AIR TRANSPORT DEPARTMENT
FACULTY OF OPERATION AND ECONOMICS OF TRANSPORT AND COMMUNICATIONS
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Head of Air Transport Department

University of Žilina, Slovakia

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E-mail

inair@fpedas.uniza.sk

kld@fpedas.uniza.sk

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DETERMINANTS OF INTRA-INDUSTRY TRADE IN VARIOUS SERVICES APPLIED TO AN INTRA-INDUSTRY TRADE IN AIR TRANSPORT SERVICES

Ing. Martina Blašková
Air Transport Department
University of Žilina
Žilina, Slovakia
martrina.blaskova@fpedas.uniza.sk

Abstract *– The paper deals with intra-industry trade and review of studies dealing with the determinants and hypothesis of intra-industry trade in financial, tourism and insurance services followed by applying knowledge to intra-industry trade in air transport services and determining potential determinants.*

Keywords: determinants, air services, international intra-industry trade,

INTRODUCTION

As the importance of international trade in services increases, increasing demands on monitoring and analysis of various trends, including the development of international intra – industry trade in services.

Based on our current knowledge the following studies deal with international intra – industry trade in services:

- *Intra – industry trade in services (Lee, Lloyd; 2002)*; this study analyzed the lack of model or models of international intra – industry trade in services. Analysis was given to the market share of services in total trade in goods and services, the average Grubel-Lloyd index and marginal Grubel-Lloyd index for the 20 OECD countires in period from 1992 to 1996. The analysis showed uniformly high and stable Grubel-Lloyd index at the time. The study showed the need for the development of theoretical models of international intra – industry trade in services.

- *The role of intra – industry in the service sector (Shelburne, Gonzales; 2004);* the main problem to which economists focus in this study is statistical reporting of the services. For analysis of international intra – industry trade in services have been used the data from OECD statistics on international trade in services and the Bureau of Economic Analysis in the period from 1992 to 1998. Unfortunately, these two sources are not comparable in a transparent manner. The data is not presented in a similar hierarchical structure and this lack of harmonization is a problem in the empirical estimation of indices of intra – industry trade, which have been analyzed in the study. For analysis was used Grubel-Lloyd traditional and marginal index to measure the intensity of intra – industry trade in services in OECD countries (34 countries and 10 regions). The results shows different problems compared to the trade with goods. Data availability is a major constraint, especially in the case of comparing countries with each other and also in time. Even if data are available, countries use different classification of services and this just complicates the comparison.

- *The Determinants of Intra-Industry Trade in Insurance Services (Li, Moshirian, Sim; 2003);* authors have analyzed and measured the size of intra-industry trade in insurance services in USA. As a measuring method authors used Grubel-Lloyd index. Mentioned authors used Grubel-Lloyd index along with marginal Grubel-Lloyd index also in study *Intra-Industry Trade in Financial Services (2005)*, where they analyzed and measured the size of intra-industry trade in financial services between USA and trading partners.

- Static Grubel-Lloyd index was used in *Intra-Industry Trade in Tourism Services (Leitao, 2011)* to measure mentioned trade between Portugal and trading partners (Spain, USA, Italy, Greece, Turkey and Canada)

Three of the mentioned studies have examined the determinants of international intra-industry trade in services. Overview of hypothesis with determinants of intra-industry trade in services is included in Table 1. It can be seen, that authors share the view that, there is a relationship between international intra-industry trade and differences in per capita income and also between the size and intensity of county´s economy and international intra-industry trade in services.

Table 1 – Overview of hypothesis in the analyzed studies

Author	Hypothesis
Li, Moshirian, Sim	There is an inverse relationship between the difference in income per capita and intra-industry trade (IIT)
	There is a positive relationship between market concentration in goods and services and IIT
	IIT is negatively related to the difference in the size of the financial market
	IIT is negatively related to an imbalance in the market for goods and services
	There is a positive relationship between IIT and FDI
	IIT is negatively associated with the overall flow of services between U.S. MNCs and their foreign brances
	There is a negative correlation between the difference in market openness and IIT
Nuno Carlos Leitao	There is a negative correlation between the difference in income per capita and IIT
	Size of the economy positively affects the extent of IIT
	The market is growing if partners are geographically close together
	Common border, lower transport costs
Li, Moshirian, Sim	The share of IIT in total financial services is positively associated with an average per capita income
	The share of IIT in the market for banking services will be negatively correlated with the intensity of market U.S. multinational corporations with their foreign branches
	Economies of scale in banking contribute to the IT in financial services
	The share of IIT in banking services is positively associated with the intensity of the market for banking services

Source: Custom processing based on analyzed studies

INTERNATIONAL INTRA-INDUSTRY TRADE IN AIR TRANSPORT SERVICES (DETERMINANTS)

DATA AVAILABILITY IN CASE OF AIR TRANSPORT SERVICES

As it was mentioned in study *"The role of intra – industry in the service sector"(Shelburne, Gonzales; 2004)*, there is a problem with data availability and this problem also affects international trade in air transport services. Table 3 shows some examples of data availability in the period from 2002 to 2012. As it can be seen data for year 2012 is not available for any of chosen countries jet. States like Portugal and Spain do not provide statistical data on trade in air transport services, so we cannot integrate them into planned analysis. Because of incomplete state of database we cannot analyze and measure the intra-industry trade in air transport services of chosen countries for the whole period between 2002 and 2012. It´s common knowledge, that data on trade in goods are collected directly at the border, while data on services (export and import values) are obtained through a survey of various information sources and that is the reason why the lack of data about air transport services exists.

Table 2 – Availability of data in the period 2002-2012 for chosen countries to USA

	USA										
	02	03	04	05	06	07	08	09	10	11	12
RU	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x
UK	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x
BE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x
PL	x	x	✓	✓	✓	✓	✓	✓	✓	✓	x
HU	x	x	x	✓	✓	✓	✓	✓	✓	✓	x
DK	x	x	✓	✓	✓	✓	✓	✓	✓	✓	x
EL	x	x	✓	✓	✓	✓	x	✓	✓	✓	x
LU	x	x	x	x	x	x	✓	✓	✓	✓	x
IE	x	x	x	x	x	x	x	✓	✓	✓	x
RO	x	x	x	✓	✓	✓	✓	✓	✓	✓	x
PT	x	x	x	x	x	x	x	x	x	x	x
ES	x	x	x	x	x	x	x	x	x	x	x

Source: Custom data processing based on International Trade Center

International trade in air transport services has big impact on international trade because it includes all air transport services, which are performed by residents of one economy for those of another. The mentioned services include air transportation of passengers, transport of goods, rentals of carriers with crew and related supporting and auxiliary services[1]. Air transportation is a major facilitator of international trade in terms of the value of goods and services involved, and is important to specific industries, such as tourism, that are being developed by many lower income countries.

It´s not easy to identify the determinants of IIT what represents a searching problem. There were compiled econometric models for trade in goods for individual commodities based on determinants. Regarding the IIT in services the problem is less explored.

Table 3 – Overview of determinant in the analyzed studies

Traded commodity	Determinants
Insurance services	*Per capita income, Trade intensity,* Trade imbalance, *Market size,* Foreign direct investment, Multinational corporations, Market openness
Tourism services	*Per capita income, Market size,* Geographic distance, Common border
Financial services	*Per capita income, Trade intensity,* Economies of scale

Source: Custom processing based on analyzed studies

[1] *freight insurance, goods procured in ports by non-resident carriers and repairs of transportation equipment, repairs of railway facilities, harbours, and airfield facilities and rentals or charters of carriers without crew*

As it can be seen in Table 3, in mentioned studies authors examined various determinants for various services. There are different types of determinants, but authors concurred in certain determinants such as per capita income, market size, and trade intensity. The Table 3 lists examples of the other determinants used in studies as trade imbalance, foreign direct investment, multinational corporations, market openness, geographic distance, common border and economies of scale.

Therefore, we selected market size and per capita income as determinants for international intra-industry trade in air transport services along with air liberalization index and index of globalization, which are discussed more detailed in next chapter.

Suggested determinants of international intra-industry trade in air transport services

- *Per capita income*

When analyzing IIT in air services determinants the available theoretical and empirical literature on world trade serves as a starting point. The theory of IIT in goods proposed a concept of demand similarity which contributes to similar commodities being imported and exported among countries. Demand similarity is driven by higher per capita incomes of the trading countries because customer demand at higher levels of per capita income is in general higher, more differentiated and more complex. As it was supposed by Balasa and Bauwens (1987) the difference in per-capita income between trading partners represents a difference in the demand structure. As the studies devoted to IIT in services used demand similarity concept for development of IIT determinants, we can also stipulate that the share of intra-industry trade in air services is negatively correlated with per-capita income between two trading partner countries.

- *Market size*

Market size (and economies of scale) is further common determinant of IIT in the researched categories of services. This determinant is generally argued by differences in resource endowments in larger countries with larger markets which enable that more differentiated commodities are produced under conditions of economies of scale (Loertscher and Wolter, 1980). Subsequently, less volume of similar commodities traded can be assumed, the trade in air services included. Therefore, a larger difference in size between the countries – trading partners indicates a lower volume of air services traded within the industry. For the country´s market size approximation GDP or population can be used as options.

- *Air liberalization index*

Intra-industry trade in goods has been investigated so far in negative correlation with trade barriers existing. Air services internationally traded are regulated by a complex grid of unique Air Services Agreements bilaterally or plurilaterally agreed between countries. Thus, we can stipulate that if barriers to international trade in air services are being decreased higher IIT in air services will be. Reduction of trade barriers means a more free access to the market due to a more liberal air services agreement between trading partners. To quantify the level of market access protection, air liberalization index[2] can be used. Our approach based on the level of market access protection coincides with a concept of market openness in the studies mentioned above.

- *Index of globalization*

As air transportation is generally considered as a driver of globalization, we can assume that a higher integration of countries - trading partners generates higher volumes of air services bilaterally exchanged within the industry. Thus, intra-industry trade is assumed to be positively correlated to a lower divergence between the countries integration within world global economy (Loertscher and Wolter, 1980). For quantification of integration of economies into world global economy, index of globalization3 can be used.

Conclusion

Identifying determinants is the main base for the formation of an econometric model for intra-industry trade in air transport services. After specifying the determinants there´s a place for design an econometric model, which will analyses mentioned determinants of international intra-industry trade in air transport services, which will be the main subject of our following research.

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[2] *The Air Liberalization Index (ALI) constructed by the WTO Secretariat (WTO, 2006) is an expert based index. The weights assigned to the different provisions of air agreements were defined in consultation with a group of experts on aviation industry with the view to capture the relative importance of each provision in liberalizing the sector. The ALI ranges between 0 and 50, where 0 is associated with the most restrictive agreement and 50 denotes the most liberal agreement.*

[3] *measures the three main dimensions of globalization: economic; social; and political*

BASIC PRINCIPLES AND USE OF LIDAR DATA

Ing. Peter Bobáľ, Ph.D.
YMS, a. s., Hornopotočná 1, 917 01 Trnava, Slovensko
peter.bobal@yms.sk

Mgr. Miroslav Holubec
YMS, a. s., Hornopotočná 1, 917 01 Trnava, Slovensko
miroslav.holubec@yms.sk

Abstract *– Nowadays there are a lot of methods for obtaining information about the objects on the Earth surface. The special importance is on accuracy and reliability of this information. One of the active remote sensing methods which allow obtaining very accurate data about the Earth surface is LIDAR. LIDAR is usable in different areas and is an accepted method for data acquisition. This article examines the basic principles of LIDAR and the possibilities of utilization of this technology.*

Key words – LIDAR, laser scanning, DMR, DPZ, modeling

INTRODUCTION

The concept of LIDAR is an acronym of the English words "Light Detection And Ranging". In some literature, it is possible to meet even the acronym ALS (Airborne Laser Scanning) indicating the airborne laser scanning. It's a technology operating on the same principle as radar. However, instead of radio waves to gain information about objects using light radiation. It is therefore a method of active remote sensing (RS), based on the measurement of the distance between the object and studied alone with LIDAR, most often placed on aircraft, helicopters or drones. Since it is an active remote sensing method, it can be used to gain information during the night. Unlike radar, data acquisition through LIDAR is not possible during high cloud, rain or heavy fog.

HISTORY

The beginnings of LIDAR technology dates back to the 60s of the last century and are associated with the invention of the laser. At that time it was used mainly terrestrial LIDAR with static location, to monitor atmospheric and meteorological phenomena. Currently, LIDAR is a powerful tool for weather observations throughout the world (eg for Climate Change Research).

The use of ALS systems for the purpose of collecting topographic data started until 1980 and for commercial purposes has been introduced since the mid-90s. Development of ALS systems is associated with the introduction of GPS (Global Positioning System). Today, technology has had LIDAR widely used in various fields such as: hydrology, construction, forestry and the like.

LIDAR SYSTEMS DIFFERENTIATION

There are several types of ALS. Select type depends on the possibilities of its use and the specific needs of the project. Depending on the location of the device itself, it is possible to allocate two basic types: aerial and terrestrial LIDAR [2]. These can be further broken down - see the following figure.

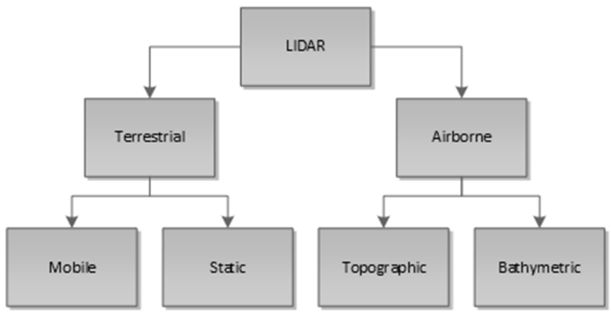

Figure 1 – Basic LIDAR typology

ALS, usually located on the aircraft or helicopters, can be divided into bathymetric and topographic. Topographic used primarily for modeling over terrain and can be used in various fields such as forestry, hydrology, geomorphology, etc. Bathymetric LIDAR systems are characterized by the fact that under appropriate conditions, can penetrate a portion of the water column. It can be modeled as the day of reservoirs, etc. Penetration depth depends mainly on the degree of turbidity of water and its flow. Most bathymetric LIDAR systems operating in two parts of the electromagnetic spectrum. The infrared spectrum is used to monitor the water surface. Green spectrum is characterized by excellent penetration and is used to monitor the bottom of water bodies. Combined topographic and bathymetric LIDAR systems placed on air carriers are often used to monitor coastal areas [3].

Figure 2 – Mobile lidar (photo by author)

Terrestrial LIDAR can provide very accurate data characterized by a high density of points. Thus enabling the creation of accurate, realistic 3D representation of roads, buildings, bridges, dams. They can be either mobile or static. Mobile LIDAR dwell placed on moving media, such as cars, trains, ships eventually. The design of these systems is similar to that of air LIDAR. They can be used for example to analyze road infrastructure, monitoring of potholes on roads, and the like. Still LIDAR systems consist of collecting information from a static location (tripod). They can be used outdoors as well as indoors. Commonly used in mining, archeology, but also in other areas. The next section of the text we will deal mainly air LIDAR [3].

Figure 3 *– Drone – a modern technology of lidar a photogrammetry data acquisition (photo by author)*

Principle of operation

The construction of LIDAR consists of laser, optical and mechanical system, the detector of the reflected electromagnetic radiation and precision clock measuring the time between sending a beam and capturing them through the detector. LIDAR units placed on mobile carriers (airplanes, satellites, cars, etc..) require the device to determine the exact position of the vehicle and its orientation. For this purpose are used GPS and IMU (Inertial Measurement Unit).

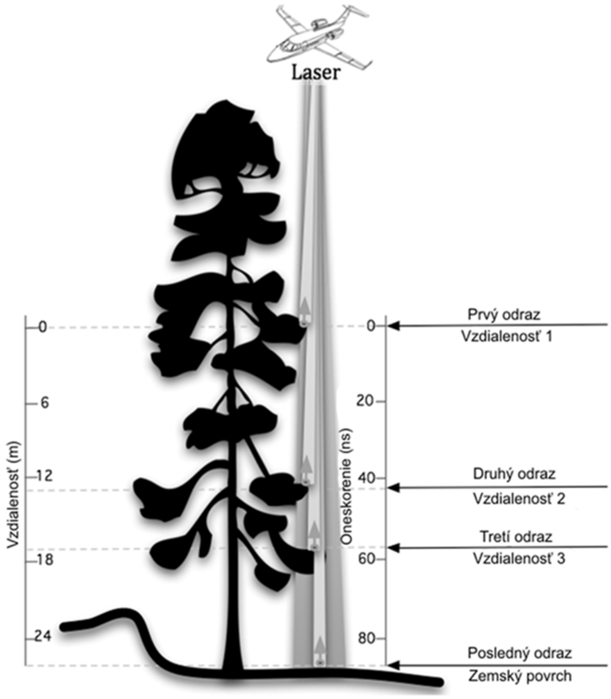

Figure 4 *– Basic principle of lidar data acquisition (source: http://ucanr.org)*

The basis of the system itself consists of a laser, which is a source of laser radiation. There is now a large variety of laser devices. Their use is dependent on both the power and also the wavelength at which the laser operates. LIDAR can operate in the ultraviolet, visible, infrared and infrared - the proximal portion of the spectrum. For some laser devices can be done to complete the conversion from one wavelength to another. In these cases it is necessary to carry out a set of electromagnetic radiation detector to enable them to radiation in the part of the spectrum capture. Lasers in LIDAR s work mostly in pulse mode [4].

LIDAR principle is quite simple. The optical system focuses the laser pulse generated by a very narrow beam. This beam is then deflected by a mechanical device across the line of flight of the carrier. Shift of the beam in the longitudinal direction ensure the movement of the carrier. After sending a light pulse computer records the time of posting. Together with the time of posting shall be recorded and information about the position and orientation of the vehicle and also the angle of the beam mechanical systems. Beam reflected from objects on the Earth's surface (vegetation, buildings, surface ..) is recorded by the detector and the time of arrival and intensity of the reflection. From the above data and knowledge of the speed of light is finally possible to determine the position and height of the point at which there was a loss [1].

One of emitted laser pulse can return to the detector as well as multiple reflections. Width of the beam incident on the earth's surface can reach several tens of centimeters (depending on the altitude of the carrier). Therefore, there are still a fact that the beam reflected from a number of different objects. First reflections captured taking with it usually represents the highest element of the surface, such as the top of the building. Recent reflections captured the detector is characterized majority of the ground [2].

The process of obtaining data from LIDAR is a network of highly accurate georeferenced points (cloud points) representing objects located in space. This data is prior to actual use for a specific purpose, yet necessary process. For this purpose, various methods are used filtering and classification.

USE OF LIDAR DATA

According to the preceding text, LIDAR technology is currently widely used. Is primarily used for production of high-precision digital elevation model (DEM), which can then be utilized in various fields. Besides high accuracy due to the high density of scanned points, the immense advantage of the possibility of application of this technology in forested areas. Small width of the beam emitted from the laser makes the assumption that a certain portion of the beam is able to penetrate well below the treetops. This can be used to obtain information about the terrain under forest cover. Digital elevation model, characterized by high precision, can be of great use for example in modeling of environmental processes (hydrological modeling, erosion modeling)[4].

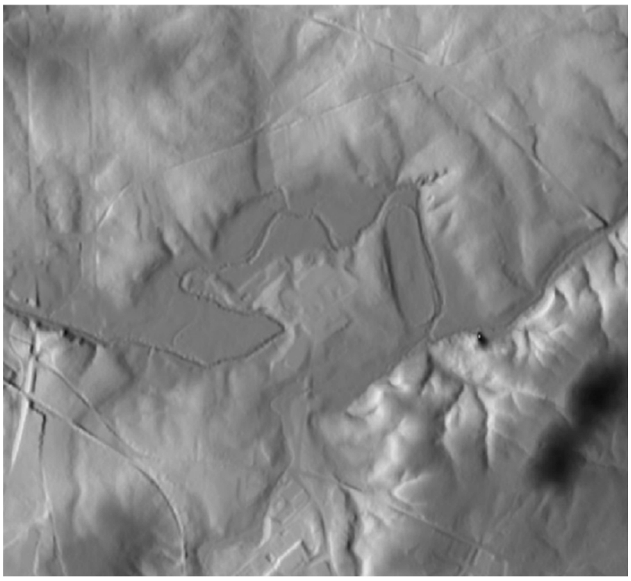

Figure 5 *– Digital elefation model (DEM) obtained by LIDAR (source: http://web.cs.swarthmore.edu)*

Repeat the same area scanned by LIDAR can be applied to produce highly accurate differential models. DEM created at different times give the opportunity to examine the changes that have occurred in the area of interest for a certain period of time. Thus, it is possible to evaluate the intensity of erosion processes such as the area, monitor changes building, quarrying, carrying sediment, or even to evaluate the changes of snow cover, which can be of great benefit to modeling rainfall-runoff processes in the catchment area [1].

Another possibility of using LIDAR is the creation of 3D models of buildings. Process to detect the points representing the building separated from the building points representing the surface of the ground or other objects in the space (trees, roads, etc..). , A relatively comprehensive problem dealt with a range of publications, such as: [5], [6].

LIDAR has a wide area of application in forestry, where it is possible to use multiple reflection beam emitted from LIDAR and get information such as the amount of vegetation, leaf area or canopy structure. Represents a contribution to forest management, forest inventory (monitoring vegetation characteristics), or in the planning of technical operations in forests (logging planning, silviculture activities) .

As already mentioned in the preceding text , LIDAR has a wide application in the field of hydrology. Bathymetric LIDAR systems allow, under certain conditions pass water column and get information about the terrain contained underwater. In addition, accurate DEM obtained from LIDAR is suitable input for modeling floodplains using hydrodynamic models or to generate drainage networks for rainfall - runoff modeling .

In addition to the above-mentioned possibilities LIDAR applications, the technology is also used in other areas , such as: agriculture, geology, mapping over power lines, road infrastructure mapping, mapping leaks, mapping of natural resources and the like .

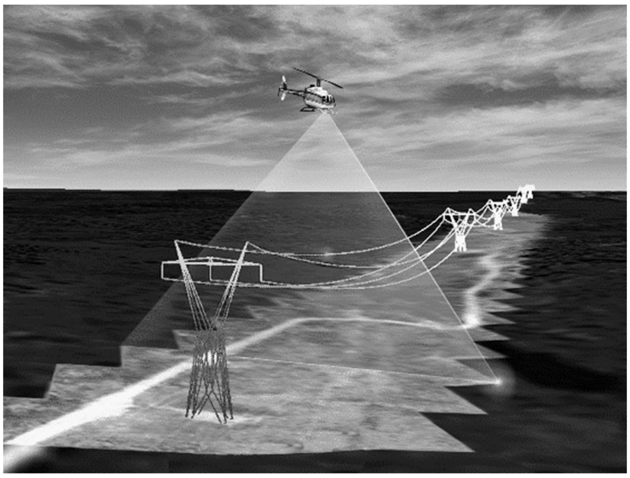

Figure 6 *– Corridor mapping principle (source: http://www.geoinformatics.com)*

PROS AND CONS OF LIDAR TECHNOLOGY

Laser scanning technology provides over other methods of obtaining spatial information several advantages. This is particularly the following benefits:

- High level of accuracy - high density of points (up to a few points per m2) to simulate the course of terrain with high precision (vertical accuracy of ± 15 cm)
- The ability to scan large areas in a relatively short time

- Ability to provide detailed information on the vertical distribution of vegetation
- Data can be obtained even at night
- Detection of ground surface in forested areas

The main drawbacks of this technology are:

- Inability to pass through very dense vegetation
- Very much data-intensive processing
- A relatively high price
- Inability to obtain data during high cloud, rain or heavy fog

CONCLUSIONS

LIDAR is a relatively new, rapidly evolving technology that has a wide application in various disciplines and sectors. Data collected by LIDAR provide high reliability and accuracy, which will be in the future with improving the technology has increased. Despite some limitations to LIDAR major assumptions of the future for its further use and development.

