorific value, sulphur content or the point of crystallization are set. The most commonly used aviation gasoline is fuel with octane number 100, with low lead content, known as AVGAS 100 LL (Low Lead). [1]

Fuel Requirements

Requirements laid on aviation gasoline are less strict than those laid on jet fuel. However, it still needs to meet certain specifications adhered to in the manufacturing process.

The required values are presented in the following table.

Table 2: Required properties of AVGAS aviation fuel.

Property	**Units**	**AVGAS 100**
Octane number, lean mixture	min.	99.5
Octane number, rich mixture	min.	130
Lead	g Pb/dm3, max.	0.56
Colour	-	blue
Distillation test:		
10% vol. distilled under	°C, max.	75
40% vol. distilled under	°C, min.	75
50% vol. distilled under	°C, max.	105
95% vol. distilled under		135
End of distillation, FBP	°C, max.	170
Vapour pressure at 37.8 °C	kPa	38-49
Point of crystallization	°C, max.	-58
Sulphur	% mass, max.	0.05
Resinous products	mg/100cm^3, max.	6
Calorific value	MJ/kg, min.	43.5

Source: **BLAŽEK, Josef a Vratislav RÁBL.** *Základy zpracování a využití ropy*. 2. edition. Praha: VŠCHT, 2006, 254 s. ISBN 80-708-0619-2. Retrieved from http://skripta.kachitta.net/download/isbn-80-7080-619-2.pdf

Properties

The properties required of aviation gasoline are the same ones as for jet fuel.

Price

The price of aviation gasoline as well as of jet fuel depends on the price of crude oil on global markets. At the moment, it is possible to buy 1 litre of AVGAS 100 LL on average for CZK 50 in the Czech Republic. The price also depends on the airport of refuelling.

Impact on environment

Based on different attributes there will be significantly different impact on environment. But for air operator there is no significant impact because all law regulations are based to standard Jet A1 fuel. Even for counting of required allowances for EU ETS system there is always same coefficient counted [5]despite different quality of fuel. This inaccuracy may lead to over usage of less quality fuel, for lower prices, which will burden environment more significantly. So there is risk that EU ETS system for environmental protection shall have directly opposite influence because of lack of information about actual fuel used. Another issue is deference between Jet A fuel used in USA and in Europe this difference again may significantly impact the amount and composition of emission produced by aircraft.

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