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Európska únia

CONTEXT OF THE DIFFERENT TYPE OF AIR CARRIER OPERATION AND THE REGIONAL AIRPORT PERFORMANCE

Ing. Michal Červinka, Ph.D.
Department of Trade and Marketing, Business School Ostrava, plc.
Czech Republic
michal.cervinka@vsp.cz

Abstract *– The author deal with the regional airport performance, the volume of handled passengers, operational and commercial impact of different kind of airlines operation. The increasing air traffic volume at regional airports does not automatically bring improvement of economic efficiency. The demand for air transportation is very often satisfying by low cost carriers operation. The paper examines the performance and selected economy indicators at a sample of regional airports in Central Europe, and their common influence. The paper published the findings of field research carried out at the selected regional airports in Central Europe.*

Key words – Airport cost, airport performance, economic impact, low cost airlines,

INTRODUCTION

The Air Transport has changed during last couple of decades. The Central Europe in not an exception, the demand for air transportation was caused by economic, social and political changes in Europe. Air transportation is undergoing the significant changes, caused by the legislative and political reasons, during recent periods. The liberalization brought the emergence of low-cost carriers. The political changes in Central and Eastern Europe (the end of communism era, the abolition of the Iron Curtain, the entry of these countries into the European Union, the entrance to Schengen space) had changed the former status quo. These changes on a one hand allow increased mobility of people, and on the other hand contribute to the economic growth of these countries and increase the wealth of people. In some countries, such as Poland, these changes allow the massive travelling abroad because of a work. The result of these circumstances is the increase in demand for air transport. Social changes have also contributed to the abolition of restrictions on the development of regional airports. In the past the development of main airports was preferred and the development of regional airports was often slow. This situation contributed disinterest of flag carriers, which preferred flying from major airports. The flying from regional airports was understood mainly as connecting flights to the capitol. They thus used consistently HUB and SPOKE philosophy The pressures on the development of regional airports was contributed to the onset of low-cost carriers, and their philosophy of point-to-point connection and flying from secondary airports. With the development of air transportation demand comes the development of regional airports. Fast transformation of airports often prevents neglected infrastructure or vice versa oversizing former military bases. It is often necessary to create a new airport company.

REGIONAL AIRPORTS DEVELOPMENT

The decrease military spending, including the Air Force began with the political changes (the Cold War) and the result was the reducing of the number of aircrafts and leaving a military bases. These airports, earlier full military or mixed traffic was opened fully for civilian traffic. An example may be Brno, Ostrava, Pardubice airports (Czech Republic) Katowice, Szczecin, Wroclaw (Poland), but also Norway (Oslo Airports Oslo Torp and Rygge). Regional airports often have to solve cost of transformation such as lack of infrastructure, both technical infrastructure and equipment (i.e.: runway lighting systems, navigation, construction of the terminal) and handling technology such as GPU, stairs to the aircraft etc. Military airports often did not meet ICAO regulations. Transformation of the airports often brings a change of an ownership. Airports are often managed by a company owned wholly or in part by the public sector (i.e.: Karlovy Vary, Ostrava, Pardubice, Katowice, Wroclaw). The property is inserted into the society or rented. New airport companies are able to earn on traffic, but they are not able to cover the investment costs. These costs are usually dealt with subsidies from public budgets. A significant opportunity has been utilized with the EU funds in 2007-2013 after joining the EU. There were constructed, for example, airport terminals at the Brno, Karlovy Vary, Ostrava, Katowice, Wroclaw airports and more. Smaller investments into the airport infrastructure were made at the Pardubice airport. For the possibility of absorption of EU funds is necessary to clear the property ownership structure.

Figure 1 – Regional Airports in Central Europe

If you successfully start the civil airport operations, it is necessary to deal with the use of new or transformed infrastructure. These paths are possible: using classic (network operators), charter carriers or low cost carriers. Classic carriers will hold a majority HUB-SPOKE scheme; operating charter carriers will depend on demand and business prowess of tour operators. Another phenomenon is the low cost carriers. Their operation is boisterously developed after the year 2000. Management is often confronted with performances airports (number of passengers, number of destinations), and there is pressure both public (potential voters) and subsequently representatives of the owners (often politicians) to launch low cost carriers. Management is faced with a difficult decision.

PERFORMANCE OF SELECTED REGIONAL AIRPORTS

The airports are in different conditions. They have different building infrastructure such as the length and width of the runway, various potential of catchment area, from various developed civil service to full military operation without personal. Table 1 shows the traffic development at selected regional airports from 2003 year.

Table 1 – Performance of selected regional Airports

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OSR	197 439	216 259	265 864	300 735	332 266	353 737	307 130	279 973	273 563	288 454
PED				71 655	93 659	86 863	49 032	62 302	65 246	125 008
KLV	25 805	38 704	37 313	34 975	64 641	81 720	68 369	70 903	99 014	103 682
BRQ	171 200	171 888	315 672	393 686	415 276	506 174	440 850	396 589	557 952	534 968
KTW	257 991	622 612	1 092 385	1 458 411	1 995 914	2 426 942	2 364 613	2 403 253	2 544 124	2 550 848
WRO	284 334	351 850	465 528	865 933	1 280 511	1 486 442	1 365 456	1 654 439	1 657 472	1 996 552

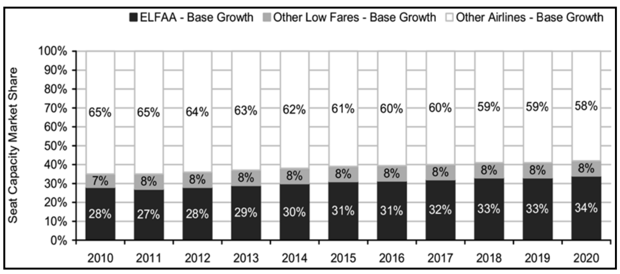
The bargaining power of the low-cost carriers is increasing. If Ryanair carries 80 million passengers a year from 180 destinations, it gets into position with a strong power. Due to the fact that there are still plenty of airports that have transformed, and who are willing or forced to accept these conditions, the low cost company stronger player. If the volume of airport traffic is low, the cost per passenger clearance is between 12 and 14 EUR (as is clear from expert interviews with managers of several regional airports). Usual price full handling for the B737-800 is 300-400 EUR. The average airport tax in the Czech Republic is 14 EUR. At a price of landing charges EUR 12 per 1 ton MTOW (B737-800 has 80 tons MTOW) is the price of one landing EUR 960. The revenues from a one turnaround aircraft at 70 percent load factor (140 pax) moves round (140x14 + 960 + 300 =) 3220 EUR. When negotiating around 2003 it was possible to achieve sales per one departing passenger 6-8 Eur. The landing fees or the fees for handling was not considered overtime, after the bankruptcy of some low-cost carriers, this amount decreased to EUR 4 and nowadays it is offered for less attractive airports 0-2 EUR per passenger,

The table shows the dynamic increase in passengers at Polish airports Katowice, Wroclaw and Czech Brno, where a greater or lesser extent, began to operate low-cost carriers. Ostrava, Pardubice and Karlovy Vary are not operating the low-cost carriers. Since the middle of 2013 Ryanair flies 3 times a week from Ostrava and it is expected that this operation will supply 40,000 passengers by the end of the year.

THE INFLUENCE OF LOW COST CARRIERS TO OPERATIONAL AND ECONOMIC PERFORMANCE OF AIRPORTS

As can be seen from the table 1, the emergence of the low cost carriers has significantly increased the volume of passengers at the airport. The chart 1 shows the share of low cost carriers on the number of passengers grows. The table shows that the share of low cost carriers in Europe will increase from 35 percent in 2010 to 42 percent in 2020. It can be assumed that this trend will continue well beyond 2020.

Chart 1 – Airline Seat Capacity Market Share Forecast



Source: York Aviation analysis of OAG data

moreover, it is often required contribution to marketing, which might make 100-400 000 EUR depending on the number of weekly rotation, or flights on the destination.

FINANCIAL EFFECTS OF ACCEPTANCE OF LOW COST CARRIERS

Daily operation of one B737-800 can provide to airport from 100 to 120 thousand passengers per year, which means an airport tax of 50-60 000 passengers. If the airport receive 4 EUR per passenger, that means revenue from 200 to 240 thousand EUR. It often does not even cover marketing charge when it is applied. During operation of 300 to 350 flights of classic or charter carrier for the price of 3000 EUR per 1 Turn round the airport would receive 900,000 - 1.05 million EUR. The difference amounts to 700 -800 000 EUR. The decision to follow the path of air travel by low cost carriers, if the airport accepts the terms, thus has a strong economic impact. Low cost carriers argue that they will bring passengers to the airport which brings revenue. As a possible way they expect the income from non-airline activities such as parking, commission fee from restaurants and duty free shops. The problem of the transformed airports is underdeveloped infrastructure and the nature of the passenger for whom a price is a the major limit for spending at the airport. When combined the marketing fees with low cost traffic lines it does not bring a profit but a loss. Airports usually do not published this fact, it is difficult to obtain economic data from the airports that focus exclusively on the operation of low-cost carriers. Airports that have more traffic other types of carriers have a better bargaining position. They can afford to take on the usual conditions of a system of discounts does not affect their economy. Airports that have more traffic of other types of carriers have a better bargaining position. They can effort to take on the usual conditions and the system of discounts does not affect their economy. Conversely the airports that provide such a relief may get into trouble because of other carriers may seek the same level of discounts. Such a development could be destructive to the economic performance of the airport. Such an airport could be permanently unprofitable, and without the support of the public sector would not survive.

CONCLUSION

Airport, which focuses on the operation of low-cost carriers only, can get into economic or legislative troubles. On a one hand it does not cover even the cost, on the other hand it may get you into legal trouble.

For example, with Charleroi airport, which in 2004 handled more than 2,000,000 passengers, the European Commission launched proceedings for illegal support of the Irish low-cost airline Ryannair of public funds. This case led to the development of new rules for public support for airports from public funds because it is clear that without public support, the airlines have not started the less attractive regional airports to fly.

Airports often find themselves in difficult situations where low-cost carriers choose from airports that offer support to launch new lines. This support often reaches such a level that the airport handles these aircraft at prices that do not cover even operating costs. This situation is becoming increasingly unfavourable to the airport, especially in economically bad times as high fuel prices.. Claiming of low-cost carriers that airport gets new revenues from non-airline activities, such as car parking and a higher turnover of shops and services at the airport is not often real, because at airports with a low number of passengers is rarely developed the necessary infrastructure that would be able to offer services to the desired level. Also, the low-cost carriers customers are not wealthy business travellers, but the clients for which it is decisive in price and are often willing to spend more money. Therefore, when creating a business plan, namely airports with low traffic, it is necessary to assess the risk of attracting low-cost carriers, and the possibility of loss-airport despite the positive operating performance.

Despite the rising standard of living it can be expected to increase revenues from non-airline business. Due to the development of low-cost carriers operating we can talk about dramatic changes in the number and composition of passengers. Rapid development experience of regional airports such as Poland, where the major regional airports (Krakow, Katowice, Gdansk, Poznan and Wroclaw), the share of low cost carriers in 42% of passengers in 2005 rise to 63% in 1st half of 2007. At the airport Wroclaw this share grew even more significantly, from 22% of the low-cost carrier passengers in 2005 to 62% in 1st half of 2007. In subsequent years, these trends continued.

Despite the development of the air transportation in Poland is caused by to the country's size and high mobility Polish passengers to work in countries in Western Europe, large increases of passengers in recent years was recorded also at airports such as the Bratislava airport by developing traffic of Sky Europe. At the airports in Western Europe, particularly in tourist destinations, often number of passengers transported by charter carriers stagnate. The growth in passenger traffic is achieved by the development of low-cost carriers. The customers also change.

The benefits of operating low-cost carriers:

- low cost carriers can help increase the market share of airport traffic and generate growth in the number of passengers (1 line operated daily by B - 737-800 carrying approximately 100,000 passengers per year)
- development a direct connection from point to point, it is not necessary to change the plane at a HUB
- smaller airports can use their spare capacity.

Financial specifics of the operation of LCCs:

- grow revenues primarily from non-airline activities,
- turnover from non-airline activities coping with a turnover of aviation activities,
- operation may generate a loss

Due to the development of low cost air travel and competition from neighbouring airports the regional airport with sufficient potential are not able to hinder cooperation with low-cost carriers The market of low cost transportation outweighs demand of airports over supply of low-cost carriers, and it is not likely to reach favourable financial conditions for their operation that the other airports if it has not a strong position. Therefore, it is necessary with the development of low-cost carriers operating, for the airport to develop the infrastructure for non-airline revenues such as parking, car rental, retail space for advertising, shops, restaurants, etc. If the airport has not built an infrastructure it will have to invest in these facilities. There must be prepared a fully consistent finance plan with an emphasis on return on investment especially in the period when the airport handles less than 1 million passengers.

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PRACTICAL USE OF THE PASSIVE COLLISION AVOIDANCE SYSTEM IN SLOVAK REPUBLIC

Portable Collision Avoidance System (PCAS™)

Ing. Andrej Cíger
Department of Air Transport, University of Žilina in Žilina, Slovak Republic
andrej.ciger@fpedas.uniza.sk

Abstract *– This paper deals with description of Airborne Collision Avoidance System (ACAS) in less expensive form represented by commercially used product PCAS™(Portable Collision Avoidance System). Paper also discusses practical use of this collision avoidance system in Slovak region.*

Key words – ACAS, TCAS, PCAS, Airborne Collision, Traffic Advisory, Resolution Advisory, Slovak Republic, SSR – Secondary Surveillance Radar, GA – General Aviation.

INTRODUCTION

Annual increase of amount of aircraft which are safer, newer and every year more instrument equipped and pilot training becomes widely available for public, causes that airspace is potentially more dangerous for mid-air collisions. These facts led producers of aircraft to develop more affordable collision avoidance system designed just for GA.

Zaon Flight Systems is American company which produces passive portable collision avoidance system (PCAS™). This product is available from 2003 in its fourth generation and is primarily aimed for general aviation. As opposed to ACAS generally used in commercial air traffic system PCAS™ does not transmit any signal. Basic operation is described in next section.

OPERATING PRINCIPLE

Operating principle is very simple. System PCAS™ is receiving signals up to ten SSR transponders or a TCAS systems and is able to indicate relative bearing, altitude, relative altitude and distance from surrounding aircraft. Indication is provided on LCD screen and user could see three potential threats in different modes. Potentially dangerous is plane only in same altitude. This is motto of Zaon Flight Systems. If any aircraft is potentially dangerous its position is indicated in three dimensions. Pilot could see distance, relative altitude and bearing in 45° segments. The rest of screen is reserved for indication of aircraft which do not constitute significant danger. Built-in antenna is able to receive signal from SSR transponder in chosen range from 1, 3 to 6 Nautical Miles (NM). Altitude is measured in range from ±500 ft, ±1500 ft do ±2500 ft (feet). The device is very complex and connects buit-in barometric altimeter, magnetic compass, thermometer, and sensor of banking and yawing. System is also equipped by speaker for acoustic indication and RS-232 connector for integration with wide scale of different devices and external displays like Garmin 396, 495/496, 695/696, 795/796, AERO 500/550, Dynon SkyView or iPad – FlightGuide iEFB. For acoustic indication could be used also pilot´s headphones and indication is given in the form of synthetic female voice.

Figure 1. PCAS™ XRX™ device [1]

Advantage of the device is that is portable and its usage is very simple anywhere in the world. It is standalone device which could be installed into various planes in few minutes. After receiving signal from SSR transponder system evaluate if surrounding aircraft is potential threat. From information about relative altitude, vertical trend and distance the traffic advisory is issued in two different levels which depend on chosen ranges (Table 1.). Device is usable both in the metal and composite aircraft up to FL220. It is also able to receive TIS-B (Traffic Information Service-Broadcast) and ADS-B (Automatic Dependent Surveillance–Broadcast) signals. System very actively precedes mistakes like false signal reflections and absorption of replies. If the system is used in pressurized aircraft the transponder data of own plane are used as main source of altitude information.[1]

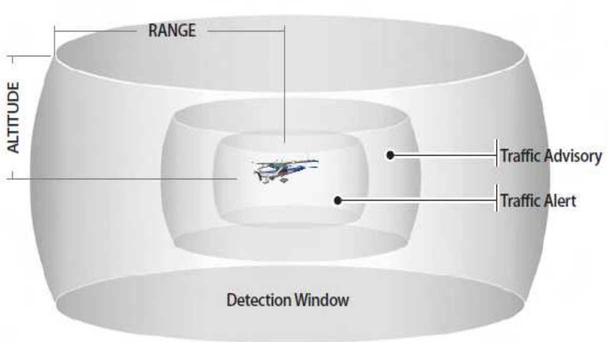

Figure 2. Threat detection envelope [1]

Table 1. Table description table description table description [1]

Level	Audio	Range setting	Distance from threat	Relative altitude is less than…
Advisory	Headset: “Traffic advisory. Monitor Closure Rate” Beeps: 2	6 NM	2.0 NM	±1000 ft.
		3 NM	1.0 NM	±1000 ft.
		1 NM	0.6 NM	±500 ft.
Alert	Headset: “Traffic alert. Obtain visual contact. Beeps: 4	6 NM	0.7 NM	±700 ft.
		3 NM	0.6 NM	±600 ft.
		1 NM	0.3 NM	±500 ft.

On the other hand system PCAS™ has few shortcomings. Device is not able to receive requests but just replies from SSR transponders and other ACAS devices. Correct function is highly dependent from coverage of secondary radar. If there is radar shadow system remembers just last known position and there is danger of near miss of aircraft. There is not necessary to carry SSR transponder in own aircraft. If reply received by PCAS™ is only in “Alfa” mode, there is no possibility of indication. For accurate indication pilot have to limit bank angles. In some specific situations threat aircraft could be displayed twice caused by reflection of the signal from the ground.

PRACTICAL USE OF PASSIVE COLLISION AVOIDANCE SYSTEM IN SLOVAK REPUBLIC

System is currently tested at University of Žilina in Žilina. University disposes of two PCAS™XRX™ devices. First one is installed in Zlín Z-43 aircraft tail number OM-LOW. Second one is used as mobile device ready to be used in any aircraft. Tests started in January 2012 and till 12-th April 2013 there were 168 flights with total time of 243 flight hours. Because of localization of Žilina airport in the middle of mountains the operation of device is not reliable. The most cases of near miss of aircraft are in airfield circuit. Circuit altitude in Žilina is 2150 ft. We chose a subjective assessment of the PCAS™ performance during each flight. Pilots were asked to fill a questionnaire concerning the evaluation the performance of installed device. The results were within the expected performance. In device manual there were couple of shortcomings which are significant for traffic in airfield circuit in Žilina. On the other hand there was almost no significant problems during cross country flights where flight altitude was higher and coverage of secondary radar was continual. During April 2013 there was made second analysis in different part of Slovak Republic. As destination was chosen airfield Lučenec and near surroundings. Slovakia is covered by two Slovak secondary radars and also radars from bordering countries. Operation of the device is dependent on altitude of the aircraft in airspace. Air traffic services of Slovak Republic made mathematical model of coverage of two Slovak secondary radars. They used Radio Mobile software. (Javorník and Veľký Bučeň radar). Coverage is shown in Figure 3 and 4. Every curve means 1000 ft. gain starting at 2000 ft. From attached figures is obvious that device is possible to use in Žilina airport from 9000 ft. (Veľký Bučeň radar) or 5000 ft. (Veľký Javorník radar). Compare to normal circuit altitude (2150 ft.), there is no

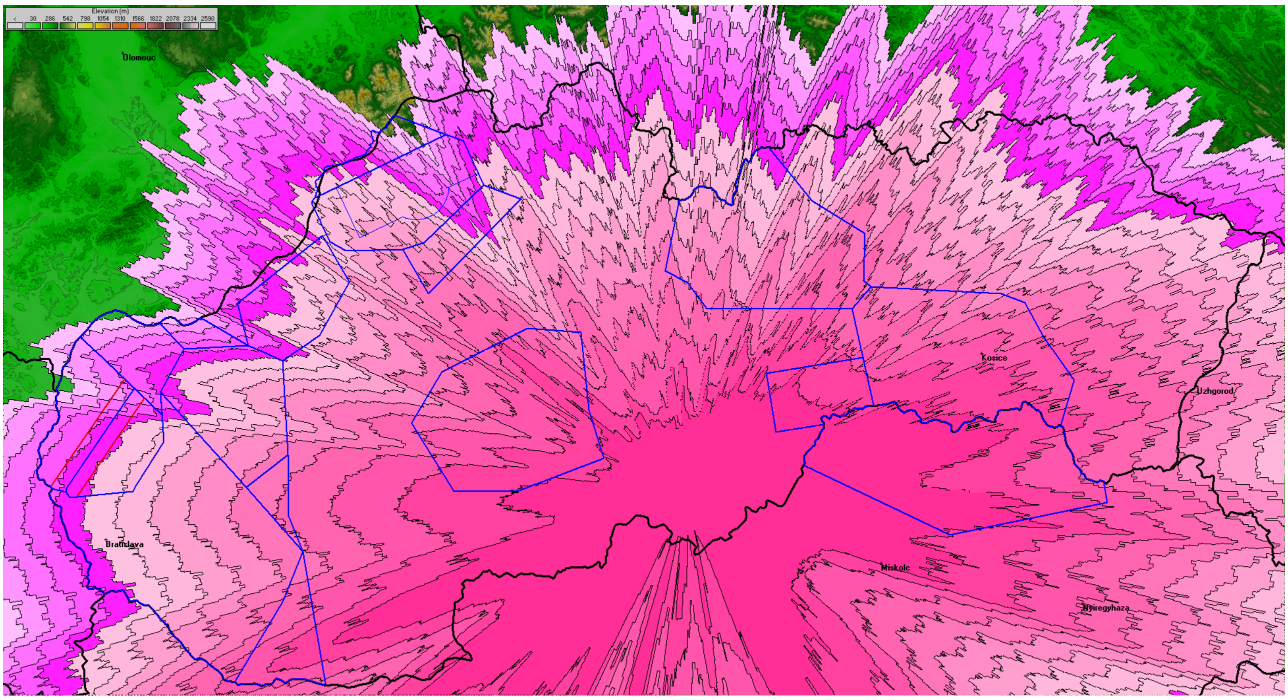

Figure 3. Coverage of Veľký Bučeň radar from FL020-FL150 (Source: ANS SR)

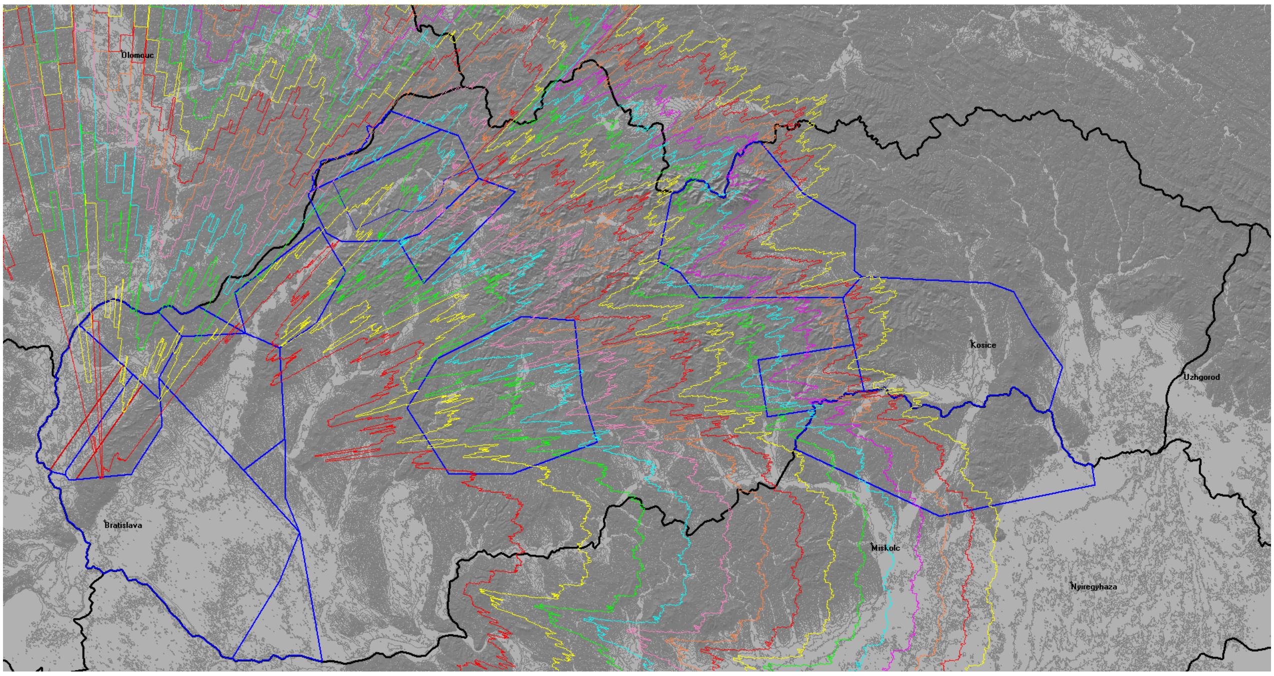

Figure 4. Coverage of Veľký Javorník radar from FL020-FL150 (Source: ANS SR)

possibility to use it for basic pilot training in this conditions. During second test in airfield Lučenec we simulated midair collisions in two separate flights. Cessna F150 (OM-ACC) and Stylus X3 (OM-M477) were used to simulate different indications of device. Both aircraft were equipped by SSR transponder mode "Charlie". Location of airfield is on low lands in the south of Slovak Republic. Next figure shows coverage of both secondary radars from the ground. Area where system was tested is exactly in this covered region. In all flights PCAS XRX was installed in Stylus aircraft and Cessna was flying around and tried to simulate near miss. All flights were recorded by two cameras. In both flights some shortcomings occurred. Generally system did not work properly and couple of times did not indicate plane which was less than 30 meters away. During second test flight third aircraft were nearby and system indicated same aircraft twice. To secure continuous coverage of radar all flight were provided in altitude more than 2500 ft.

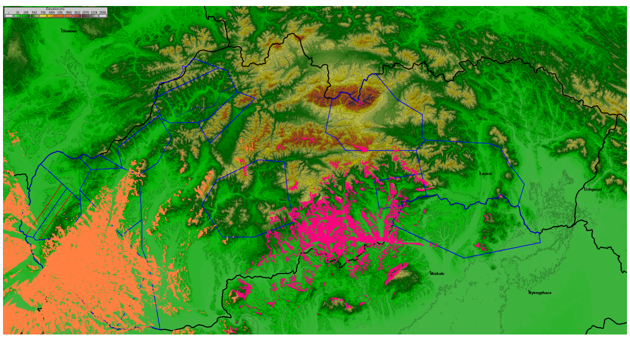

Figure 5. Coverage of both radars from the ground in Slovakia (Source: ANS SR)

Conclusion

System PCAS is designed to increase situational awareness and avoid midair collisions. Main customers are private pilots and flying schools. It is necessary for pilots to be informed about capabilities and also shortcomings of the system. During flight pilot has to focus on different instrument and if collision avoidance system does not work reliably it loses its main function. Pilots start to avoid to use this system because of false alarms or incorrect information displayed. Reliability of system is proportional to the coverage of particular area with a signal of SSR. System is very difficult to use in low level flights or during flight in airport circuit in mountainous regions of Slovak Republic.

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GNSS CENTRE OF EXCELLENCE AND IMPLEMENTATION OF GNSS BASED APPROACH PROCEDURES

Project oriented to the General Aviation airports in the Czech Republic

Ing. Tomáš Duša
GNSS Centre of Excellence, Czech Republic
t.dusa@sh.cvut.cz

Ing. Jakub Kraus
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
kraus@fd.cvut.cz

Ing. Tomáš Duka
Air Navigation Services of the Czech Republic, Czech Republic
dukat@ans.cz

Abstract – *This article introduces the project of transformation regional VFR aerodromes into airports with IFR operations in the Czech Republic in hand-to-hand with implementation of GNSS based approach procedures. The key parameter is to minimize managerial, operational and cost aspects of the transformation process. The project is realized by a consortium consisting of the ANSP of the Czech Republic, the GNSS Centre of Excellence, Department of Air Transport of the CTU in Prague and in close cooperation with the Czech CAA. The article describes whole transformation process together with the stakeholders' responsibilities and roles in each particular step. Arguments for implementing approaches based on GNSS are discussed further on. Last, but not least obstacles together with challenges to broader development of small aviation are introduced.*

Key words – GNSS, aerodrome, GNSS Centre of Excellence, IFR operations

I. INTRODUCTION

Improving the quality of aviation does not depend, or should not been focused only on commercial air transport at international airports, but on General Aviation as well. Focusing on the GA, however, carries one obstacle to be reckoned and that dramatically affects any development in this area. It is a small number of carried paying passengers, to which the cost of implementing new systems and technologies can be split into. Therefore, the development of GA aerodromes must be aimed to the use of already developed systems that are freely available.

One such a system is a GNSS, particularly widespread GPS system with the help of European augmentation system EGNOS. Expanding the use of GNSS in aviation is highly supported by international organizations and directly ordered by the ICAO Resolution A37-11 [1], where all airports must for each threshold implement RNP approach (RNP APCH) until 2016 using only satellite navigation signal as position information.

RNP APCH is an umbrella term for four approaches that differ in precision of used avionics and thus in the accuracy of aircraft navigation along the track.

Table 1 *- RNP APCH – the four approaches [2]*

PANS-OPS Terminology	PBN Terminology	Chart Minima	Minimum Sensor
NPA	RNP APCH down to	LNAV (MDA)	Basic GNSS[2]
APV Baro-VNAV	RNP APCH down to	LNAV/VNAV (DA)	Basic GNSS + Baro-VNAV
-No criteria available	RNP APCH down to	LP (MDA)	SBAS
APV SBAS	RNP APCH down to	LPV (DA)	SBAS

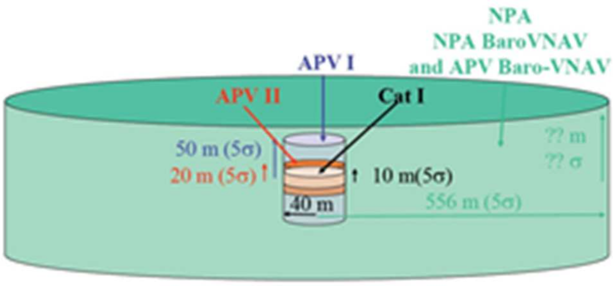

Figure 1 *- ICAO GNSS signal performance requirements [4]*

II. THE CONSORTIUM

The project's consortium comprises of following three members: the ANSP of the Czech Republic, the GNSS Centre of Excellence and the Department of Air Transport of the CTU in Prague. The consortium closely cooperates with the Czech CAA.

The ANSP is a Czech national navigation service provider (hereinafter RLP). A member of the ANS procedures department has been delegated to the project. As national expert and certified PANS OPS designer, he is responsible for the publication of approach procedures according to standardised design criteria. RLP is a consortia member of various GNSS related European projects (e.g. Mielec and ACCEPTA). A know-how gained within these projects makes good use in maximum extent, thus reducing costs of subsequent projects and economizes on budget.

The GNSS Centre of Excellence (hereinafter GCE) was founded in December 2012 by Air Navigation Services of the Czech Republic (RLP) and Czech Railway (CD) with support of Czech Ministry of Transport. The reason for creation of the GCE was to strengthen current and future activities of the Czech Republic in development, testing and deployment of GNSS applications. GCE builds on experience gained from successful development and testing projects (e.g. A-SMCGS, TE-VOGS) together with intention to implement similar projects with a vision to become a leader of GNSS applications in Europe. The Centre provides following services: defines ideas for new systems to industrial partners, provides specification of technical and user requirements for new applications, provides consultancy tailored to customers' needs, centralizes the on-going activities and initiates new ones, offers the use of large local testing platforms at Airports and Railway Testing Ring to SME's and industrial partners. Last but not least, the Centre prides itself on close cooperation with GSA headquarters in Prague.

In June 2013 the Road and Motorway Directorate (RSD) joint the Centre. With a full accession of this organization, the scope of activities expanded from aviation and railways also to road and highway network.

GCE as an interest association is open to welcome any subject having its research, development or business activities bounded to satellite navigation. Thanks to its key members as well as associate members and associate universities the Centre covers full range of GNSS market, e.g. application for the air traffic, for aerodrome operations, railways, road and highway applications and others.

Referring few of recent activities, GCE is a leading member of the consortium awarded to establish Business Incubator Centre of the European Space Agency (ESA BIC) in the Czech Republic. GCE provides experts to the broad international team of the tender submission placed by the Deloitte CR to GSA. GCE provides B2C networking for the company developing new EGNOS-guided system for safer, more economical and more ecologically responsible salt spreading on winter roads and B2C networking for the WheelTug system.

Within this project, the GCE's role is to provide experts participating on the research, implementation and safety topics, networking with government, national and international organisations, lead negotiations with the GSA and last but not least the fund rising issues.

The Department of Air Transport is education, research and development oriented institution under the Faculty of transportation sciences of CTU in Prague. The department has 11 years history in education professionals in the air transport domain, focusing on technological, operational and economic aspects. Each member has its deep knowledge in particular aspects, solving challenges of modern aviation research. Few of them have got broad overview of GNSS evolution and implementation in civil aviation. The whole issue of the project began in 2012, when the Department of Air Transport (ULD) identified gaps in research of the possibility of extending the EGNOS use for aviation. With this idea an internal project started, whose objective was to find the best way to use EGNOS for aviation improvements. Thanks to the access to world scientific research papers rich knowledgebase is being built serving as an best practice portfolio for solving challenges in the Czech Republic. Debating with representatives of various bodies of the European aviation (RLP, CAA, EUROCONTROL, Avinor) the project gradually begin focusing on general aviation, which is mostly out of the scope of international implementation effort. For better clarity, the department propose to divide general aviation into big and small. Department's role is to define an implementation concept, challenges identification, solutions proposition and safety studies assessment.

III. Initial research in the field of GNSS starts at ULD

Research in the field of GNSS at ULD is focused on general aviation - big and small GA. Big GA stands for large airport with good infrastructure, paved runway and operations of private business jets (e.g., Hradec Kralove, Ceske Budejovice), while small GA is represented by aerodromes with grass runways (e.g. Klatovy) with the typical aircrafts Cessna 172, or Zlín Z43. The first have always faced the decision to introduce air traffic control service and IFR operations, but because of the high cost none airport has undergone such change yet.

The promoted project of extending the use of EGNOS in GA is therefore very well suited for large GA airports, as it can zero the cost of construction of terrestrial radio navigation equipment required by existing regulations for IFR operations. This began to open the way for allowing IFR operations at VFR aerodromes. However because of the considerable differences between VFR and IFR rules there was necessary to first identify the main obstacles of this transition. These include:

- Type of the airspace around aerodromes,
- Need for the presence of ATC service,
- IFR requirements for aerodrome,
- IFR requirements for the runway – marking, lighting system,
- Competences and responsibilities of AFIS,
- Radar coverage in the vicinity of the aerodrome,
- Appropriate system (technology) for approach,
- Approach procedure,
- Current legislation for aerodrome certification,
- Requirements for aircraft equipment,
- Requirements for pilot training,

All of them need to be solved.

The ULD has started its work on eliminating each of them, with a primary focus on eliminating the need for the presence of ATC service at the airport with IFR traffic and the type of airspace around the airport.

After one year of research, the ULD had the opportunity to promote outcomes to other professionals in the field of GNSS navigation at the Galileo Services Meeting held at GSA headquarters in Prague, where the consortium of GCE, ATC, ULD started to take shape.

IV. Implementation Issues of IFR Operations on GA Airports

Implementation of the new thing that is not supported by rules is always difficult, because to solve it, the cooperation of all affected stakeholders involved in the change is needed. They must agree on a common approach, think of the changes and subsequently incorporate them into legislation and regulations. This process faces two obstacles areas. The first is related to the questions how to implement the change (i.e. process phase), and what change to implement (i.e. operational phase). First question means the need to create process with defined steps how to implement the change. The complexity of the process phase increases extremely with increasing number of actors and therefore it is subsequently appropriate to invite an expert subject in the role of facilitator. Second question is all about operational barriers directly related to the introduction of changes relating to its invention and its implementation into operation.

Process Phase

From the process perspective the main stakeholder in Czech aviation is the Czech Civil Aviation Authority, which is obligated to examine and evaluate all received requests.

As the ULD has got fourteen months overview and know-how about the issue of allowing IFR operations at VFR aerodromes, we got to the point where several airports in the Czech Republic became real interested about the implementation of this research into practice. Parallel to the ULD's activity, the first change has been proposed by the CAA solving the need for presence of ATC service supporting IFR operations. The process of changing L 11 standard (Czech version of Annex 11) regarding the provision of AFIS is undergone. In the Czech Republic there was always applied the rule where every VFR aerodrome is AFIS airport. But not all operators could provide the same high quality service and as a result AFIS were more amateur service than professional one thus not being in conformity with the concept of AFIS as it is applied in other countries in Europe. Thanks to the pressure from large GA airport operators to authorize IFR operations at airports without ATC service, the Civil Aviation Authority changes the aforementioned L 11 and makes AFIS more professional with a must of certification. Taking into consideration that AFIS is considered sufficient for IFR operations worldwide, this was relatively easy step to make this change by CAA itself.

However, other areas, e.g. mainly type of airspace, affect more stakeholders in the aviation and government and therefore participation of all of them is needed. Except the CAA, other stakeholders are the Czech ANSP (RLP), Ministry of Transport (MDCR), Ministry of Defence (MOCR) and representatives of general aviation – the Aeroclub of Czech Republic (AeCR) and the Light Aircraft Association of the Czech Republic (LAACR).

Because of the novelty of this issue, there is none experience with IFR operations at uncontrolled aerodromes in the Czech Republic. In spite of that, the airport operator Hradec Králové (LKHK) shows long-term efforts in introduction of such an operation onto its airport. Except the LKHK, there is only one another airport with certified AFIS (the LKKU). Concerning these facts, the Hradec Kralove airport has been chosen for the pilot project. Due to this, the negotiations were conducted also with representatives of the operator LSHK.

Unfortunately, the overload of the State administration greatly reduces their ability to work on novel and progressive projects. Taking into account the complexity of the issue, the best solution seems to find an external expert that focuses at the area for a long time and knows the best practices and optimal solutions, which can overtake a large amount of work from other stakeholders thus facilitating the overall process. This situation resulted in collaboration between the Department of Air Transport and *working group for the implementation of class F in the Czech airspace*. Reasons to implement airspace class F in CR are explained in the sub-chapter „operational phase". The establishment of this working group was initiated by the *Concept group to change the Czech airspace* because of a clear focus of the problem and the expected high time demands. In the working group for the implementation of the class F are now participating two of the three members of the consortium (ULD and RLP) and one representative each of the CAA, MOCR, MDČR and GA.

Changes in the airspace of the Czech Republic are made continuously, but to allow, IFR operations onto currently uncontrolled aerodrome is a major intervention in the airspace structures and rules of the air. On the basis of the collected know-how and best practice from abroad the consortium proposed concept, which consists of two areas - regulatory and operational - each with two main outputs and their associated activities.

Table 2 *– Proposed Implementation Concept*

Area	Output
Regulatory	1. Analysis of standards and regulations, where introduction of class F implies the need for change
	2. Create a guidance material for the parameters of class F
Operational	3. Constructing LPV approach procedures in a new class F
	4. Practically implement operational procedures in relation to new types of operations

This concept was subsequently approved by the CAA with the main priority at the output number 1.

As each member of the workgroup has his own point of view, it is necessary to obtain all of them. The solution was therefore chosen in form of the questionnaire. The first step was the creation of questions related comprehensively to introducing

IFR operations at uncontrolled aerodromes, to which the working group members have been asked to respond. Based on the synthesis of responses the required amendments are being proposed. They will be drafted and the working group must be ready to review, comment and approve them. This method will ensure rapid implementation of the necessary changes. The responsibility of management of this activity from creating the questions through the synthesis of responses and preparing amendments has been charged the consortium member - the ULD.

The associated topic is private area and mutual agreements between the stakeholders, some of which will also need to be adjusted. In this case, it depends only on the individual stakeholders whether they would be interested to look up help from the experts (the consortium), or make the changes themselves.

In parallel with the output No. 1 (Analysis of standards and regulations, where introduction of class F implies the need for change) the output No. 3 (Constructing LPV approach procedures in a new class F) is being worked on. This is under responsibility of another consortium member - the RLP.

Operational Phase

The operational aspects of the implementation of IFR approach at VFR aerodromes faces to all identified obstacles mentioned above. Fortunately, most of them could be solved using the model already used for IFR operations on large GA airports in other parts of Europe. The question is only which model should be used and whether to introduce it in exactly the same way or take the model only for inspiration. European civil aviation regulations are slightly different from the rest of the world, so we were in our project looking for inspiration in European countries, which already have a precision approach procedures at uncontrolled aerodromes applied. Among them, we identified three main options.

The first one is characterized by permitting IFR flights in the class G airspace, which appear from the perspective of the current Czech rules of air as extremely big change. The second option is to use a new type of airspace called Traffic Information Zone (TIZ), which is used for example in Norway, having same function around uncontrolled aerodromes as the CTR airspace around controlled ones. But, the actual implementation of TIZ airspace is insufficient and airspace class in TIZ needs to be defined to permit IFR flights and to have sufficient requirements to ensure the safety of these flights. The third option is the implementation of the German model, namely the introduction of Class F airspace, into Czech legislation and the definition of this space to safely allow IFR operations at VFR aerodromes. From the perspective of air transport in the Czech Republic, only the introduction of the class F airspace comes into consideration, with a possible future extension of TIZ.

The Concept group to change the airspace agreed on the German model (the introduction of class F), and also created a working group for the Class F implementation mentioned above. Chance for TIZ is still open.

A similar problem of two possibilities is also for other areas to solve, such as the necessity of two-way radio communication in a defined airspace around the airport for IFR operations. This situation is illustrated in Figure 2, where there is always the option to choose between two possibilities. After choosing one or the other come consequence of a decision and the process continues to the next milestone.

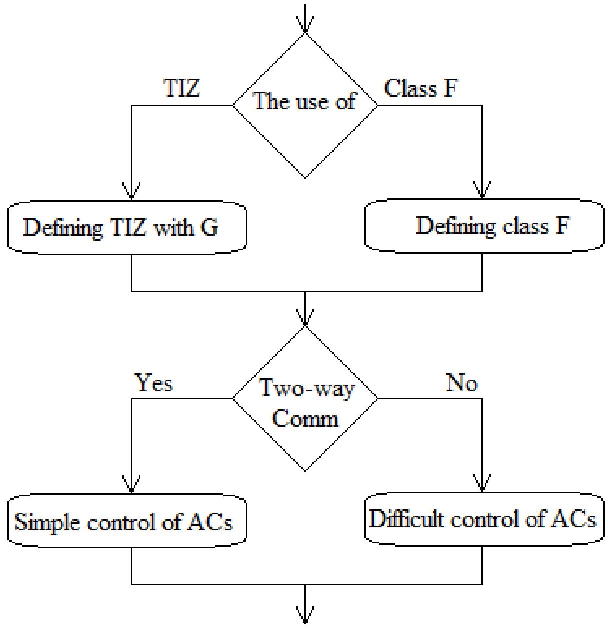

Figure 2 – *Two solutions for „everything“*

The same can be seen for the necessity to equip aircraft with SSR (Yes, No), with the definition of the upper limit of the class F airspace (will interfere to E, will not interfere to E), or as the need for the introduction of air traffic advisory service (to be implemented, not implemented).

V. The Use of GNSS for Enabling IFR operations

The project of implementation IFR operations at VFR aerodrome had one main trigger, which is the development of GNSS systems - introduction of EGNOS, improved RNP APCH concept, and pressure from the European Commission and the GSA to implement GNSS applications. RNP APCH, mentioned in the introduction, is the best choice among all types of approach for the introduction of the brand new approach to VFR aerodromes because of zero cost to build terrestrial navaid equipment. Thanks to ICAO Resolution it is also the only logical choice, since RNP APCH will be required for all instrument runway ends in 2016.

RNP APCH is defined in ICAO Doc 9613 Performance-based Navigation (PBN) Manual [5], where there is a choice of four approach types, four chart minima (LNAV, LNAV / VNAV, LP - unused, LPV), and at the same time for each specified minima required navigation infrastructure, obstacle clearance, controllers training, approval process, requirements for aircraft and pilot and his training. All such features operationally differentiate each minima, even though the base is the same. One fundamental consideration is also applied here - the more strict requirements, the lower the decision height could be applied. So it is always necessary to find a compromise between the requirements of DH and aircraft equipment. With the same basis for all RNP approach, considering implementation costs, the best practice is to implement all three minima, thereby allowing operation with either simpler aircraft avionics (in the appropriate IMC conditions), or very well equipped aircrafts for weather conditions approaching ICAO CAT I limits.

VI. Future Challenge

In the current situation is the possibility of implementation of IFR operations at small aerodromes important step to encourage not only GA, but the whole air transport.

The arrival of new technology in the form of the European satellite navigation system Galileo and continuous improvement of EGNOS will bring better signal parameters and thus the possibility of new minima e.g. LPV200 which are considered by European authorities (ESA) today. The extension of this may be an attempt to reduce costs of infrastructure. While ATC redundancy and introduction of RNP APCH dramatically reduce the necessary costs for implementing IFR operations to VFR aerodromes on one hand, the further expansion of GNSS usage is still prevented by existing regulatory requirements that pose high initial costs for the aerodrome at the other hand side. An example might be requirements for runway equipment (navaid equipment, RWY marking, visual approach light system, etc.). However, reducing these costs should not be overly difficult. This idea is based on several rules relating to aviation safety. These are:

- Standards must be followed
- Standards are here to ensure quality
- In aviation, quality is safety

From these three points it is a clear that the use of GNSS depends only on safety issues. Therefore, it is possible to create a simplified equation of safety of approach:

$$Safety\ level\ of\ approach = safety\ of\ technology + \\ + procedure + aircraft + aerodrome \qquad (1)$$

This equation is very important for any further development in aviation and means that the level of safety must be ensured.

To adapt this general equation to our case to further increase the use of GNSS (EGNOS and Galileo), the minimum decision height could be pointed out as irrelevant. General aviation can now use most aerodromes (84 out of 92 in the Czech Republic, or a fraction of all 4600 in Europe) in VMC conditions only. For this reason, there is plenty of leeway for trade-offs between technology, procedures, aircraft and aerodromes. Taking as an example, the implementation of an instrument approach, which could have a decision height about 400-500 feet and allow aerodromes operation even in poor weather conditions (but not extremely poor, where DH250ft is needed). According to safety level of approach equation (1), on the right side there is safety of the procedure and safety of the aerodrome. Therefore, it must be possible to trade-off a few hundred feet of the decision height (rising minimal DH) for reduction of the aerodrome infrastructure (to accept worse aerodrome infrastructure). Or use precise technology for approach (Galileo) while maintaining the decision height and trade-off it for a reduction in aerodrome's infrastructure.

The implication of this equation means that it must be possible to design a precision approach with a decision height of 500 ft for VFR aerodrome with very limited infrastructure and get certification as shown in equation 2 and 3.

$$ILS\ Cat\ I + compatible\ aerodrome = LPV500 + \\ + compatible\ aerodrome \qquad (2)$$

$$ILS\ Cat\ I + Annex\ 14\ Airport\ Infrastructure \\ = LPV500 + Airport\ Infrastructure for\ this\ approach \qquad (3)$$

This consideration could bring huge savings for aerodrome operators and efficiency in spending public funds. The investments into development and operation of European brand new satellite navigation system GALILEO will have therefore another great employment in the entire aviation and not only in one part. Investing in infrastructure strengthen the economy in European Union in consequence.

VII. Conclusion

The implementation of a very dramatic change in civil aviation, especially in GA has been introduced within this paper. In order to bring added value in aviation from rapid technology development of modern age, it is in upmost importance to change from the scratch rules of the air, that are based on dozens years old basis.

The usage of GNSS as a primary navigation means could be considered as such a dramatic change. The instrumental flight rules have to be applied when using GNSS, however these rules are not yet defined for approach phase on VFR certified aerodromes.

Thanks to unyielding pressure of few stakeholders in the Czech Republic (including the consortium and the ULD) the first step has been done. The debate about implementing IFR approach onto VFR aerodromes has been opened within the state administration organisations.

We are glad, that the consortium consisting of three professionally oriented entities on GNSS issues in the Czech Republic (the RLP, GCE, ULD) taking its role in this significant process.

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SYMBOLIC POLITICS AS A MATTER OF AIRPORT NOISE MITIGATION PROGRAMS

Prof. Dr. Hansjochen Ehmer
German Aerospace Center (DLR), Institute for Air Transport and Airport Research, Germany
h.ehmer@dlr.de

Jana Carolin Kromm
International University of Applied Sciences Bad Honnef – Bonn, Aviation Department, Germany
jana.kromm@iubh.de

Abstract – *This paper is about the performance of political measures aiming at noise reduction. Airports experience pressure of stakeholders to reduce noise. They use a symbolic detour to noise reduction that helps simplifying communication to their stakeholders, gaining their acceptance also by implementing noise protection measures. The idea of symbolic policy is presented and applied to the airports of Cologne and Hamburg.*

Key words – Noise mitigation programs; symbolic vs. substantial politics; sustainability in aviation; acceptance of regulations; Corporate Citizenship of airports.

INTRODUCTION

As aircraft noise is proven to have negative impacts on human health the regulator, as well as all companies, are made responsible of taking care of this problem by applying policies that reduce noise and consider its impact on the affected population. In addition to reducing the actual impact of aircraft noise, the difficulty of growing demand and resulting increase in movements has to be tackled.

Since there is a growing pressure of the affected population the airports have to react to reduce their pressure for future investments. Therefore, the need of effective policies aiming further reduction of noise congestion is an urgent target. This paper shall provide insights into the effectiveness and efficiency of noise protection measures by analyzing if airports' noise protection measures are of rather substantial or symbolic nature.

POLITICAL NOISE ABATEMENT MEASURES

To protect people living in the vicinity of airports more and more rules and regulations have been introduced. We have to differentiate between global and national regulations and local rules set per airport.

GENERAL REGULATORY FRAMEWORK

The international framework of ICAO (International Civil Aviation Organization) is setting standards and guidelines which the 189 member states are asked to ratify and then apply. The Committee on Aviation Environmental Protection (CAEP) is responsible for the noise section. The ICAO Annex 16 of the Chicago Convention sets standards for noise certification of aircraft representing guidelines to be transformed as directives into EU law, which then are to be transformed into national law. It divides the so called noise chapters of aircraft into four chapters.

After chapter 3 was introduced in 1978, the need for a more stringent class was detected and therefore, in 2005 chapter 4 was introduced which classifies aircraft that absorb 10 dB less noise in average than chapter 3 aircraft.[4] Stepwise, chapter 1 and, since 2002, also chapter 2 aircraft, such as Boeing 727, are not permitted to operate anymore in the EU.[5] Based on these chapters, many airports grant financial benefits to the less noisy aircraft.[6] As future outlook, in 2017 a new, more stringent noise class shall be introduced in Annex 14. Since ICAO is a global institution where all member states tries to influence the results it can be stated that the incentive to reduce noise via these classes is rather small since – at least in western countries – most aircraft fulfill the norm already before it is introduced.

In 2007, ICAO certified the "Balanced Approach" principle which should be applied in the member states in order to make the assessment of noise at individual airports and the determination of suitable and cost-effective noise abatement measures more efficient. A sequence of efficiency is incorporated in the four pillars: (1) reduction of noise at source, (2) land-use planning and management, (3) noise abatement operational procedures, and (4) operating restrictions.[7] In the airport package of the EU of December 2012 more emphasis is laid on the Balanced Approach.

On the national level there exist regulations claiming noise protection zones around commercial airports according different noise levels. Within these zones no building licenses are issued, or on a next level new flats may be permitted if noise protection elements are used. These regulations target at reducing the number of noise affected people around the airport without influencing directly the emitted noise.

AIRPORT ORIENTED NOISE ABATEMENT MEASURES

The liability of noise is at the airport operator's side, whereas airlines are causing the noise. Hence, the airport has to

[4] cf. Girvin (2006), p.13
[5] cf. Sterzenbach, Conrady & Fichert (2009), pp. 75
[6] cf. Sterzenbach, Conrady & Fichert (2009), p. 7
[7] cf. ICAO (2007)

task to control compliance with the existing set of rules and regulations that are applicable at the specific airport.[8] The airport has on the one side, to guarantee capacity for the future growth of air travel has, on the other side to face public campaigns against aircraft noise in the communities around the airports. Therefore, most noisy airports apply a different set of sound insulation measures to combat this problem.

More or less, all environmental protection measures come along with economic disadvantages. Either the measures directly target at reducing traffic growth, as for example night curfews do, or the measures indirectly reduce traffic growth as they are combined with additional costs being added on top of ticket prices. Thus, they harm demand and profitability of airlines and airports, as well as traffic growth.

Luckily, not every airport is concerned in the same way. The number of affected people around airports varies depending on the number of inhabitants in the vicinity of the airport. If the airport is located close to a city center, the number of affected persons will be significantly higher than at a more remote airport. Hence, the extent and sort of measures has to be adapted on per-airport basis. This decision is also characterized by some sort of trade-off between economic and ecological advantages which should be carefully considered before applying specific measures.

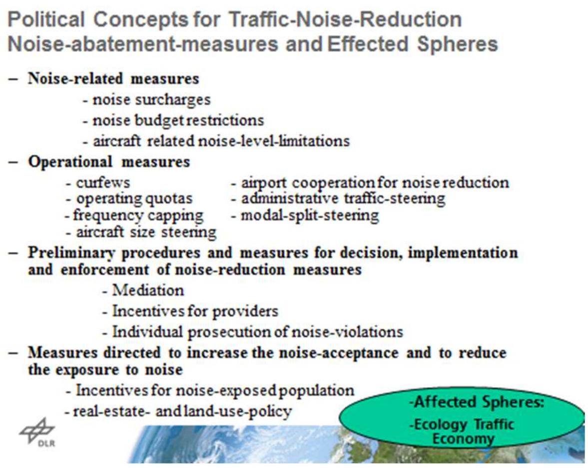

***Figure 1** – Overview of noise mitigation measures*

Noise protection can be classified into passive noise protections and active ones. Passive measures reduce the nuisance of emissions while leaving the actually emitted noise level constant, whereas active measures actually reduce noise. Further differentiation is needed since a lot of instruments are directly noise oriented, whereas others influence the movements at the airport assuming that a reduction of the movements will lead to a reduction of noise. This is not obvious since the existing demand then will be served very probably with bigger aircraft. Further differentiations are possible but not relevant for this paper. Figure 1 gives an overview about the most relevant measures. In the next paragraphs only some of these measures will be presented a little bit more in detail.

The most important noise-related measure is represented by **noise-related landing charges**. Airlines are charged per landing, per take-off or both, based on their noise emissions. This can be the noise emission according the MTOW in relation to the ICAO chapter, it can be the noise according the aircraft certificate or it can be the measured noise at the airport or a combination of one of these possibilities.

The other way round, airlines may get discounts on the payable charges if more quiet aircraft are operated. Often, airports develop noise categories to more precisely differentiate the charges and hence improve incentive settings. The charge has to be high enough to be considered by the airlines, as the renewal of the fleet is relatively costly. But airlines will reduce their efforts that are based on charges whenever the marginal cost of noise reduction exceeds the charges they have to pay. [9]

Those charges are used not only to set incentives, but to cover the cost, as the airport has to finance the noise abatement programs. But this information is not communicated. A further differentiation can be made based on the landing fees, namely the increase during night. The main aim is that the airlines use less noisy aircraft in the most sensitive hours of the day or as an incentive to postpone flights with noisy aircraft to less sensitive hours of the day.

Furthermore, **cumulative noise limits** or **noise quota** limit physical quantity of noise. The airport and the regulator fix a maximum of available noise that may be emitted within a season and fairly splits this among all airlines. The amount of noise maybe different during day and night time, as this is the case in AMS,[10] for example. While aiming to reach a change in fleet decision, this measure may lead to other problematic questions such as the really fair distribution of noise on airlines, as well as the possibilities to avoid wasted capacities of unused noise at the end of the time period. Girvin found out that cumulative noise limits are preferred to **per-aircraft noise limits**.[11] Like all other levied charges, the polluter-pays principle is applied, which makes the causing polluter pay the affected people for their economic losses. [12] But this counts only if the quota is distributed using the price system which is not obvious seeing the distribution of the scarce resource of slots.

Another option is the set-up of a **night curfew** which forbids any movement during the night time. Hence, it takes care of the most sensitive phase of human sleeping time. It varies from airport to airport, firstly in terms of the time and the terms of restrictions, as well as fines and exceptions to the rule. It is very useful for the residents, though the trade-off for airport and airlines at least brings along a loss of revenue. In addition, passengers' flight schedules are more restricted. As less cargo will be transported during night, productivity and profitability of the airport will decrease, and job losses are consequently ensured.[13]

Furthermore, a **capping of movements** only fulfills the aim of reducing noise if the bigger aircraft are relatively quieter than smaller aircraft. Absolutely the noise per noise event might even be louder. But as noise in this case is not measured, the efficiency is not guaranteed. Similar constraints apply to aircraft size steering which also only aims at the

[8] cf. Wells & Young (2003), p. 356

[9] cf. Knorr (2011), p.7
[10] cf. Girvin (2009), p.17
[11] cf. Girvin (2006), p. 25
[12] cf. Knorr (2011), pp. 10-11
[13] cf. Girvin (2009), p. 20

preferred use of increased capacity, but does not really care for noisiness of the used aircraft.

In order to reduce noise disturbance in the closer area around the airport several **land-use planning instruments** are available: Firstly, the noise protection areas that are regulated classify the areas around the airport into several protection zones, e.g. two during the day, and one at night. The more affected day zone 1 with equivalent sound levels of 65 dB is completed by day zone two with 60 dB and the night protection zone of noise level of 55 dB is completed during the night time (2200 to 0600). Thus, noise protection is enhanced in the most affected areas and also building permits are affected.[14]

In addition, **noise insulation** programs enclose the installment of noise insulation windows and air conditioning in sleeping rooms of accommodation units that are located in a certain noise exposure area. They are executed in order to protect affected people from flight or ground noise. The effectiveness, though, is restricted to the times in which windows are closed and people stay in the protected rooms.

The implementation of an environmental management system (**EMAS**) is considered not only by airports, but also other industries. Companies can certify for a predefined standard of environmental management for which they have to proof the fulfillment of certain environmental criteria that are of concern in their industry.[15] As regards aviation, those areas are mainly covering gas and noise emissions, but also water and waste management is part of the controlled criteria. Examples: certifications according to EMAS, which is a European wide standard system, or DIN EN ISO 14001, a private audit scheme of German origin. Through such a certification the basis for an efficient environmental sustainability of the firm is created.

The **management of complaints** is a tool of growing importance realizing increasing problem awareness. The number of complaints may serve as an indicator for perceived nuisance but is no accurate means of representation, as people deal differently with affectedness. That means that not everyone complains to the same extent.[16] Indeed, many people use the possibility of complaining and therefore airports install complaint management offices. Exposure of the neighboring community is rendered and problems concerning the check of deviations from flight paths or not permitted take-offs and landings with DFS, can be permitted to fulfill indications on law.[17] Girvin, though, argues that this tool is no real policy instrument as “it fails to interact with the source” of noise,[18] like also the insulation programs. Obviously, it is important to gain acceptance in public, a fact that presumes personal and direct communication.

[14] cf. Fecker (2012), pp. 209
[15] cf. Baumann, Schulz & Wiedenmann (2010), p. 231
[16] cf. Fecker (2012), p. 14
[17] cf. Girvin (2009), pp. 20-21
[18] Girvin (2009), p. 28

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Policy	Explanation	Grading
Noise-related landing charges	Only efficient if extremely high, otherwise airlines do not consider it as reason to overhaul engines or fleet; incentive to reduce noise at source for airlines. ICAO: airports may use these charges to cover the cost for noise relief and prevention management. But this information is **not** communicated.	Low impact, therefore not considered as efficient. Proof of asymmetric information distribution. Hint for symbolic acting which aims at financing other measures while pretending to represent
Raise of landing charges around night hours	Does it really decrease traffic or do airlines not care? Charges also levied to cover expenses for other measures	Proof that dissonance of information. Hint for symbolic acting which aims at financing other measures while pretending to represent incentive for airlines
Reduction of ground noise (engine test run halls, APU restrictions)	Only works for people living in the close vicinity of an airport. Hence, benefit for very few people of the broad public, but the employees of the airport also profit. And it shows action.	Rather substantial, and partly symbolic action
Land-use planning	Minimizes the population affected	Rather substantial

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Policy	Explanation	Grading
Environmental Management System	Basis for efficient Env. Management is laid, with certification, but once certified, no instance objectively controls the implementation of measures and efficiency. Critical as it implies that environmental management is ensured	Rather considered as tool to create positive image, which may bring positive results, if airport itself puts emphasis on it
Operating restrictions	Helpful enforcement of restrictions concerning noise levels , regulation by ICAO and the national government	Efficient as noise is really reduced, but no measure from airport side
Operational capping	Reduce frequencies, which results in usage of bigger aircraft types which are noisier. Measured noise decreases, but personal perception about noisier events is not changing	Critical if really efficient. Definitely, partly creates positive feeling that noise is reduced
Housing Programs	Protect houses from noise, but not in case of garden usage and opened windows	Efficient for some parts of the day and rather for winter that summer times

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***Figure 2** – Overview of evaluation of some measures*

The above figure gives an overview about the effectiveness of the different measures. It might be a bit one-sided since the effectiveness is seen mainly under the viewpoint of noise reduction, not so much about the other mentioned spheres which also have to be considered. But since the pressure comes only from one stakeholder, the people living there, their viewpoint has to be considered preeminently.

SYMBPOLIC VS. SUBSTANTIAL POLICIES

DEFINITION AND ATTRIBUTES OF SYMBPOLIC POLICY

Basically, the basis of solving an environmental problem is to assess a way to a proper solution. Firstly, the problem has to be detected by someone, for example the public. Then, the topic has to be explored, followed by an assessment of possible risks and impacts. Based on that knowledge a decision of how to act consequently is made by the organization or the individual. There are different ways to get to a solution, concerning the way how to act, as well as concerning the efficiency of actions.

Efficiency and effectiveness of actions depend on the choice of the approach by the policy makers. One way to take is made by substantial actions. These are characterized by forming tangible changes in an organization that affect procedures and goals in a company[19], whereas the symbolic approach creates an impression which forms the perception of being substantial. Therefore, the less substantial content is in an action, the less efficiency is brought across by that action. However, this does not mean that the aim can't be reached, as effectiveness can still be realized. The following illustration will explain ways policy making.

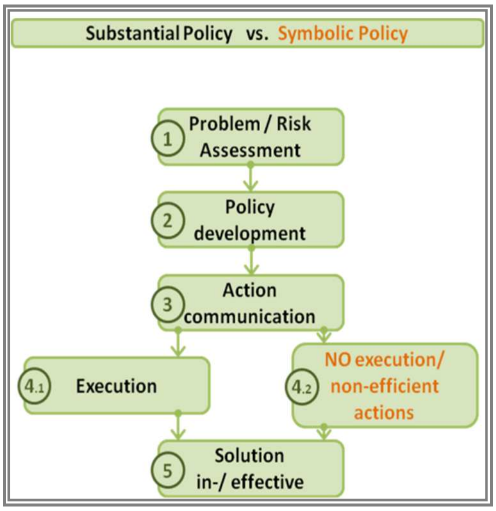

***Figure 3** – Policy approaches to solving problems*

Symbolic policy can be seen as a tactic which is applied by firms that are seen as environmentally threatening aiming at reducing public inspection.[20] Additionally it can be a tactic of try to impress the public communicating that an environmental issue is identified and a solution is being developed, whilst it is not intended to be applied.[21] The ultimate clue of symbolic policies is that optimally, nobody realizes that anything really happens in the background or that actions are not fulfilling the promised aims: A company can create a positive environmental image through mere impressions. It is successful when the public simply notices that the problem is started being solved.[22]

Symbolic policy can mainly be described by the following three attributes, namely **transparency** of the issue, the information distribution by the user to the addressees, and the possibility of external control of the result.[23] Describing the **applicability** of symbolic policy, it only works if the public doesn't see through it.[24] Therefore, the first attribute that is presumed is the absence of transparency of an issue. The difficulty in measurability displays an important factor of hindering transparency.[25] Data gathering is often aggravated as the topics in question, such as the degree of air pollution due to CO2, are often not perceivable by human senses and therefore have to be measured with technical instruments.

Another attribute of symbolic policy is that the user provides **information** which gives an **asymmetric** share of content to the addressee.[26] This means that pieces of information that would be helpful to judge policy making are not communicated or even communicated with distorted content concerning planned actions and their real outcome. Other attributes includes the possibility of controlling the results by the ones being affected. The following figures gives an overview of the differentiation in the attributes between substantial and symbolic policies.

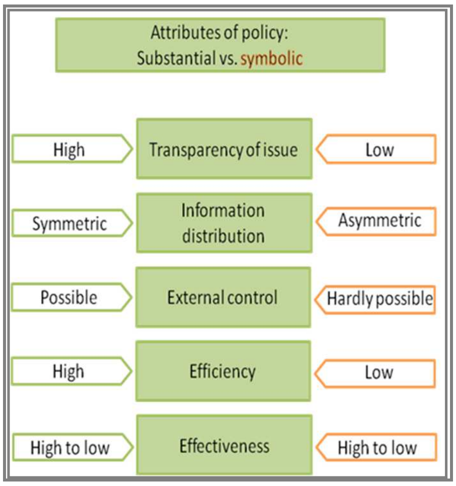

***Figure 4** – Attributes of policies*

Application of Symbolic Policies

Out of a first view symbolic policy seems to be very near to green washing, since the companies assume to act but in the end they don't move. In the special case of an airport it can easily be a problem: do they have an interest that their instruments work substantially? That airlines with louder aircraft move away, or that they come in – if this might be possible – with less noisy aircraft so reducing the revenues of the airport?

But the symbolic approach does not necessarily stand for negative results. It is possible that through its usage certain aims can be fulfilled. Trying to clearly differentiate between substantial and symbolic, as for example in environmental law, is not really worth a try as symbolism is to be graded.[27] Often, symbolic actions are based on substantive activities, but the extent varies to which the symbols are built in conformity with substantive content.[28] The symbolic approach can essentially contribute to communicating concepts that concern a risk that has to be published in order to change behavior and attitude towards a threatening issue. Assuming that the context is hardly explainable, as the scientific background is extremely complicated symbolic policies make it communicable to everyone and reach an increase in awareness.[29]

All in all, it is not easy to judge symbols as being morally wrong, because the corporation's intentions and the respective outcomes of the symbolic management may be extremely complex. Furthermore, environmental issues are often vague and uncertain which let the company have a certain range of action possibilities disguising environmental liabilities as

[19] cf. Bansal & Kistruck (2006), p.166
[20] Rodrigue et al. (2012), p.125
[21] Karl (2000), p. 213
[22] cf. Bonus and Bayer (2012), p. 16
[23] cf. Matten (2003), p. 221
[24] cf. Hansjürgens and Lübbe-Wolf (2000), p. 26
[25] cf. Matten (2003), p. 221
[26] cf. Matten (2003), p. 221
[27] cf. Lübbe-Wolf (2000), p. 25
[28] cf. Bansal & Kistruck (2006), p. 167
[29] cf. Matten (2003), p. 219

well.[30] Reversely, the negative effects of symbolic policy firstly, pose an ethical question of whether pseudo-acting is morally reasonable at all. Secondly, as the action only suggests the impression of action, it might be that the problem stays unsolved.[31]

The basic conceptual framework of how **noise protection policies** arise clings together with the fact that the airports stakeholders have social expectations on the polluter's environmental protection, namely the aircraft's noise. Therefore the regulator and the airport have to show commitment and action. Furthermore, the addressees of the policies are the stakeholders, who in this case are mainly the affected residents, the general public and the investors.

Concerning the **transparency** of measures taken, noise seems to be more easily perceivable and understandable than it really is. At the first glance, airports publish the noise emissions measured at the installed stations around the airport. Interested persons can easily look up noise and routings of aircraft in the internet and check those data against legal permits. Additionally, noise is clearly perceivable in comparison to other emissions, such as different gas emissions. Therefore, the checking on results should be easy. "But transparency can be a trap."[32] This is due to the fact that the human ear can't perceive a change in a noise limit that is only about 2 dB. Also the accumulation of noise events is physically extremely complex. Therefore, people have to rely on published noise measurements by the airports which demands more technical background knowledge to be able to judge it. Furthermore, noise measurement is underlying different applicable formulas which need comprehensive background knowledge for understanding the elements contained in the calculation. Additionally, noise can be measured in different units. This means that a reduction in noise terms is not equal to the same reduction if another formula is used.

Definitely, a vital interest of the airport is to **communicate** what has been done for the benefit of neighboring residents and possibly also what is still be going to be done. Information is typically communicated in diverse forms of media channels varying at each airport. Thus, responsibility is demonstrated creating a **positive feeling** with the stakeholders. It keeps up strengthening the image.[33] Environmental commitment as part of lowering the enormous pressure from on stakeholders' side is a necessary obligation of airports. Whether and to which extent embellishment and distortion of information takes place has to be checked in single airports' cases and cannot be generalized.

Finally, **external control** of the mix of measures at an airport is hardly controllable by an external party. As already mentioned above, efforts towards noise reduction are taken by many different actors in the aviation industry, as well as from legislative side. So, many different factors influence the development of noise reduction that cannot be looked upon separately during evaluation, which makes this part quite difficult. The residents' weak power of opposition can only try to follow the development, plead to authorities of legislation, and claim improvements. What can mainly be checked is whether airports stick to the posed rules and regulations and whether enforcement strategies are implemented. Due to few possibilities of control, the opposition has hardly any chance to discover inefficiencies.

[30] cf. Bansal & Kistruck (2006), pp.166

[31] cf. Hansjürgens & Lübbe-Wolf (2000), p. 14; Rodrigue et al. (2012), p.125

[32] Bansal & Kistruck (2006), p. 165

[33] cf. Bansal & Kistruck (2006), p.168

CASE STUDY: THE AIRPORTS OF COLOGNE AND HAMBURG

Both airports Cologne (CGN) and Hamburg (HAM) apply different operational restrictions and procedures. But those groups of measures will not be examined any further as a grading would require technical background knowledge which is beyond the focus of this paper. CGN and HAM, both are noise sensitive airports, located close to its' city center, namely the distance in CGN is around 15 km, and HAM only around 12km, which gives reason for noise complaints of the residents at both airports. Therefore, pressure on the airports to act arises. As an answer to this pressure, CGN and HAM have realized several noise measures over the years and therefore serve as a suitable example for this analysis.

The combination of analyzing these two airports becomes especially interesting when regarding the contrasting **night operation** patterns: At the one side, CGN expands its focus on express freight by FEDEX and UPS, which is mainly forwarded during nights as nightly operation is a core business at this location. Therefore, noise protection measures are extremely important to protect the residents and are therefore worth investigating as regards real efficiency. On the other side, HAM, since decades, has a night curfew in effect. These two focuses get more obvious when looking at the contrasting passenger and freight numbers.

Considering the year 2012, CGN transported only 9.3 million passengers, whereas HAM transported 13.7 million passengers. Concerning freight, CGN is the leader, carrying 730 thousand tons of freight, whereas HAM only has a fraction of it, namely 28 thousand tons.[34] These different focuses enable the reader to get insights into two altered mixes of protection measures.

THE CASE OF COLOGNE

Already in the 1980s the airport CGN started to show commitment as regards to noise protection of people living in the vicinity of the airport. Noise-related landing charges were introduced based on a differentiation between ICAO's noise categories 2 and 3. 1996 a further differentiation was introduced.

Today the structure of the landing charges is based on the aircrafts' MTOW (maximum take-off weight) which is raised by other components, such as an emission surcharge and a noise surcharge. The applicable charges manual reveals that degression values give relative cost advantages for big aircraft.[35] During recent years the development of levied noise-related landing charges for airlines is generally decreasing from 2006 to 2009. In the years to follow, the values stagnate until 2012.

Finally, since 2009, further incentive setting was done on basis of separate **noise surcharges** that were charged on top of the regular landing charges. Those charges consider actual

[34] cf. Albatross (2013a,b)

[35] Umweltbundesamt (2004), p. 97

emitted noise of the operated aircraft as basis for calculation and are based on 7 noise categories, implemented in order to enable minor differentiations between aircraft. Exemplarily, an extremely noisy Boeing B 707 is charged 560€ per landing in addition to the basic landing charges, whereas a less noisy Boeing B 744 pays only 140€. A Cessna 150 pays only 10€ as it is least noisy. These charges apply to day time, whereas during night they simply double. It shows that the noisiest class, namely class 7, is charged with the highest penalty. Additionally, the less noisy the aircraft are, the lower is the levied charge.

The application of **operations-related restrictions** at CGN started in 1992. The man purpose was to protect neighboring residents during night. The operation was forbidden for extremely noisy aircraft, namely the ones which are classified as chapter 2 aircraft and the ones that are not even in the classification scheme of Annex 16. Five years later, in 1997, a noise contingency was implemented that narrowed the area of a noise contour of six night movements noisier than 75 dB(A) for future years to the level of 1997. From 2000 on, compliance has to be proven on calculatory basis. From 2002 on, all non-“Bonusliste” (similar to chapter 4) aircraft were banned from night operations.

Under these above mentioned measures, a favorable **noise development** took place: While in the beginning of the nineties only fewer movements took place, a lower noise level was measured. The graph below (see figure 14), however, indicates that the noise per movement was on a high level. Afterwards, in the end of the nineties, noise levels experience a peak, combined with a simultaneous increase in movements. A positive consequence can be recorded: After applying several measures noise increases on a lower level. Hence, noise per movement is reduced at that time. Nowadays, the level of noise is lower compared to the decrease in movements. Obviously, the trend during recent years implies an inverse development.

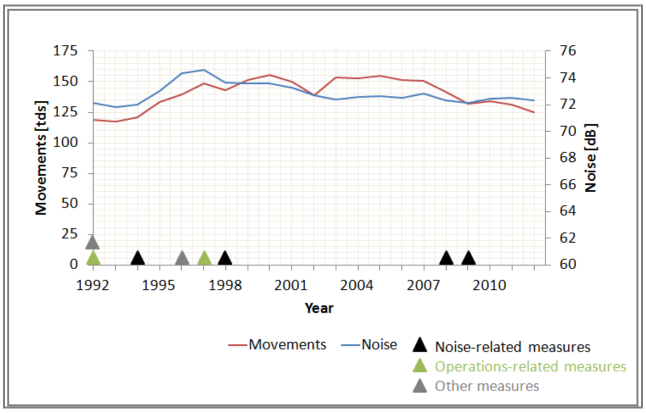

Figure 5 – Developments of noise and movements at CGN

Due to increased awareness, CGN decided to implement a complaint management system in 2002 and consequently started distinct documentation. The underlying sums of complaints per year do not suggest taking multiple complainants into consideration. The graph below shows the relation between noise development and noise complaints (see figure 6). The number of complaints is demonstrated on yearly basis, whereas in reality there are seasonal changes. In summer, for example, mostly the complaints reach high levels as more movements take place. In this survey, constant complainants are excluded as they would distort the general direction of the insight. The graph indicates that while the level of noise stays at steady level of 72 dB over ten years, the number of complaints in the early 2000s sum up to more or less 1000. Since mid 2000s, this trend gets more and more unsteady. Obviously, complaints are not directly related to noise development.

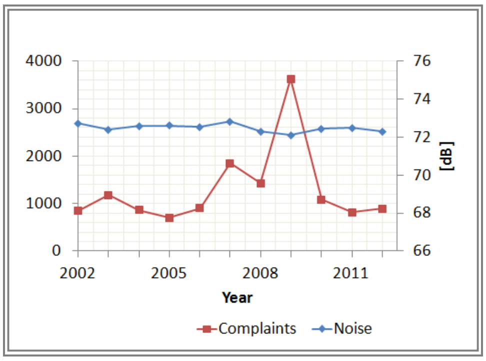

Figure 6 – Developments of noise and complaints at CGN

The Case of Hamburg

The first efforts of noise reduction at HAM have already been made in 1981 by introducing **noise-related landing charges**. Currently, the transition times to the night curfew are charged with higher charges for landing in order to reduce the planned number of flights during those noise sensitive hours. Therefore, the later the landing takes place, the higher are the operational cost for the airline. So, a flight that lands between 2200 and 2259 is charged an additional 100% of the original noise surcharge and between 2300 and 0559 additional 200% are charged. Furthermore, since 2001 a noise surcharge has been levied, for which 7 noise categories serve as calculation basis. As an example, an ATR42 in class 1 pays 5.50€ as surcharge for emitted noise, an Airbus A320 in class 4 pays 55€ per movement and a B747 in class 7 is charged 1350€.[36] Also, the German regulation on the chapter 2 phase-out was completely effective from 2002 on.

Since the early 80s, at HAM a strict **night curfew** from 2300 to 0559 has been realized that does not permit for any scheduled flights. Furthermore, since 1998, the operation of noisy aircraft has been restricted to the day hours between 0800 and 2000, and landings from 0700 to 2100. About one decade later, common efforts of HAM, airlines and DFS started to steer flights to earlier landings.

Since 1999, a **noise contingency** has been effective which is based on the area of an equivalent sound level of 62 dB(A) measured in $L_{eq}3$ in reference year 1997. The contingency ensures that the area of noise does not enlarge. This aim was successfully reached as it reduced from 20.4km² in 1997 to 12,9km² in 2012 which the following map visualizes.[37]

Looking at the noise development curve of HAM, a steady decline until 2006 can be noticed. The noise exposure came to its lowest point in 2006. Then, in 2007, a higher number of movements lead to higher noise levels, but after 2008 the

[36] cf. Hamburg Airport (2013a)
[37] cf. Hamburg Airport (2013b)

noise level sank on a level of below 72 dB(A). Concerning the noise per movement, it was higher during the nineties, then assimilated more and more over the years. Since 2009 the development shows a slight drift apart, meaning that the noise per movement overall increases again.

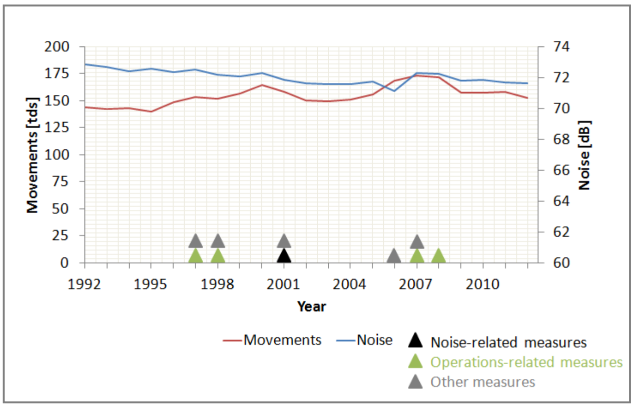

***Figure7** – Developments of noise and movements at HAM*

At HAM, the documentation of noise complaints started in 2003. The number of complaints of disturbed people around HAM increased up to 2007, similar to the development of noise. Afterwards, a steady downward trend can be recognized. Apparently, from 2007 a seemingly linear relation of noise and complaint reduction is obvious. As an exception to the rule, the year 2012 falls clearly out of the alignment, as a comparatively high number of complaints, more than 2500, arose due to a signature campaign conducted by noise opponents.

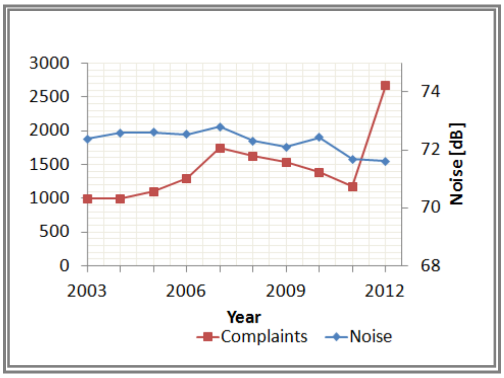

***Figure 8** – Developments of noise and complaints at HAM*

Discussion of the Results

First of all, when it comes to aircraft noise policies, there is always a user and an addressee of applied policies.[38] In all regulatory cases, which comprise per airport individually applied noise-related or operations-related measures, the sender of the policy is CGN or HAM airport together with the responsible federal government of North Rhine-Westphalia or Hanseatic city of Hamburg implementing the policies for the respective airport. The addressees are the stakeholders of the airport CGN or HAM, mainly the airlines and hence indirectly the travelers, as well as the residents in the airports' vicinity.

[38] cf. Matten (2003), p. 215

The degree of transparency of aircraft noise protection is rather low as there are different sources of mitigation available being in effect altogether at the same time. In order to better understand each single instrument, a lot of detailed background knowledge is necessary on all levels: First of all, noise measurement practices on airports' side are very complex. Different possibilities of calculating noise result in varying impressions on the quantity of noise. Secondly, the theory of noise nuisance on medical level is compound as well as its harming impacts on health. Thirdly, the technical side of aircraft and engine manufacturing contributes highly to improvements in noise mitigation. Hence, as sufficient transparency is not given, one criterion of successful application of symbolic policies is rendered.

The noise issue is a field numerous actors are involved on various levels of policy making. Firstly, the jurisdictions relating to different measures are in different responsibilities on national and international levels. Furthermore, a whole variety of institutions contributes to a sustainable development of environmental noise protection, as for example airlines, airports, organizations, manufacturers, as well as lobby groups which all influence the development to a certain degree.

At both airports noise-related landing charges are in effect, based on the ICAO noise chapters which do not display an incentive for most aircraft anymore as high standards are fulfilled within European fleets. At CGN airport the charges were reduced over the last decade, which at the same time lowers the incentive for airlines to use less noisy aircraft. In addition, a degression factor is applied to calculate the charges for large aircraft types, giving freight aircraft a cost advantage, giving those an advantage over smaller aircraft types as charges in relation are lower. Further details on the HAM noise charges were not available. As a conclusion, those noise-related charges do decrease the incentive on the use of quieter aircraft, as well as encourage the use of bigger aircraft. Though the charge is communicated to externals as noise-related, it creates an image of reducing noise. As this effect can only be related to few extremely noisy aircraft, the charges at both airports are graded as rather symbolic policies nowadays. During their implementation they may have a bigger impact on incentive setting as the used aircraft types were louder and therefore categorized in more chapters than nowadays.

Furthermore, **noise surcharges** are effective at both airports and are based on further differentiation, namely seven noise classes. Whereas HAM applies a higher charges level, airlines might consider operational fleet decisions of quieter aircraft at HAM airport. CGN charges much lower amounts, it reaches the charges level of HAM only during night as the charges at CGN are doubled. Generally, levying charges to users of the airports is a reasonable possibility to internalize the external cost of flying, namely let the user pay for the noise he makes. This is communicated as setting incentives to airlines, which is questionable in terms of long-term real effectiveness on airlines decisive criteria on fleet renewal because airlines might focus their decision on the much bigger cost factor of kerosene consumption. As the real effectiveness of this surcharge can't be verified, the policy includes a prevailing symbolic content.

In both cases, **noise contingencies** are applied. It can be criticized that they hardly set an incentive as they should normally do. This is because the year 1997 still serves as reference year as regards noise peaks and has not been adjusted to a more stringent level, although steady improvements in noise reduction could be recorded. The communication to the public though, takes place one-sidedly, considering the fact that the noise range is getting less disturbing. But this only happens by using other incentives and measures so that the effectiveness of this measure itself is doubtful and graded as rather symbolic.

Generally speaking, several **advantages** can arise from the **usage of symbolic policy**, on the airports as well as on the stakeholders' side. Firstly, CGN and HAM can use it to communicate the sophisticated noise issue to the stakeholders while increasing awareness amongst them. In most cases the implementation of somewhat symbolic measures involves comparatively low investments compared to more substantial ones. This can be seen as, for example, the night curfew at HAM is more effective on noise reduction than the rather unsubstantial noise contingency at CGN and HAM. The cost of the night curfew means lost revenue during night for HAM, but the cost of a noise contingency basically implies the effort of calculating the area within the given noise constraint. Another advantage for the airports is that through communicating commitment, be it symbolic or substantial, the airport gains an image increase and therefore competitiveness is upgraded. As a further positive consequence a change in society's reflections and behavior can be reached.

Today and in the future, a call for action on the airlines' side is required. As the restructuring of the fleet is an extremely high investment, airlines need a reason to act. This pressure comes from outside and airlines are partly already adapting, but also seem to hesitate. This hesitation possibly is derived from the fact that as technological development is never standing still and therefore is expected to realize even bigger improvements, the cost of intermediate solutions would still overweigh the option of paying higher landing fees until the aircraft would reach the end of service time.

After several noise reduction and protection measures became effective at CGN and HAM, the **noise development** could successfully be decreased, in HAM more effective though than in CGN. Obviously, there are no separate relations of measures and noise, however, as all are in effect at the same time. The noise per movement in the nineties was quite high, then improved and nowadays it is higher again. The increase in noise per movement today indicates an increasing average size of aircraft by the airlines. It is questionable whether this recent trend is sustainable on reducing the impact of noise as fewer but louder flight events might increase nuisance on neighboring residents more than few more movements of explicitly quiet emissions.

The analysis of the **development of complaints** in relation to noise at CGN and HAM offers different results. The development at HAM shows that the development of noise and resulting complaints is almost parallel. Although HAM has a night curfew, the number of complaints in the observation period is overall lower than CGN's. At CGN, complaints are varying in comparison to noise levels. The focus in express freight operation at CGN leads to the fact that more than 80% of all noise complaints concern night flight movements.[39]

CONCLUSION

To recap, the objective of this thesis was to give insights into a new approach to state the appropriateness and virtue of political noise measures at airports. By conducting a case study on CGN and HAM airport, the applicability and extent of symbolic substance in the applied measures were to be checked and evaluated. This approach was brought to completion with the following results:

The main finding of this research is that different measures at airports are containing symbolic elements which apply the ambivalent nature of symbolic policies in a contributing way. This is done in order to strive for the aim of sustainable noise abatement. The symbolic content in all three groups of measures examined could be proven, (1) noise-related measures, as well as (2) operation-related ones and (3) other passive noise measures.

The general applicability of symbolic policy was rendered as the subject of noise at airports served as criteria to grade symbolic content in individual measures. Firstly, the topic was found to be rather non-transparent. Secondly, measure- and noise-related information was found to be not completely objective as it is communicated only from airport side, which thirdly aggravates external control. Furthermore, the result of the individual measure displayed another criterion to evaluate the grade of symbolic content in the individual measure and to accordingly evaluate the supposed intention.

Overall, the position of the airport in noise reduction was revealed as rather weak as no measure so far is considered to be optimal for sustainable noise reduction. The main role of noise reduction is detected on the airlines side because aircraft noise is the dominant sort of noise at airports. So far, the mix of political measures at airports is rather seen as a sustainable interim solution until better solutions are implemented by the industry. These achievements are essential when considering that further operational restrictions would have fatal effects on the development of the aviation market.

[39] cf. Mr. Partsch (2013)

OPTIMIZATION ON CURRENT AIR TRAFFIC MANAGEMENT BENCHMARKING METHODS

Andrej Grebenšek, M.Sc.
University of Ljubljana, Faculty of Maritime Studies and Transport, Ljubljana, Slovenia
grebensek.andrej@gmail.com

Tone Magister, Ph.D.
University of Ljubljana, Faculty of Maritime Studies and Transport, Ljubljana, Slovenia
tone.magister@fpp.uni-lj.si

Abstract *– This paper presents one of the possibilities on how to mould the process of Air traffic Management Performance Plans creation in such a way that they reflect the European Commission requirements and at the same time support efficient service provision. It scrutinizes current benchmarking methodology used and gives an insight into possibilities on how this methodology could be improved in order to give more objective results, thus enabling more efficient managerial decision making process.*

Key words – Air Traffic Management, Air Navigation Services provision, benchmarking, ACE Benchmarking Report, cost effectiveness.

I. INTRODUCTION

The air traffic growth is more and more limiting the capacity of available airspace and airports [1]. Some parts of the airspace in particular the core European airports are close to or already at the point of saturation, which leads to lower quality of service for air passengers and higher costs for airspace users [2]. Air-carriers are exercising constant pressure on air navigation services providers (ANSPs) to enhance the quality and efficiency of service provision [3] in order to offer additional capacity on ground and in the air.

The only tool available for ANSPs, to measure their own efficiency, is benchmarking. Widely accepted benchmarking method so far is the Eurocontrol Performance Review Unit (PRU) yearly ANSPs performance assessment, publically available in the form of Air Traffic Management (ATM) Cost Effectiveness Benchmarking Report (ACE Benchmarking Report) from 2002 on [4]. Similar exercise has been so far executed also by the Civil Air Navigation Services Organisation (CANSO), which has this year issued CANSO Global Air Navigation Services Performance Report, for the third time in the row [5].

Both Reports are addressing similar issues, measuring and analysing similar factors by taking into account similar variables. The real major difference between the two is in the collection of ANSPs, where ACE Benchmarking Report focuses only on European actors and CANSO on selected (volunteers) global actors. Further on in this paper only ACE Benchmarking Report will be scrutinized.

Methodology used by the PRU is according to the research performed so far, appears somehow bias, favouring larger ANSPs or those ANSPs that are servicing larger airports with a lot of terminal traffic [6, 7, 8, 9]. PRU benchmarking is performed by analysis of facts only, so far not yet introducing any methodology that would through the so-called normative analysis enhance the objectivity of the results. These results can therefore not adequately support the process of the managerial decision making by helping the management structures of particular ANSPs to discover their weak points in performance and proposing the tools and methods on how to efficiently introduce changes that would foster more efficient service provision.

II. CURRENT MODEL

Eurocontrol in 2013 issued ATM Cost-Effectiveness (ACE) 2011 Benchmarking Report [10] that among other gives an overview and comparison of cost effectiveness of service provision of 37 European ANSPs. It contains information about Key Performance Indicators (KPIs) linked to the cost effectiveness and productivity for 2011 and provides forecast and trends as well for the period from 2012 until 2016. Air Navigation Services (ANS) gate-to-gate costs are not entirely comparable across the full range of European ANSPs (for example, some of the services are not necessarily provided by certain ANSPs); structure of those costs is presented in Table 1.

Simultaneously division and allocation of en-route and terminal costs is not uniform within Europe as well. Therefore current model focuses on gate-to-gate operations that encompass both types of services. As a basic toll for financial cost effectiveness and productivity calculations Composite Flight Hour (CFH) has been introduced, consisting of En-route Flight Hours (EFH) and Instrument Flight Rules (IFR) Airport Movements (IAM).

Table 1 – Division of ANS costs in current model [10]

Gate-to-gate ANS costs [€ M]	*2011*	*% of Total*
ATM/CNS provision costs	***7.839***	***88,3***
MET costs	***424***	***4,8***
EUROCONTROL costs	***456***	***5,1***
Payment for regulatory and supervisory services	***93***	***1.0***
Payment to government authorities and irrecoverable VAT	***65***	***0,7***
Total gate-to-gate ANS costs	***8.877***	***100***

Factors influencing performance

ACE Benchmarking reports are providing quantitive data about observed cost effectiveness and comparison of ANSP performance as observed by their users. Such data cannot give full insight into observed differences in performance and consequently cannot directly serve as an objective guideline for implementation of performance improvement. In order to be able to evaluate the differences in performance it is important to understand where do the causes for discrepancies observed originate from. This is in particular important in the light of the second Single European Sky (SES2) Legislation Package, as well as the SES2+, which are both requesting that the ANSP performance is consistent with the quantitative target set.

In principle these factors can be subdivided into three groups [10]:

- endogenous factors, which can be influenced by the ANSP, such as:
  - organizational factors
  - managerial and financial aspects
  - operational and technical set up
- institutional factors, which can be influenced by the ANSP in a limited way, such as:
  - national and international institutional and governance arrangements
- exogenous factors, which can not be influenced by the ANSP, such as:
- legal and socio-economic conditions
- operational conditions

Exogenous factors contain wide and diverse spectre of effects on ANSP performance. By default they are not uniquely determinable or objectively measurable. Extensive studies are and will have to be carried out to be able to extract, evaluate and validate factors that could potentially be used in benchmarking exercises.

On the other hand certain improvements could potentially be introduced immediately.

III. Current model optimization

Composite flight hours calculations

CFH used for benchmarking by PRU consist of EFH and IAM weighted by an arbitral factor that reflected the relative (monetary) importance of terminal and en-route costs in the cost base [11]:

$$CFH = EFH + 0.26IAM \tag{1}$$

EFH in (1) are the summation of minutes (expressed in hours) that flights which are overflying an area of responsibility of an ANSP, spend in that portion of the airspace. They can be obtained directly from the EUROCONTROL statistical data. On the other hand weight factor attributed to *IAM* translates to 0,26 *CFH* per single IFR airport movement, regardless whether the airport is a large national hub or a small regional airport.

Alternatively *EFH* can be calculated by multiplication of the number of flights (N_{of}) with the average overflying time of the relevant airspace ($\bar{t}_{of}$):

$$EFH = N_{of}\bar{t}_{of} \tag{2}$$

To illustrate the alternative for EFH determination five high performers (excluding MUAC as it only provides service to the en-route traffic) in terms of ATCO-Hour Productivity (AHP) and five low performers, (having selection of countries as much as possible within the EU in order to make the results more objective and also to have the required data available) have been identified in the ATM Cost-Effectiveness (ACE) 2009 Benchmarking Report and average overflying times extracted in Table 2.

Table2 – Average overflying times for five top and low performers

ANSP name	Av. Overflight time
Skyguide	11,5
NATS	14,66
EANS	20
DFS	17,5
Austro Control	17
Aena	26
MATS	25

ROMATSA	34
Oro Navigacija	15
Slovenia Control	10
Average Total 10	19,07

Data for 2009 were used since structure of the ACE Benchmarking Reports for 2010 and 2011 changed significantly, omitting some data (e.g. average overflying times per ANSP), needed for the analysis. Nevertheless consistency of the results has been verified also with the available data form other older ACE Benchmarking reports.

For selected ANSPs, $\bar{t}_{of}$ ranges from 10 minutes for the smallest ANSP to 34 minutes for the ANSP, which has majority of the traffic running along the longest routes in the route network. Average calculated overflying time for all 10 of them is 19,07 minutes.

PRU methodology attributes 0,166 *EFH* to one single over flight for the smallest ANSP and on the other hand 0,566 *EFH* for the ANSP with majority of the traffic along the longest routes. The difference factor is 3.4, meaning the that first ANSP would need to have at least 340% increase in traffic in order to reach the productivity of the second ANSP, this all under the condition that the number of Total ATCO-Hours (AH*)* remains the same. This is by no means possible.

On the other hand weight factor attributed to *IAM* translates to 0,26 *CFH* per single *IAM*, regardless whether the airport is a large national hub or a small regional airport.

Since terminal part of the *CFH* is determined by consensus, equal for all ANSPs, regardless of the size of the airports they are servicing, it might be fair to use the same logic also for the en-route part of the *CFH*, by also attributing the weighted factor to the *EFH*. Let weighted factor be the average calculated overflying time for all the selected ANSPs. For the ten selected ANSPs in this study, this factor is 0,317.

AHP is determined as quotient of *CFH* and *AH*:

$$AHP = \frac{CFH}{AH} = \frac{EFH+(0.26IAM)}{N_{ATCOs}\ \bar{t}_{year}} \qquad (3)$$

In (3) the CFH are defined by (1); while *AH* are defined as the Total number of ATCOs (N_{ATCOs}) multiplied by the Average ATCO-Hours on duty per ATCO per year ($\bar{t}_{year}$).

The results of (3) are summoned in Figure 1 (similarly as in the ATM Cost-Effectiveness (ACE) 2009 Benchmarking Report showing the rank of the ANSPs per ATCO-Hour Productivity).

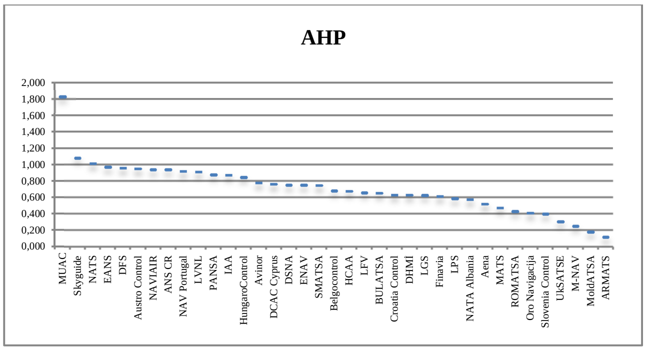

Figure 1 – AHP of full range of ANSPs on a yearly basis

PRU ranks the ANSPs by their *AHP* on a yearly basis. This gives a certain picture, which is potentially misleading. When *AHP* is broken down to monthly figures, it suddenly becomes visible that low performers, even in the period of their highest productivity, never reach the productivity of the top performers even when they are in the period of their lowest productivity (Figure 2).

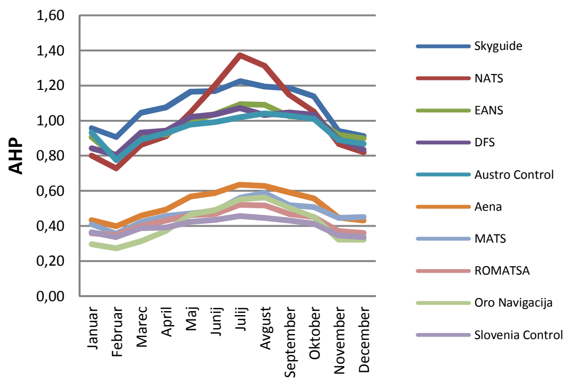

Figure 2 – AHP of selected ANSPs on a monthly basis

Results in Figure 2 imply that low performers obviously provide their service in an entirely wrong way, by being so inefficient. In practice this could not be true, since none of the airspace users would support and pay for such inefficiency. As evidenced by quality of services of majority of smaller ANSPs, they optimize their performance for the periods of heavy traffic load. The conclusion drawn from this exercise could only be that current benchmarking methodology does not provide objective results being trimmed more towards the ANSPs that provide service to the major airports with a lot of terminal traffic. This statement has been tested and verified also by performing the same calculations with split/ isolated terminal and en-route data.

If *AHP* is calculated as proposed, with the weighted factor of 0,317 attributed to the *EFH*, the rank of the ANSPs changes significantly. Suddenly the size of the ANSPs or the amount of the terminal traffic is not so decisive any more (Figure 3).

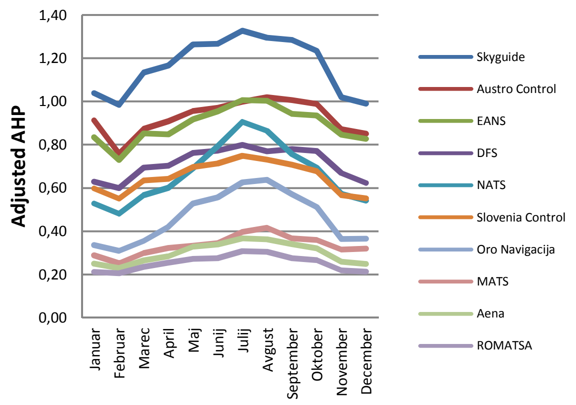

Figure 3 – Adjusted AHP of selected ANSPs on a monthly basis

Another factor that contributes to the non-objectivity of the results is the $\bar{t}_{of}$. Since 2007 PRU allowed that the *EFH* also includes time spent in terminal manoeuvring areas (TMAs) and therefore account for airborne holdings. By this an ANSP that produces more delays through delaying actions in sequencing the arriving and departing aircraft, automatically becomes more cost effective and productive.

Calculations have shown that the $\bar{t}_{of}$ reported by PRU in the ACE Benchmarking Reports until 2009, and the $\bar{t}_{of}$ obtained with the reverse calculations form the data form those very ACE Benchmarking Reports, on average differs by 28% and as much as 96% with one ANSP. This discrepancy is to be attributed to the additional times due delaying actions, distorting the picture.

TRAFFIC VARIABILITY

Traffic variability pays significant role in the objectivity of benchmarking results. Airspace users are expecting that ANSPs would match the capacity of the airspace with their demand at any time of the year, month, week or day. ANSPs are therefore expected to enhance their capacity through upgrade of their technical capabilities, technological solutions and constant increase in manpower. All this is inducing additional fixed costs for the ANSPs, automatically making them less cost efficient.

The higher the variability, the smaller is the utilization of technical and human resources. Since labour costs in Europe on average add to about 60 – 65% of total ANSP costs, this represent a significant amount of money that is potentially lost if resources are not properly utilized.

Traffic variability factors are calculated by the PRU, but still not directly used in the determination and evaluation of the KPIs. Current model defines the traffic variability (TV) as the fraction of the traffic in the busiest week of the year (T_W) and the average weekly traffic ($\overline{T}$):

$$TV = \frac{T_W}{\overline{T}} \qquad (4)$$

To add to the accuracy of the results, adjusted traffic variability (TV_S) might be determined as the fraction of fictitious maximum traffic (twelve times the maximum monthly traffic (T_{max}) and actual yearly traffic (T_Y). Calculation of the actual time that ATCO spends controlling the air traffic can only be done on the basis of the traffic statistics. In comparison to (4) it is more sensible to define the variability (5) in such a way that the calculation interval is from one week expanded to one month as this correlates to the minimum interval that ATCOs are being paid:

$$TV_S = \frac{12T_{max}}{T_Y} \qquad (5)$$

Figure 4 also shows that by calculating the traffic variability as defined in (5), entire range of traffic variability is taken in to account whereas in current model (4), everything that is less than average weekly traffic is lost (light yellow area in the Figure 4).

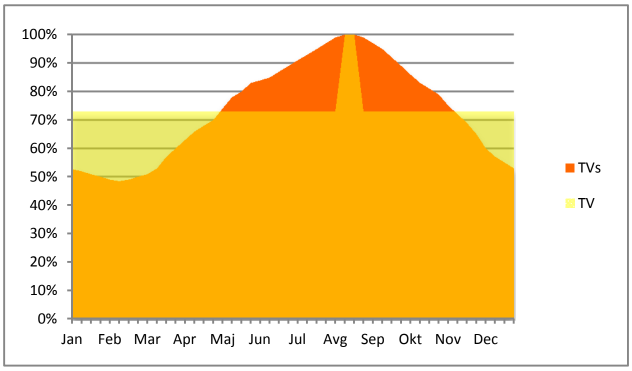

Figure 4 – Comparison of TV and TVs definition

In Europe, on average 25% of resources is underutilized, meaning that they are fully paid but not rendering any service. These underutilized resources represent the so called unused composite flight hours (UCFH), which directly translate into lower *AHP* and consequently into lower financial cost-effectiveness (FCE):

$$UCFH = CFH(TV_S - 1) \qquad (6)$$

As shown in Figure 5, by introducing the traffic variability into the calculation of *AHP* through (6) the rank of the ANSP changes significantly (if compared to Figure 1) .

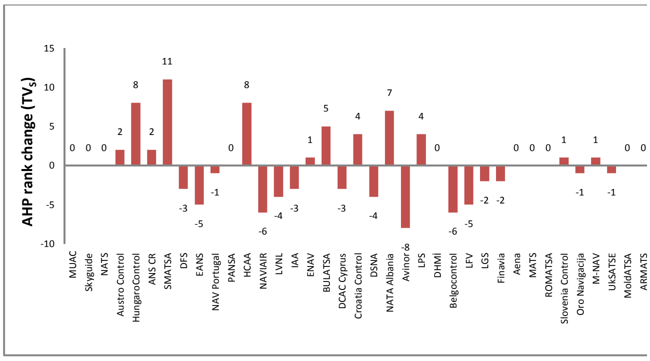

Figure 5 – AHP rank change due TV_S

AIR TRAFFIC COMPLEXITY

Air traffic complexity affects the *AHP* and *FCE* simultaneously but here, for a change, not in an ambivalent way. On one hand more complex traffic requires increased effort of ATCOs or even higher number of ATCOs or additional technical solutions, on the other hand the utilization of existing resources is increased.

The PRU yearly measures the traffic complexity attributed to the airspace of particular ANSP, however it is not directly used in the benchmarking exercises. Alternatively it could be normalized by the average traffic complexity of all included ANSPs, thus creating a weighting factor that would enable the comparison of deflections of individual ANSPs from the average complexity of the European airspace. Relative traffic complexity factor (TC_R) could be defined as fraction of PRU reported traffic complexity factor (TC) and average traffic complexity ($\overline{TC}$):

$$TC_R = \frac{TC}{\overline{TC}} \qquad (7)$$

PRU is in their ACE Benchmarking Reports reporting *TC* separately for the en-route part (TC_{ENR}) and for the gate-to-gate operations (TC_{ANSP}) (at the level of an ANSP). Results of the TC_R calculations for the en-route (TC_{Renr}) and at the level of an ANSP (TC_{Ransp}) are presented in Figure 6.

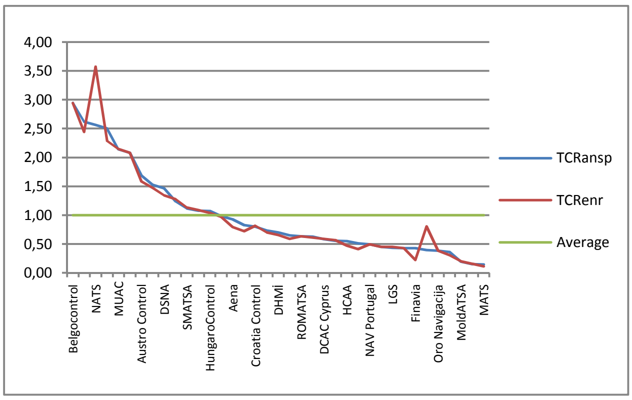

Figure 6 – Relative traffic complexity

Traffic complexity influences the *AHP* in a way that an ATCO controlling high complexity traffic, is due to the additional stress (increased interaction with aircraft), physically not able to control the same amount of aircraft as an ATCO controlling low complexity traffic. This translates into lower amount of *CFH* per *AH*.

To check the influence of complexity on the ANSPs rank in relation to the respective *AHP*, adjusted *AHP* (AHP_{TCR}) has been introduced:

$$AHP_{TCR} = AHP * TC_R \qquad (8)$$

AHP_{TCR} influences the *AHP* rank of the ANSPs significantly (if compared to Figure 1) as presented in Figure 7.

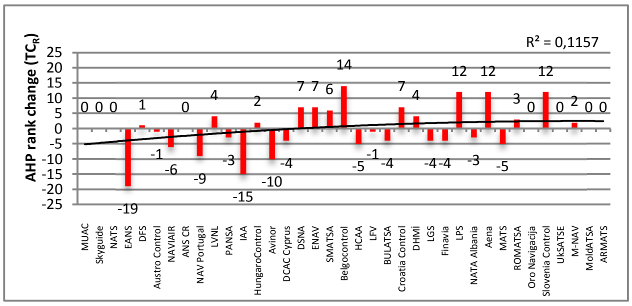

Figure 7 – AHP rank change due TC_R

Trend line is indicating that *AHP* calculated on the basis of the current model is for the ANSPs with high traffic complexity somehow undervalued, whereas it is overvalued for the ANSPs with low traffic complexity.

IV. THE DECISION MAKING PROCESS

In order for an ANSP to be able to assure efficiency in performing ANS, following steps should be followed:

- First an ANSP has to, with the help of qualitative and objective benchmarking, evaluate the potential of human resources and position itself in a proper place within the rank of the competitive ANSPs.
- Then it has to evaluate how efficient it is in relation to specific parameters of air traffic flow (Table 3).
- Next step is to research the market and the competition if technical or technological solutions that would enable greater capacity with the same manpower, exist.
- Last step is the cost-benefit analysis of potential technical and technological solutions.

Table 3 – Parameters for human resources efficiency evaluation

ANSP	N_{Ovf}/ ATCO	EFH/ATCO	IIFR Km*1000/ ATCO	A/ATCO	CFH/ATCO
PANSA	5066	2981	2141,98	3064	1040
NAV Portugal	4621	2976	2221,98	7644	1627
EANS	8368	2921	2200,64	4283	1628
DCAC Cyprus	5817	2642	2073,60	3783	2027
ANS CR	7233	2515	1801,24	903	1423
Austro Control	7661	2494	1697,78	693	1453
MUAC	6811	2440	2013,22	1193	2440

LVNL	8827	2374	1119,75	853	1477
Hungaro Control	7319	2350	1801,40	1120	1301
Croatia Control	5068	2031	1516,72	1904	870
HCAA	2715	2007	1487,70	2289	992
NATA Albania	8969	1924	1516,96	1994	977
DHMİ	2145	1857	1432,74	2544	1162
NAVIAIR	5489	1843	1239,79	1477	1462
Finavia	3772	1778	1095,59	6803	903
Avinor	3032	1741	923,08	4132	1295
LFV	2711	1665	1105,09	2604	1067
Skyguide	5745	1630	1112,24	365	1377
BULATSA	4902	1629	1283,90	1466	861
IAA	3307	1608	1245,53	2874	1373
LGS	5369	1606	1165,69	2474	1052
DSNA	1961	1546	1058,91	726	975
MATS	3046	1477	1134,63	8214	875
LPS	6341	1431	1080,81	919	856
NATS	2353	1382	880,08	925	1260
SMATSA	3328	1367	1091,29	952	997
Oro Navigacija	4770	1305	890,99	2288	642
Belgocontrol	6307	1296	664,59	459	942
ENAV	1838	1242	889,75	880	1081
Aena	1499	1132	796,07	1952	874
DFS	2028	991	651,58	289	1086
ROMATSA	1486	903	692,88	873	600
Slovenia Control	4487	787	545,07	377	572
M-NAV	3476	586	440,07	689	364
UkSATSE	661	539	414	1360	375
MoldATSA	1327	348	265,27	1021	262
ARMATS	1415	336	244,65	876	172

(source of data [11])

Subject to data in Table 3, the managerial staff of an ANSP should question why is particular ANSP, with the same amount of staff capable of:

- handling up to 8 times more overflights (N_{ovf}),
- having up to 6 times more *EFH*,
- servicing up to 6 times greater distance of Kms flown (IFR Km*1000),
- controlling up to 9 times bigger area of responsibility (A),
- having up to 6 times more *CFH*.

The amount of parameters influencing the above is to great to be able to analyse all ANSPs with the help of one uniform model. Managerial staff of an ANSP should rather sort the competition according to one parameter, pick out the one that is better and dissect it fully in technical and technological sense. Next step is then to perform the cost-benefit analysis, taking into account that if, in order to meet the demand for increased capacity, an ANSP is introducing new technical solutions instead of employing and training new staff, the total cost of acquisition and depreciation of such equipment over a limited period of time (usually seven years), should not exceed the total labour cost over that same period of time.

Last element that can be decisive is the economic cost effectiveness. Here the parameters for the decision-making are not specified yet, therefore the decisions have to be taken based on experience and also in the context of broader, political solutions.

Any decision taken has to be evaluated through costs on one hand and through quality of service on another hand, where safety should never be compromised. The key variable for decision-making are the delays due lack of capacity of an ANSP. In other words it is about deciding how to lower the ANSP costs at the expense of increase of other costs such as costs of fuel, delays, aircraft resources, productivity of the flight crew etc.

Since airspace users ultimately pay these costs and if managerial staff of an ANSP uncritically evaluate the optimum solution and invests too much in the capacity increase, airspace users might end up with no savings but even with some additional costs. Decision makers should strive to always stay in the close proximity of a minimum of a economic cost effectiveness convex function (sum of increased capacity costs and costs of delay).

V. Conclusion

Air Traffic Management is unique and complex business. Common economical arguments are not always appropriate for decision-making. Air traffic is with the help of rules, standards, recommendations and legislation fully regulated globally, regionally and nationally in terms of operations as well as economics. On one hand ANSPs are expected to provide an absolutely safe and efficient service on the other this service is expected to be as cheap as possible. This directly leads to contradiction.

Since the ATM processes are fully regulated, inputs and outputs of these processes are at the global level nearly uniform. Differences arise only due local particularities. Certain impacts can be influenced, while certain have to be taken into account as granted. In another words this means that if an ANSP from entirely another part of our Globe would take over the services in our region, this particular ANSP would still have to overcome all constraints and differences from this particular area, meaning that his way of service provision although extremely efficient at home, might not be as efficient as expected over here.

At this point it is also safe to assume that economy of scale does not automatically translate into better productivity and cost effectiveness. The higher the area that an ANSP is covering the greater the chances are that this ANSP would provide service to high density and low density traffic, to traffic with high and low traffic variability and complexity etc. Taking these arguments into account it is safe to state that if larger, more efficient ANSP would take over the smaller, less efficient ANSP this might not mean that overall productivity and efficiency would automatically increase, but would rather mean that the efficiency of bigger ANSP would slightly decrease. Already PRU benchmarking proves (Figure 1) that is not so obvious that smaller ANSP will eventually cease to exist, since

Estonian ANSP easily compares to German or British one. Obviously PRU benchmarking parameters somehow suit the Estonian ANSP. Subsequently proper adjustments of current benchmarking methodology could provide more objective chances also to other smaller ANSP, with less traffic.

Proper benchmarking is essential for correct and efficient decision making, therefore it has to be objective as much as possible. However EU performance targets can only be achieved if airport service providers are included in the process as well. So far they heavily resist to any attempts to draw them in.

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FLIGHT INSPECTING ADS-B AND WAM SIGNALS

Dipl.-Ing. Thorsten Heinke
Aerodata AG, Germany
heinke@aerodata.de

Abstract *– The safety requirements arising due to expanding capacity in civil air traffic are generating several new surveillance techniques for commercial airplanes. ADS-B (Automatic Dependent Surveillance Broadcast) and WAM (Wide Area Multilateration) are such techniques. They are used in all new commercial air transport and most general aviation aircraft. This safety relevant signal regarding flight information for each individual aircraft is transmitted through different data links. The level of implementation of ADS-B and WAM ground stations for area-wide coverage is steadily increasing.*

What are the requirements to flight inspect such data derived from ADS-B or WAM stations in accordance to its sensitivity for flight safety during surveillance? What kind of flight checks have to be performed to uphold the accuracy and integrity of this signal?

This paper summarizes the legal background, experiences and requirements regarding flight inspecting ADS-B and WAM systems. It discuss general requirements for the inspection of the ADS-B and WAM service. Examples of flight inspection of existing ground stations using modern flight inspection systems with ADS-B and WAM capability are presented and explained. By flight check it can be verified that the surveillance systems fulfill their dedicated specification. The corresponding procedures are examined in detail and evaluated in regard to accuracy and integrity.

Key words – flight inspecting, AdS-B, WAM..

INTRODUCTION

All modern commercial airplanes a equipped with capable transponders using the ADS-B transmission. In the past three different ADS-B techniques were followed, explored and analyzed in regard to its advantages and disadvantages.

One ADS-B technique is the transmission via a separate VHF data link, which requires special equipped VHF radios to fulfill the requirements according to MOPS ED108A. The second technique focuses on the dedicated Universal Access Transceiver (UAT) working in the 978 MHz band. Each aircraft has to be equipped with such unit which complies with RTCA DO 282B and TSO C154c. This technique is mainly used for the lower airspace in the United States. The third method for transmitting ADS-B signals is the extended squitter technique in the 1090 MHz Band. It complies with RTCA DO 260B and TSO C166b. The extended squitter method is suitable for the lower and upper airspace and used by all commercial airplanes.

WAM is a well growing pinpointing technique to determine the position of an airborne aircraft in conjunction with ADS-B and Radar.

This paper focuses for ADS-B on the extended squitter method and describes in regard to WAM the possibilities in flight inspection. It highlights the type of transmitted data and evaluates reason for flight checking such data. Examples from flight inspection systems, which are capable to perform such inspections, and their requirements are shown.

REQUIREMENTS FOR ADS-B FLIGHT INSPECTION

The general requirement to establish an ADS-B link is to have an airborne segment, which encodes and transmits the necessary data in a special format and a ground segment which receives the data and decodes it. The newest flight inspection systems, like the AeroFIS©, are equipped with state of the art transponders, which are capable to transmit the required data for the ground station. The ground stations are normally equipped with ADS-B receivers to display such data to the radar or ADS-B display operator.

Figure 1: AeroFIS© capable to perform ADS-B flight inspection missions

The flight inspection system included a Rockwell Collins TDR 94 latest revision supporting the transmission of elementary and enhanced surveillance and ADS-B messages. Therefore the aircraft is equipped with an additional L-Band antenna for the transponder transmission. Only the newest revision of this transponder complies with TSO C166b capable for the transmission of ADS-B.

Figure 2: Suitable ADS-B Transponder latest revision

o operate a non primary transponder on an airborne system special rules according to airworthiness standards have to be followed. The special and advance design of the certified aircraft installation has to make sure that not two targets are visible for the ATC controller. The airborne flight inspection transponder is fully controlled by the flight inspection operator, which enables him to submit via the data-link special test data. This assures proper decoding at the ground segment and/or allows the ground station to perform fully autonomous checks with such specialized data. The AFIS computer is connected to the transponder via a digital data link. The computer submits automatically the necessary dataset required by the transponder to transmit the desired and requested ADS-B data.

The flight inspection mission of a receiving ADS-B ground segment has to focus on three main tasks:

- Coverage Checks
- Interference Checks
- Data Continuity and Integrity Checks

The coverage checks are performed together or in accordance with the regular radar flight inspection missions. The data continuity and integrity has to be monitored at the ground segment continuously. The time stamped data recordings from the flight inspection system will be compared fully automatically to those recordings from the ground segment. The format of such data is customized and adaptable to the dedicated ground station. During commissioning customized special datasets can be transferred to ease the ground facility installation.

DATA TRANSMISSION

Nowadays a dataset with below listed information is able to be transmitted via the ADS-B link.

- Time
- Selected Altitude
- True Track Angle
- Ground Speed
- Magnetic Heading
- Indicated Airspeed or Mach Number
- Barometric Altitude Rate or Inertial Altitude Rate
- Barometric Pressure Setting
- Track Angel Rate or True Airspeed
- Position (including horizontal and vertical integrity limits with its accuracy and quality)
- Velocity (including integrity limits with its accuracy and quality)
- Length and width of the aircraft
- Emitter Category
- GPS Antenna Offset
- Geometric Altitude and its quality

Not all aircrafts are capably to transmit the complete information. This is caused on the one hand due to missing sensors connected to the extended squitter transmitter or on the other hand due to an old standard of the transponder itself. Nowadays only a few of such transponder are fully certified according to TSO C166b, but of course also the availability of such units is growing.

An example picture for a visualization of such received ADS-B data at the ground station is shown in Figure 3. (The mode S code and the call sign is masked on this paper)

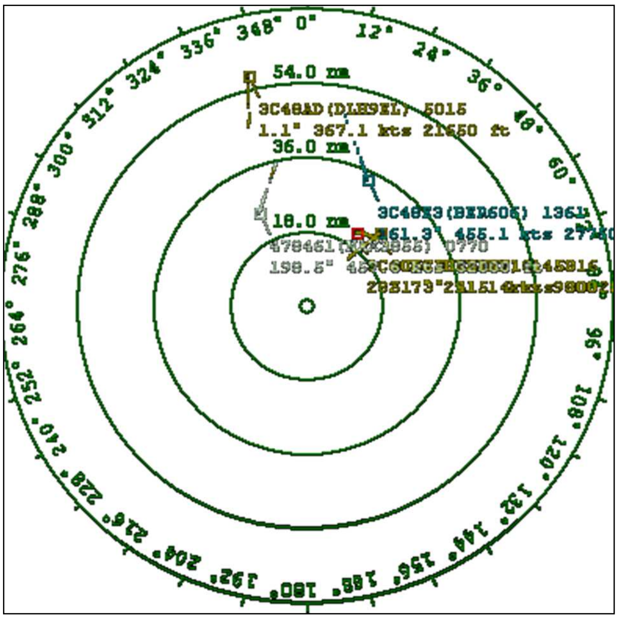

Figure 3: ADS-B information on a polar diagram received on ground

It is generated by a simple commercial of the shelf ADS-B receiver connected to a commercial of the shelf antenna and controlled by Windows based PC. The information of the ADS-B link is decoded on alpha pages and can be recorded for further data evaluation.

Flag	Code	Callsign	Country	Altitude	Speed	Track	Vert Rate	Squawk	Latitude
	3C60D0	HLX1BX	Germany	9.800 ft	291.1 kts	282.7°	-512	1453	52.396°
	3C5EEC	GWI018	Germany	30.025 ft	415.4 kts	51.3°	-1088	5016	52.395°
	3C48AD	DLH9EL	Germany	21.650 ft	367.1 kts	1.1°	-3072	5015	53.020°
	3C48E3	BER606	Germany	27.750 ft	455.1 kts	161.3°	1472	1361	52.609°
	478461	NAX3855	Norway	32.000 ft	457.6 kts	198.5°	0	0770	52.471°
	478369		Norway	36.975 ft	483.1 kts	178.7°	0	3535	52.333°

Figure 4: Alpha page of the ground receiver with ADS-B information

It is recognizable at this real data example that not all information is transmitted. This can be caused by reasons mentioned earlier in this paper or by intention from the aircraft operator.

FLIGHT INSPECTION OF ADS-B FACILITIES

The main aspect for flight inspection nowadays of course is to fulfill the requirement of the stipulated and announced coverage. Interference in those regions of coverage has to be precluded. The full announced observed sector has to rely on the displayed ADS-B data. This is only manageable from the airborne segment. Interference is easily detected by advanced flight inspection systems and can be eliminated once traced. In addition modern flight inspection system can modify the data transferred to the ground station to assure correct decoding of the signal and to adjust settings during commissioning. An example to show the flight track on which the desired ADS-B check is monitored and recorded is shown in Figure 5. This graphic and its alphanumeric values are compared automatically to the graphics and recordings of the ground station.

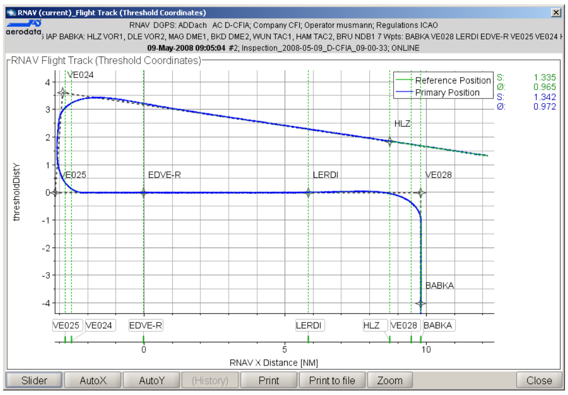

Figure 5: Flight track of flight inspection mission with monitored ADS-B information

An example of alpha pages modifiable by the flight inspection operator is shown in Figure 6. For testing purposes all values a can be set to a definable value.

ADSB + Enhanced Surveillance

ADSB Altitude	9747	ft
ADSB True Track	88.082	°
ADSB Latitude	53.04673500	°
ADSB Longitude	8.78195085	°
ADSB Groundspeed	150.3	m/s
ADSB UTC TOD	38073	s
ADSB Vertical Speed	0.0	ft/s
ADSB Velocity North-South	4.6	m/s
ADSB Velocity East-West	144.2	m/s
Mach	0.4	
IAS	0.0	kts
TAS	0.0	kts
Baro Alt Rate	4.5	ft/min
GS	0.0	kts
True Track	88.082	°
Magnetic Heading	92.847	°
Roll	-0.8	°
Vertical Velocity	4.5	ft/min

Figure 6: Alpha page of flight inspection system with ADS-B information

The defined BDS codes as per definition in [1] could also be monitored or influenced (Figure 7).

Raytheon — Status:

ARINC:

BDS 4.0: Selected Vertical Intention		
MCP/FCU Selected Altitude	13.250	ft
FMS Selected Altitude	3.750	ft
Barometric Pressure Setting	213.250	mB
BDS 5.0: Track and Turn Report		
Roll Angle	-0.417	deg
True Track Angle	0.051	deg
Ground Speed	0.051	kts
Track Angle Rate	268.407	deg/s
True Air Speed	5.747	kts
BDS 6.0: Heading and Speed Report		
Magnetic Heading	-168.407	deg
Indicated Airspeed	5.750	kts
Mach	0.008	
Barometric Altitude Rate	16.000	ft/min
Inertial Vertical Velocity	-3.204	ft/min

Figure 7: ADS-B information as per BDS-Code

Of course such modified ADS-B transmission has to be communicated with ATC and has to follow such regulations of each country.

FLIGHT INSPECTION AND WIDE AREA MULTILATERATION

WAM is often viewed as a fitting technological bridge between surveillance radar and ADS-B. Lots of different techniques can be summarized under this term. Several transmitters or interrogators can be used therefore.

- SSR Transponder (Mode A/C/S)
- VHF Com
- DME
- Theoretically any other airborne transmitter like RadAlt, Weather Radar etc.

The position is determined by synchronization and correlation of different measurements of the same signal as shown in Figure 8.

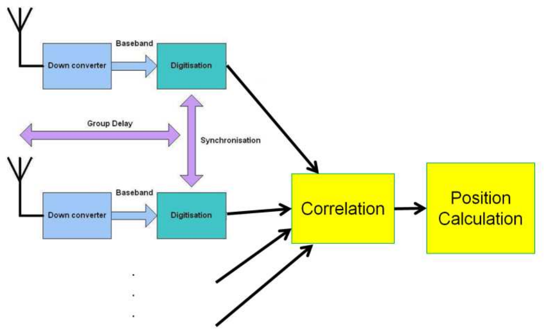

Figure 8: WAM Position Determination

DATA EVALUATION AND BENEFITS

During all flight inspection task the position data is collected and the comparison to the WAM station can be performed. The coverage and the importance of no WAM signal outages are tracked continuously in parallel. The Flight inspection system delivers its high accurate position due to its hybrid reference position calculation including PDGPS, INS, Baro etc. Commissioning of WAM ground station is very similar to radar commissioning in respect to the position calculation and its comparison. The main focus is here to determine the coverage of the signal and due to the valid border.

The benefits of WAM position determination can be summarized as follows:

- Ability to track and identify Mode A/C/S equipped aircraft at a high update rate.
- High interrogation capability and advanced target processing
- First developed for Ground Tracking of Aircraft without Ground Radar (Surface Movement Guidance)
- Identification of a single aircraft by unique address possible

(Mode S, ADS-B and Mode C only)

- System work well also in mountainous terrain
- Time synchronization of receivers is one critical path

CONCLUSION

Taking into account the required and intended improvements for the surveillance of aircrafts in regard to air traffic control, and the growing capability of the ADS-B or WAM links, it is found to be mandatory to flight inspect such ADS-B and WAM receptions. If ATC has to rely on these data the coverage has to be maintained and interference in these stipulated areas has to be avoided or announced.

The development in future for this surveillance, situation awareness and information technique is not easily foreseeable yet, but its growing capacity in conjunction with possibilities for ATC improvement will definitely require flight inspection of these techniques in the future.

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FULL-WAVEFORM LIDAR DATA

BASIC PRINCIPLES AND PRACTICE

Mgr. Miroslav Holubec
YMS, a. s., Hornopotočná 1, 917 01 Trnava, Slovensko
miroslav.holubec@yms.sk

Ing. Peter Bobáľ, Ph.D.
YMS, a. s., Hornopotočná 1, 917 01 Trnava, Slovensko
peter.bobal@yms.sk

Abstract *– Nowadays, LIDAR is one of the most progressive methods for spatial data acquisition. This technology goes through the rapid development from its formation, which brings the quality improvement and more possibilities of using the data. Oldies discrete laser scanners are replaced with full-waveform scanners, which represent different, more sophisticated way for spatial data acquisition. This article examines the possibility of use and the basis principles of full-waveform scanners.*

Key words – LIDAR, Laser Scanning, remote sensing, Full-waveform

INTRODUCTION

LIDAR (Light Detection and Ranging) is an active remote sensing method, which finds application in various fields and disciplines. It is a technology similar to radar, but that the collection of information instead of radio waves using laser beams. LIDAR principle consists in measuring the distance between the laser scanner frequently placed not on board the aircraft and researched object. The results of these measurements are called. "3D point cloud" representing objects in space.

Collecting data via LIDAR provides over other methods of benefits. The biggest advantage is the high level of accuracy, where the resulting data may contain up to several geo-referenced points per m2. Vertical accuracy of the readings achieves ± 15 cm. In addition, this technology allows for data collection during the night and shoot the ground surface in forested areas, which is a big advantage compared with photogrammetric methods.

The first aerial LIDAR-s systems for commercial applications have emerged in the 90s of the last century. It was a discreet laser systems that are technologically capable of capturing either as a discrete reflected beam or the first and last beam reflected from the subject. Since the early 21 century began to use commercial lidar systems allowing capture up to 5 reflections on the one posted pulse.

In recent years, come to the fore a new generation of so-called full-waveform (FW) laser scanners. Historically, the first FW lidar system was created already in the 80s of the last century for the purpose of monitoring areas of water bathymetry. In 1999, NASA developed the first operating system called FW LVIS (Laser Vegetation Imaging Sensor). It was created for the purpose of mapping the vegetation cover and also also had the potential for monitoring ground surface located under the vegetation. The first FW lidar system for commercial purposes was introduced in 2004, which was associated with the development of laser devices with narrow track beam. This allows to record pulses with high sampling rate (typically 1 GHz). By now, most companies engaged in the technology of LIDAR (Riegl, Leica, Toposys, ...) provides a system for recording the entire course of the reflected signal.

FULL-WAVEFORM LIDAR

Compared to discrete laser system, FW scanner can record the whole course of the reflected signal as a function of time. Based on these data can subsequently be obtained in addition to 3D point clouds and additional and more detailed information on the structure of the scanned surface. This is the width (range) of the reflected pulse and amplitude. Amplitude provides information on the intensity reflectivity of the target object. Varies depending on the radiometric and geometric characteristics of the subject. Beam Echo is an indicator of inequality and inclination sensing surface and can be used for example to distinguish vegetation from buildings. This additional information will provide end users more control over the process of interpretation of measured data. Principle FW liadrových systems following figure (Figure 1).

FULL-WAVEFORM DATA MANIPULATION

Processiing of FW lidar data allows users to manage the process of extraction points and makes it more efficient. Currently, the most widespread strategy of processing full-waveform lidar data is the decomposition of the set of components and to characterize different objects captured by a laser beam. The aim of this approach is to extract 3D point clouds with the greatest density and accuracy.

One of the most common method of this type is gaussovká decomposition. Allows FW lidar data as a set of Gaussian functions, making it possible to determine the amplitude and width of each echo. In various studies indicate that its use can lead to good results only in 98% of cases FW lidar data. There are different implementations Gaussian decomposition, which vary depending on the algorithm used for transforming the data to the file FW Gaussian functions.

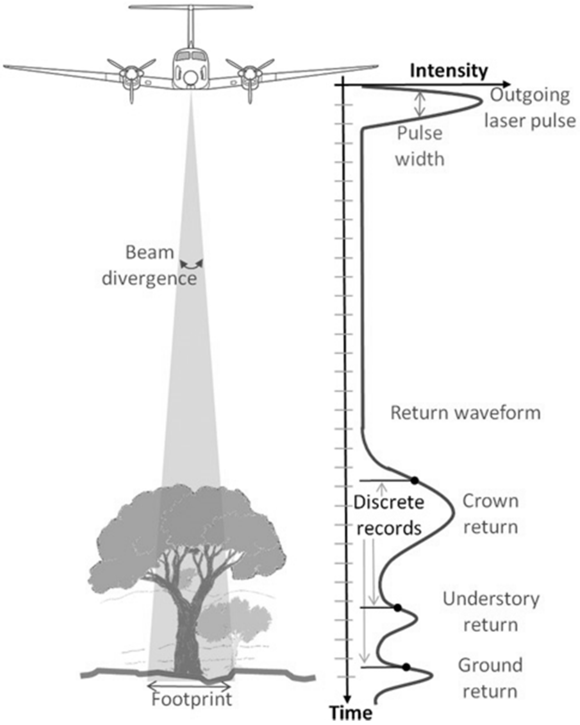

Figure 1 *- Principle of lidar imaging (source: www.imagingnotes.com)*

Another part of the processing lidar data is their classification , at which the points are classified into several categories (landscape, buildings, low vegetation, high vegetation, etc.). Points can be classified on the basis of height ratios on the point, according to the intensity reflectivity, depending on the direction of inclination of neighboring points etc. In most cases, first performed is automatic data classification. There is a large variety of classification algorithms. Their use depends on the specific objectives of the project . Later, in the case of misclassified points in the automatic classification can be performed manually using the correct classification . It should be noted that the classification process in order to achieve higher-quality data can be time-consuming and requires a considerable amount of supporting data. Either it is already on existing data or can be obtained during the actual scanning .

USE OF FULL-WAVEFORM DATA

FW LIDAR provides benefits primarily for applications that require the detection and differentiation of vertical objects. To capture the whole course of the reflected beam provides more detailed information on the vertical structure of the monitoring area. Close the laser beam incident on the surface (about 0.3 to 1 m at an altitude of 1 km) turn allows vertical objects differ from each other.

FW lidar technology finds application mainly in forestry applications in order to provide the most detailed description of the structure of vegetation. There are many treatments for FW data to estimate the characteristics of the forest. Their influences range as the size of the monitored area, forest type, level of leaf area , etc.

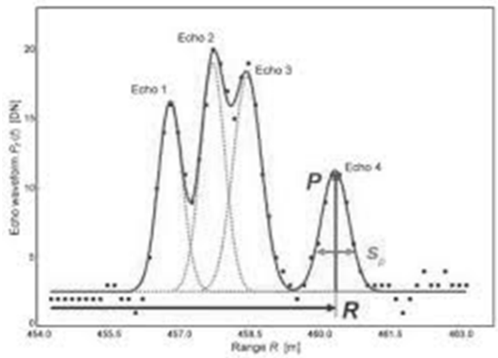

Figure 2 *– Typical full-waveform curve (source: http://geo.tuwien.ac.at/)*

FW Lidar is characterized by narrow beam footprint and high density of trapped points allows modeling of vegetation with higher accuracy. However, also requires more time for mapping of the study area, as opposed to a wide track lidar beam. FW lidar laser beams with a narrow track can penetrate through the treetops and reach the ground. It is essential to measure the height of trees. The ratio between the number of reflections from the surface and from vegetation depends on the level of leaf area and the density of the cloud of points. The ability of laser beams penetrate the canopy LIDAR gives the possibility to model the course of terrain and in wooded areas. The resulting digital terrain model can then be used as the modeling of environmental processes (hydrological modeling, erosion modeling) . In addition, FW LDAR is suitable to determine the width of the treetops, canopy structure, classification trees by species or to estimate their other specific characteristics. Information on species composition and vegetation structure are then fed as for planning, monitoring and evaluation of the risks of changes in forested areas .

When using FW lidar data in built-up areas is seldom an increase in the density of points obtained in comparison with discrete LIDAR. Compared vegetation, laser beams pass through surfaces such as roads or buildings. Multiple reflections can occur, especially at the corners of buildings. Use of FW lidar in built-up areas is based mainly on the ability to distinguish buildings from vegetation, ground surface and possibly other kinds of objects.

CONCLUSION

The commercial potential of full waveform lidar systems is large, as demonstrated by several studies. There is still only to improve these systems, but also to the creation of new applications, methods and software products, so that it is possible to extract from the data obtained the best possible information. Currently these software products is still fairly expensive, but the prospects of the development of more open-source products that will be useful for processing purposes FW data.

Also important is the question of storage and management of huge amounts of data (big data), which full-waveform lidar systems recorded during the recording process.

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Európska únia

FINANCIAL CONSEQUENCES OF APRON ERRORRS

Ing. Martin Hromádka
Air Transport Department, University of Zilina
hromadka@fpedas.uniza.sk

Abstract *– The paper analyses unnamed airline's database of apron errors. The focus is on calculating the concrete amount of financial consequences arising from both primary (repair) and secondary (delay) costs. The calculation is based on dataset provided by the airline (repair costs) and reference model provided by EUROCONTROL (delay costs). Main processes contributing to most errors are denominated as well. The article identifies the most dangerous errors in the sample operation which created the total loss of 1 289 876 Euros in 2012 at particular airport for the unnamed airline.*

Key words – apron errors, financial consequences, case study, data analysis.

INTRODUCTION

As the traffic is constantly growing, apron safety is an important and up-to-date issue. Ground handling accidents cause huge losses as much as few billions euros to the airlines all over the world each year. However, most of these accidents are caused by human errors and it can be very easy to prevent them. The aim of the paper is to identify the main causes of these operational errors together with their consequences. Within this paper, an extensive research on financial consequences of errors occurred at selected airport apron will be conducted. The aim is to calculate exact primary and secondary costs of the apron errors.

CASE STUDY SUBJECT AND DATASET

In order to do that, data from unnamed airline was gained. As these data are commercially sensitive, the airline will be denominated as an Airline X. The Airline X belongs to the top 5 European airlines in terms of passengers carried.

Until now, there are just few studies within the European region calculating the delay costs of apron incidents. None of them contains the primary costs of maintenance and labor needed for fixing the damages. This is because these costs cannot be generally estimated and the consequences of each particular incident are different. However, the only way how to be accurate is to count primary and reactionary costs together. This final number represents the total costs for an airline arising from each particular apron incident. With this perception it was obvious that this study will focus on the particular airport apron.

Data for this research were provided from the Airline X by the department responsible for ground services. Airline X devotes lot of time to operational safety. The airline is collecting errors data from daily operation by specialized personnel. Each noticed error or procedure deviation is marked by safety personnel to the record form and later added to the database. Obtained dataset contains 784 errors that happened on the particular apron in 2012 together with identification numbers and dates of observation. As for the examined apron, it is the apron of airport serving as a hub for the Airline X. Just like the airline, the airport is in the top 5 of European airports as well. Other information such as situation description, damage, involved equipment, location, aircraft identification number and number of flight, operation phase, location, caused delay and possible cause of incident was described and involved as well.

COST CALCULATION

As it was stated at the very beginning, error consequences consist of the primary (repair) costs and secondary (delays) costs which create the total costs of certain error. At first, the source of the repair costs will be explained.

The database of all repairs in 2012 was obtained from the airline. Afterwards, the particular records from error dataset (described in previous chapter) was matched with costs of the repair according to the date, type of aircraft and damage description. Labor costs were also involved in the final price.

As for cancelation costs, the unavailability of an aircraft is a tough situation for an airline. When damage occurs on the aircraft and the damage leads to a situation where the aircraft is grounded, the damaged aircraft must be replaced by another aircraft to continue the flight. If not, the flight might be cancelled. In order to prevent such situations, most airlines maintain a stand-by aircraft to replace the grounded aircraft. The costs to maintain a stand-by aircraft is estimated, according to the rule of thumb, 35 000 Euros per day for one narrow body aircraft cancellation and 125 000 Euros per day for wide body aircraft cancellation (together with indirect costs). While indirect costs are not claimed by the insurance, the cost for the repair of the damage is claimed via the insurance (direct costs).

On the top of that, there are another costs arising when the flight is delayed due to aircraft damage. In order to calculate the costs of time, the 2011 figures approved and issued by EUROCONTROL are presented. These are designed as a reference model for European delay costs that were incurred by airlines. We can split these costs into two basic stages. Delay costs can be represented as strategic (or planning costs), tactical (operational costs) and reactionary (or network costs). Table below includes all the tactical, rotational and non-rotational reactionary costs.

Table 1 - At-gate base FULL delay costs in Euros per minute [2]

Delay (mins)	5	15	30	60	90	120	180	240	300
B733	60	360	1 290	5 780	15 710	29 730	39 990	53 720	71 300
B734	70	400	1 430	6 510	17 820	33 670	45 260	60 680	80 310
B735	60	330	1 170	5 200	14 120	26 740	36 020	48 490	64 570
B738	70	440	1 580	7 200	19 730	37 270	50 050	66 970	88 410
B752	80	520	1 900	8 780	24 170	45 610	61 150	81 610	107 330
B763	150	880	3 130	14 510	39 380	84 200	119 910	149 510	186 220
B744	220	1 230	4 440	20 760	56 480	120 940	172 030	213 950	265 480
A319	60	370	1 310	5 960	16 330	30 880	41 560	55 820	74 070
A320	70	410	1 490	6 800	18 680	35 280	47 420	63 530	84 020
A321	70	470	1 770	8 150	22 490	42 460	56 980	76 140	100 320
AT43	30	160	520	2 160	5 730	10 940	15 040	20 900	29 020
AT72	40	190	670	2 900	7 780	14 800	20 160	27 630	37 690

Results

In 2012, there were 57 852 errors observed. From those, 34 610 errors are considered as safe, 10 899 as not safe and 12 343 errors were not observed during operation. This results in approximately 19% rate for unsafe error occurrence. In this calculation just unsafe errors are considered. In Figure 1 below, the incident occurrence per most frequent error types is expressed. Codes for particular errors can be found in the Appendix 1 at the end of the paper.

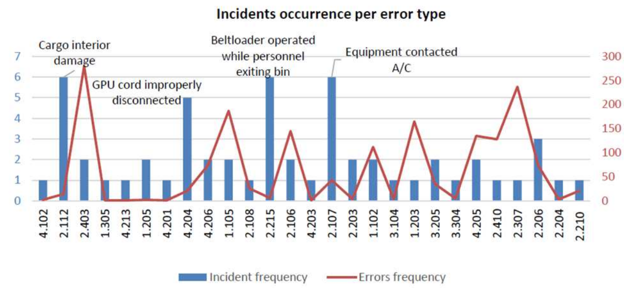

Figure 1 - Airline X apron incidents occurrence per error type

As it is obvious from Figure 1, the most frequent errors are 2.403 (Driving in a prohibited area) and 2.307 (Container/pallet contents not properly loaded or secured). However, we can see that there are extensive differences in error and incident occurrence.

The most frequent incidents occurred within very occasional errors. Most frequent incidents are 2.112 (Cargo interior damage), 4.204 (GPU cord improperly disconnected), 2.215 (Beltloader operated while personnel exiting bin) and 2.107 (Equipment contacted aircraft). Because the error versus incident occurrence is a complex problem, it is further discussed from many aspects.

Repair Costs (Primary Costs)

In this section, the repair costs of particular errors are analyzed. In 2012, Airline X maintenance department repaired more than 1300 aircrafts. 89 of these damages were caused by operational error. This resulted in total of 606 716.45 Euros loss. Figure 2 below shows the errors that caused the biggest damages to aircraft.

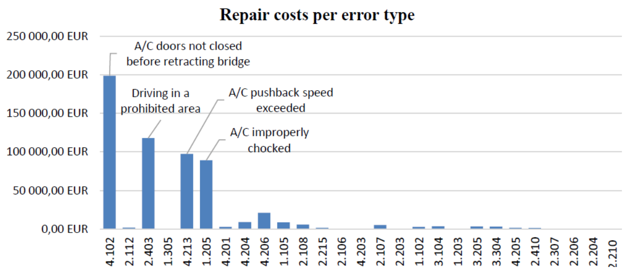

Figure 2 - Airline X apron errors repair costs

As we can see from the graph, there are four types of error that created the most of the repair costs for Airline X in 2012. The biggest loss of 198 688.70 Euros was caused by operational personnel that did not closed the aircraft door before deactivating auto leveler and retracting the bridge what caused that door was sheared off. Driving in a prohibited area with loading stairs not set on the lowest level caused that stairs was driven into the wing and seriously damaged aircraft winglet with loss of 116 406 Euros. Damage caused by pushback driver who did exceeded the allowed pushback speed created additional 97 527 Euro loss and the last serious error caused 89 038 Euros loss, because the aircraft was not properly chocked and was blown from its position.

Delay Costs (Secondary Costs)

Another part of costs was created by the delays that arose from particular errors. In the final overview, it can be seen that delay costs are even greater than repair costs in total. Primary (delay of one particular aircraft or other aircrafts on the same leg) delays caused the loss of 115 998 Euros and reactionary (delay caused to the network) delays created additional 197 161 Euros loss to Airline X in 2012. Total delay costs represent 52% of all the costs that were caused by ground handling errors. This stands for 313 160 Euros loss to the airline. Figure 3 below shows the most serious delay costs that were caused by operational personnel errors.

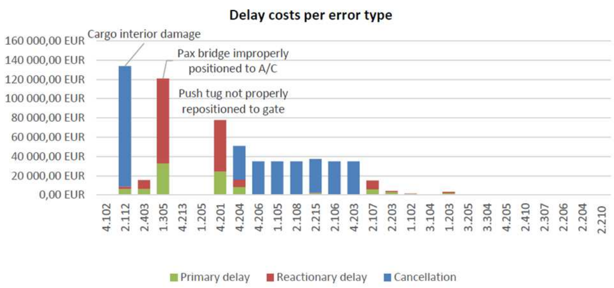

Figure 3 - Airline X apron errors delay costs

There are three basic categories of delay costs. Primary costs, reactionary costs and cancellation costs. Cargo interior damage error is obvious and the most expected. It is created mostly by cancellation. While cancellation represents the biggest part of overall delay costs, there are two error types that created the same or even bigger loss to Airline X without cancellation. Operational error 1.305 (Passenger bridge improperly positioned to the aircraft) caused 120 940 Euros loss and error 4.201 (Push tug not properly repositioned to gate) created additional 77 966 Euros loss.

Total Costs

Total costs overview can be seen in Figure 4. The first chart shows the core parts of delay costs and the second one represents repair and delay costs percentage share of total costs that were incurred at the examined apron for Airline X.

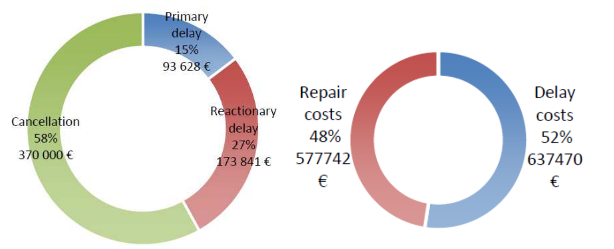

Figure 4 - Airline X apron errors total costs

As we can perceive from the Figure 4, repair costs represent just 48% of total costs (577 742 Euros). The bigger portion of 52% refers to the total delay costs (637 470 Euros). The delay costs are divided into three main categories. Cancellation costs cover 58% (370 000 Euros), 27% is covered by reactionary costs (173 841 Euros) and 15% by primary delay costs (93 628 Euros). Total incurred costs caused the loss of **1 289 876, 45** Euros. All of the costs mentioned above were incurred by ground operational personnel errors on one of the top 5 European airports when handling the Airline X aircraft in 2012.

Other Selected Results

Figure 5 gives very clear view of the most dangerous error types. The chart is reordered according to the incurred costs and divided into two main cost categories, repair and delay costs. The most urgent errors that should be threated immediately are 4.102 (Aircraft doors not closed before retracting bridge), 2.112 (Cargo interior damage) and 2.403 (Driving in a prohibited area).

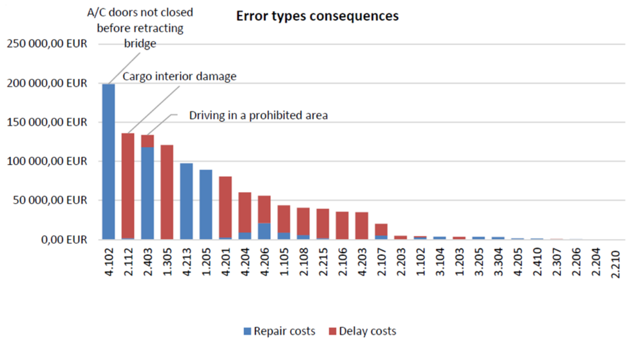

Figure 5 - Airline X apron error types consequences

It can be very hard to avoid cargo interiors damage, but it was already suggested to lower the time pressure that influences the operational personnel by changing the system from on-time departure to on-time arrival and not to hurry personnel inadequately. One can also notice that cargo interior damage costs are created mostly by delay costs. It is because damages are not so significant but it takes a lot of time to fix the problems that occurred by improper cargo loading or offloading. On the other hand, error - driving in the prohibited area and error - doors not closed before retracting bridge created mostly repair damages. It can be very easy to avoid these unnecessary damages by simple instructions (or training) to the operational personnel. The situational awareness of personnel should be increased in order to avoid these errors from happening. Figure 6 below provides closer look at incident consequences.

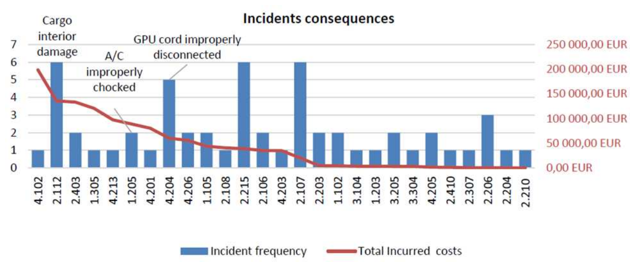

Figure 6 - Airline X apron incidents consequences

From the graph above, we can state that the frequency of incidents is not the most important factor to consider. While some of the incidents occur quite often, like error 4.204 (GPU cord improperly disconnected), but do not create such significant damages, error 1.205 (Aircraft improperly chocked) occur less, but its consequences are much greater. It is very important to emphasize that this research takes into account just incidents which were caused by operational errors and not other causes. Figure 7 shows the errors consequences that occurred in various handling processes.

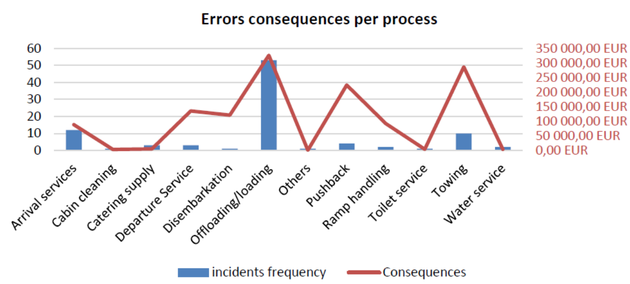

Figure 7 - Airline X apron errors consequences per process

As it was predicted, the most dangerous ground handling process is loading/offloading (326 297 Euros). It is followed by pushback (224 281 Euros) and towing (286 877 Euros). The next processes, with less important error consequences, are processes such as arrival service and departure service (because the most of services are supposed to be finished during departure services).

Figure 8 below shows the statistics of equipment which caused the damages to aircraft or other property

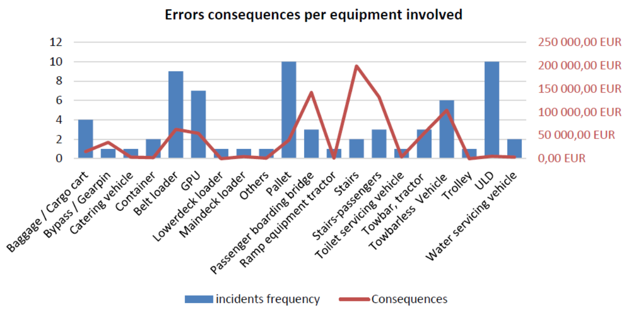

Figure 8 - Airline X apron errors consequences per equipment involved

Previously undertaken researches recommended that the equipment is poorly maintained or used as not intended. The chart 8 above can help to solve this problem. While the four most often incident causing equipment are belt loader, GPU, pallet (pallet container) and ULD, the biggest damages were incurred by following equipment: passenger boarding bridge (141 978 Euros) and stairs (198 838). These are the most urgent equipment to be maintained or better instructed to personnel. In Figure 9 one can also see the most often damaged aircraft parts by operational errors.

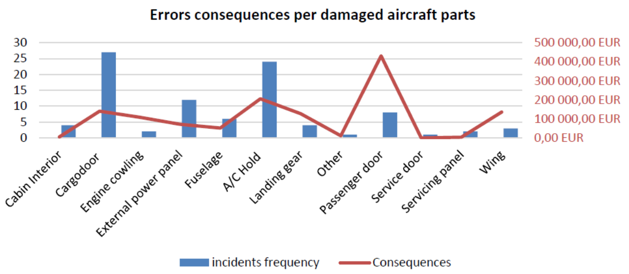

Figure 9 - Airline X apron errors consequences per damaged parts

Conclusion

As the result of this study, one is able to define the most dangerous ground services errors of Airline X. Moreover, by pointing at them, it is possible to prevent these errors from creating additional unnecessary costs for this airline in the future.

The aviation industry can point to a number of reasons for the increase in ramp accidents and incidents, such as outsourcing staff, higher volumes of flights, increased congestion in the ramp area, larger aircraft, fewer airport operations staff, and cost-cutting measures with regard to training, equipment, and staff supervision, but the increase of 15% in accidents/incidents rate measured from 2006 to 2007 is particularly alarming and numbers of accidents/incidents are yet still growing each year.

Correspondingly, various airlines' expenses from aircraft damages and staff injuries are increasing with continuous growth of traffic. While it is almost impossible to avoid all ground accidents/incidents, there is a significant factor that contributes disproportionally to accidents/incidents occurrence and that is the human error. In 2012 there were 57 852 human errors observed at examined apron. From these, 34 610 errors are considered as safe, 10 899 as not safe and 12 343 errors were not observed during operation. This results in approximately 19% rate of unsafe error occurrence.

Calculation in this paper further revealed that 1 289 876, 45 Euros loss was created to Airline X because of human errors at one apron only in 2012. These cover both direct and indirect costs such as reputation loss, impact to air traffic flow, airport operational delays, hiring of new staff because of injuries, repairs spare parts and labor costs. The primary - repair costs represent 48% of total costs and caused 577 742 Euros loss. The bigger portion of 52% refers to the secondary - delay costs which caused the loss 637 470 Euros.

It was found that there were extensive differences in error and incident occurrence. While the most frequent errors were *driving in a prohibited area* and *container or pallet contents not properly loaded or secured* , the most frequent incidents caused by errors were *cargo interior damage* , *GPU cord improperly disconnected*, *beltloader operated while personnel exiting bin* and *equipment contacted aircraft*.

The most dangerous ground handling process was loading/offloading (326 297 Euros loss). It is followed by pushback (224 281 Euros loss) and towing (286 877 Euros loss). The next processes with less important error consequences are processes like arrival service and departure service.

While the four most often incident causing equipment were beltloader, GPU, pallet (pallet container) and ULD, the biggest damages were incurred by equipment passenger boarding bridge (141 978 Euros loss) and passenger stairs (198 838 Euros loss). These are the most urgent equipment to be maintained and better instructed to the ground personnel.

The ground service is a very complex process and therefore just the most dangerous errors can be threated immediately. In order to identify errors in Airline X operation the SMS matrix could be used. The biggest advantage of this displaying method is that it is highlighting just the errors that occurred very frequently together with very high financial consequences.

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APPENDIX 1 – ERROR CODES

Error Code	Error Description
1.102	FOD check inadequate or omitted
1.102	FOD check inadequate or omitted
4.102	A/C doors not closed before deactivating auto leveler and retracting loading bridge
1.105	non-FAA, GPU not in assigned space
4.102	A/C doors not closed before deactivating auto leveler and retracting loading bridge
1.105	non-FAA, GPU not in assigned space
3.104	Access panels not secured when finished
3.104	Access panels not secured when finished
2.106	Beltloader improperly positioned (e.g., handrails out, up position) when approaching A/C
2.106	Beltloader improperly positioned (e.g., handrails out, up position) when approaching A/C
2.107	Equipment (e.g., beltloaders, loading bridge) contacted A/C
2.107	Equipment (e.g., beltloaders, loading bridge) contacted A/C
2.108	Beltloader(s)/container loader(s) not placed/aligned with A/C properly
2.108	Beltloader(s)/container loader(s) not placed/aligned with A/C properly
2.112	Cargo interior damage/FOD inspection not performed
2.112	Cargo interior damage/FOD inspection not performed
1.203	GPU power head improperly supported
1.203	GPU power head improperly supported
4.201	Push tug not properly repositioned to gate area
2.203	Equipment (e.g., beltloaders, loading bridge) contacted A/C
4.201	Push tug not properly repositioned to gate area
2.203	Equipment (e.g., beltloaders, loading bridge) contacted A/C
1.205	A/C improperly chocked
2.204	Beltloader(s)/container loader(s) not placed/aligned with A/C properly
1.205	A/C improperly chocked
2.204	Beltloader(s)/container loader(s) not placed/aligned with A/C properly
4.203	non-FAA, Bypass pin not installed
4.203	non-FAA, Bypass pin not installed
4.204	GPU cord improperly disconnected
3.205	Access panels not secured when finished
2.206	Cargo door/sills/locks check not performed
4.204	GPU cord improperly disconnected
3.205	Access panels not secured when finished
2.206	Cargo door/sills/locks check not performed
4.205	GPU cord improperly stowed
4.205	GPU cord improperly stowed
4.206	Pre-departure walkaround/FOD check inadequate or omitted
4.206	Pre-departure walkaround/FOD check inadequate or omitted
2.210	non-FAA, Platform too low under threshold during closing of cargo door
2.210	non-FAA, Platform too low under threshold during closing of cargo door
4.213	A/C pushback speed exceeded
2.215	Beltloader belt operated while personnel entering/exiting bin
4.213	A/C pushback speed exceeded
2.215	Beltloader belt operated while personnel entering/exiting bin
1.305	Passenger loading bridge improperly positioned to A/C door
1.305	Passenger loading bridge improperly positioned to A/C door
3.304	Equipment (e.g., beltloaders, loading bridge) contacted A/C
3.304	Equipment (e.g., beltloaders, loading bridge) contacted A/C
2.307	Container/pallet contents not properly loaded or secured
2.307	Container/pallet contents not properly loaded or secured
2.403	Driving in a prohibited area (e.g., marked prohibited, driving under wing, etc.)
2.403	Driving in a prohibited area (e.g., marked prohibited, driving under wing, etc.)
2.410	Brake stop(s) not performed
2.410	Brake stop(s) not performed

MODEL OF AIR TRAFFIC CONTROLLER EDUCATION AT THE FACULTY OF TRANSPORT AND TRAFFIC SCIENCES

Biljana Juričić
Faculty of Transport and Traffic Sciences, Department of Aeronautics, University of Zagreb, Croatia
biljana.juricic@fpz.hr

Doris Novak
Faculty of Transport and Traffic Sciences, Department of Aeronautics, University of Zagreb, Croatia
doris.novak@fpz.hr

Ernest Bazijanac
Faculty of Transport and Traffic Sciences, Department of Aeronautics, University of Zagreb, Croatia
ernest.bazijanac@fpz.hr

Abstract – *Air traffic controller training is a basic requirement for provision of air traffic control and management to achieve safe, orderly and expeditious air traffic. Air traffic controller training is based on the minimum requirements defined by the relevant regulations and provided in the certified training centers. Models of air traffic controller training differ from state to state and are usually carried out through the course of several months and started by the request of the users. This paper analyzes current model of air traffic controller education which was implemented at the 3-year undergraduate study of aeronautics, module air traffic control at the Faculty of Transport and Traffic Sciences and presents a new model of educating air traffic controllers developed in cooperation with Croatia Control ltd. Benefits of the new model will be defined.*

Key words – air traffic control, education, model

INTRODUCTION

Air traffic is characterized with continuous growth. In the 2014 expected growth in air traffic in Europe is 2.8% compared to the previous years [1]. Air traffic in Croatia also follows the positive trend in air traffic growth. In the 2014 expected growth is 2.2%, and for years to come, respectively 3.5%, 3.9%, 4.1%, 3.7%, and in the 2019 3.1%. Due to the anticipated trend of continuous growth, over the past decade Air Navigation Service Providers have dealt with significant traffic growth. In the current air traffic control environment the key limiting factor to increase sector capacity is the workload of the air traffic controller as they provide separation to – keep aircraft at a prescribed safe distance from other aircraft in their area of responsibility and move all aircraft safely and efficiently through their assigned sector of airspace. Depending on the sectorization of the airspace, meteorological situation, the environment, airspace complexity and the equipment they are working on, air traffic controllers (ATCO) at the same time deal with a certain number of aircraft. In the years to come, with the implementation of new technologies and navigation concepts their job will be slightly changed and we might say relieved in terms of stress as they will manage air traffic since aircraft routes will be predicted in advanced.

Nevertheless, whether talking about air traffic controller or possible managers in the future, they are and should be trained to maintain safe, orderly and expeditious flow of air traffic in the global air traffic management system. Despite of increasing traffic loads, the changing nature of traffic and technological advances in equipment controllers should be able to provide their objectives the best they can. It is consequently becoming extremely important to understand the nature of the complex demands of air traffic controllers' work and also perhaps most important to understand the importance of proper, well-organized and efficient air traffic controller training.

REGULATION ON ATCO TRAINING

Air Traffic Management (ATM) is responsible for coordination of airspace design and traffic flows according to the traffic demand. As the traffic demand is constantly growing, the airspace capacity needs to be increased. Current ATM system, generally characterized by three components: air traffic services (ATS), airspace management (ASM), air traffic flow and capacity management (ATFCM), consists of a rigid route structure where aircraft are constantly under ground-based control. Together with the other European ATM stakeholders it helps to coordinate airspace design and management, building more efficient airways over Europe. Once air routes have been planned, ATM through its ATFCM matches the flights with the available airspace capacity of different air navigation service providers (ANSPs). This is an important process because only a certain number of flights can be safely handled at one time by each air traffic controller. Once again, it is consequently becoming extremely important to understand the importance of proper, well-organized and efficient air traffic controller training.

Accordingly, air traffic controller must be a strong communicator, confident, good at making quick decisions and solving problems, an efficient leader, alert, motivated, wholly committed to the job, a person adaptive to the ever-changing working hours. Also, he/she needs to have good organizational skills and a keen eye for details and to medically fits. The selection of air traffic controller is carried out by psychologists, physicians, experienced air traffic controllers, instructors for air traffic controllers and other members of the personnel department and it consists of four modules of English language test (writing, listening, comprehension), set of cognitive tests (attention, memory, producing and understanding language, learning, reasoning, problem solving, decision making), ATC work sample test (simulator simplified tasks) and personality questionnaire. After the selection, candidates are ready to start with an air traffic controller training.

Also accordingly to specific kind of training, the specific requirements for air traffic controller training are defined by:

1.) ICAO Annex 1 – Personnel Licensing – prescribes the minimum requirements for the field of air traffic controller training,
2.) EU Regulation 805/2011 (Regulation) on a Community air traffic controller license – prescribes that training shall consist of theoretical courses, practical exercises, including simulation training, which is needed for candidates to acquire and maintain the skills to deliver safe and high quality ATC services. This regulation defines the process how to apply for, to train and to achieve ATCO license,
3.) Specification for the ATCO Common Core Content Initial Training (Specification) - prescribes the minimum program requirements necessary to obtain during the Initial Training. The Specification requirements are prerequisites to achieve a Student ATCO License in accordance with Regulation and present the minimum training requirement in accordance with ESARR.

ATCO TRAINING ORGANIZATION

The process of ATCO training must be provided within certified ATCO training organization. Competent authority as a part of National supervisory authority conducts the procedure of initial certification and later the continuous auditing of ATCO training organization. The first prerequisite for the organization is establishing sufficient management system through appointed responsible personnel – accountable manager, quality and safety manager, head of training. Also training organization must demonstrate by evidence that it is "…adequate staffed and equipped and operate in an environment suitable for the provision of the training necessary to obtain or maintain license". The basic document of the organization which gathers majority of evidence is Operations manual.

Accountable manager is responsible to ensure sufficient finance for the conduct of the training and that all training activities have sufficient insurance.

Quality and safety manager is responsible for establishment of the quality and safety management system and procedures to control and monitor harmonization and compliance with requirements defined in national and international regulations.

The person responsible for planning, management and organization of training is head of training. His/her duties are to amend and update parts of operational manual, training plans and programs in accordance with the relevant regulations. These duties include storage and keeping the records of candidates test, exams and assessments so that any relevant activity can be traceable by the competent authority.

Since Initial Training is separated into two parts (theoretical courses and practical part with simulator exercises) a certified organization may divide duties of the head of training on two persons Head of Theoretical Training and Head of Practical Training. The similar practice is defined for certified flight training organizations where two different responsible persons, among others, are recognized and responsible for similar duties: chief ground instructor for theory and chief flying instructor for practice.

ATCO training organizations are certified for unit or initial training. Only air navigation service provider can establish its own department to be certified for unit training. On the contrary any organization which proves that complies to the relevant regulations is able to get certificate for certified training organization for Initial Training.

Many years of experience on a worldwide basis (FAA, EUROCONTROL, ICAO) has shown that the best way of air traffic controller training should develop in two phases First phase is Initial Training. Currently, in the world there are several ATCO Training centers that provide training in both or one of two phases of ATC training as. It includes theory, practice and simulation that prepare candidates for training at an ATC unit. Initial Training consists of two parts, Basic and Rating training:

1.) Basic Training – candidates obtain fundamental knowledge and skills necessary for progress to specialized ATC training,
2.) Rating Training – specialized ATC training that provides knowledge and skills related to a job category and appropriate to the discipline to be pursued in the ATC environment.

After finishing Initial Training a candidate obtains Student ATCO license from competent authority and becomes student-controller.

Second phase is Unit Training consisting of Transitional Training, Pre-On-The-Job Training (Pre-OJT) and On-The-Job Training (OJT) necessary for adjustment to working environment:

1.) Transitional Training – student air traffic controllers develop skills through the use of site-specific simulations,
2.) Pre-OJT – extensive use of simulations using site-specific facilities to enhance the development of previously acquired routines and abilities to an exceptionally high level of achievement,
3.) OJT – integration of previously acquired job-related routines and skills under the supervision of O-The-job Training Instructor in a live traffic situation.

Student`s progress is monitored during each phase of training and at the end of each phase a student takes theoretical exams and practical exams on the simulator. After finishing Unit

Training a student-controller obtains ATCO license from competent authority.

EXAMPLES OF TRAINING ORGANIZATIONS

In the most cases Initial Training is organized through course that lasts several months. Organization can be certified for Basic Training only. Duration of basic training depends on the total amount of classes provided. For example, Basic Training course in UK's Global-ATS lasts for 5 weeks since in Croatia, at training centre HUSK it lasts 14 weeks.

According to the world and European regulations to the minimum requirement for student ATCO license obtained is to have at least a diploma granting access to university or equivalent, or any other secondary education qualification, which enables to complete air traffic controller training. He/she must have valid medical certificate. It is obvious that it is not prescribed for air traffic controllers to have university level education. However, there are some good examples and intentions to recruit candidates with academic degree. One good example is US's FAA that has established air traffic collegiate training initiative program (AT-CTI). This program defines a number of institutions in the USA that offer undergraduate study of Air Traffic Management or Air traffic control. The best known is Embry-Riddle Aeronautical University at Daytona Beach campus that offers undergraduate study of Air Traffic Management. The ATM curriculum provides the basic knowledge for later entry into the FAA Academy where students will be given additional air traffic control training. In Europe there are only few examples of similar institutions. French ENAC offers 5 year engineering program in air traffic management (ICNA program) equivalent to Master of Science degree. Students have scholarship and are guaranteed employment upon successful completion of their studies in French Civil Aviation Authority. The University of Norrkoping, Sweden, has a bachelor's degree program in Air Traffic and Logistic, which will have 30 places reserved for future air traffic controllers since this autumn. Their students will go through Sweden's Air Navigation Service Provider's (LVF) tests and attend air traffic control training center Entry Point North for 1,5 year for air traffic controller training program. This program is established upon request of LVF. The management of LVF determined that Swedish air traffic controllers in the near future should have an academic degree. At the Anadolu University, Turkey, at the Faculty of Aeronautics and Astronautics, Department of Air Traffic Control provide similar bachelor's program for students that include practical and theoretical knowledge. At both Universities students must meet medical criteria before enrolling in college.

CROATIAN EXAMPLE

In Croatia, on the other hand, till 2009 there wasn't any organization certified for the provision of initial ATCO training. In 2009 at Faculty of Transport and Traffic Sciences s an organization named Croatian ATC Training Centre (HUSK), was established as an ATCO training organization. Croatian Civil Aviation Authority (CCAA) as National Supervisory authority has approved its programs and certified HUSK and as an ATCO training organization (ATCTO/001) for the first part of the Initial Training – Basic Training. From July 1st HUSK is certified as HR/TOC001 after Croatia became a full EU member. HUSK provides two different training programs: integrated program of training provided through undergraduate study of aeronautics, air traffic control module, and a modular training program. The programs provide compliance and are harmonized with the requirements of EUROCONTROL's Specifications on the ATCO Common Core Content Initial Training for the basic part of training.

Organizational structure of HUSK is shown at the Figure 1. Minimum entry requirements to enroll undergraduate study of aeronautics are: passed the entrance exam by the state graduation, valid medical certificate for ATCOs – ICAO category III and passed oral test of English.

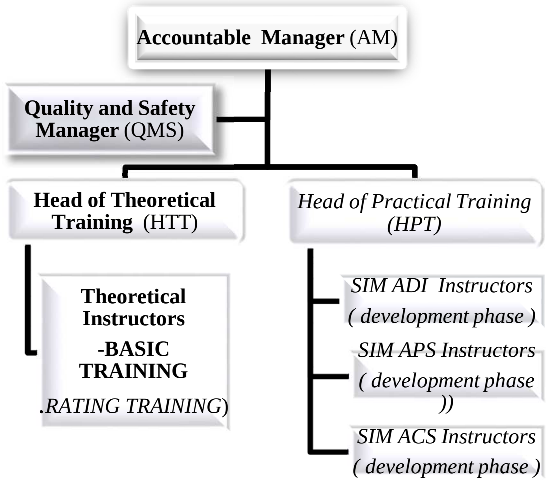

Figure 1 Organizational structure at HUSK

As presented in Figure 1, HUSK has appointed only three responsible persons: Accountable Manager, Quality and Safety Manager and Head of the Theoretical Training. Since HUSK is only certified for provision of Basic Training, there isn't a need to appoint Head of Practical Training yet. If HUSK would be a Rating Training provider then Head of practical training had to be appointed and approved by competent authority first. Responsibilities of the Accountable Manager are: to financially ensure that training process will be conducted and finished in the proper manner. Quality and safety manager has to monitor and control the process f training and actions provided by Accountable Manager and Head of Theoretical Training. He/she supervises the implementation of ATCO training standards in HUSK and compliance with the prescribed requirements. Head of the Theoretical Training is responsible for planning, organization and provision of training. In coordination with theoretical instructors prepare curriculum of training. He/she is responsible for revisions of Operations Manual in accordance with prescribed requirements.

The theoretical part of the training is carried out by professors and teachers who are full time employees of the Department of Aeronautics at the Faculty of Transport Sciences and part-time associates from the industry. All these persons must be certified by HUSK as Theoretical Instructors and approved by competent authority.

Courses and learning objectives that are required to pass according to the Specification are divided into different subjects of undergraduate study which is defined and explained in HUSK Operations Manual.

The benefits of this curriculum are that students acquire diploma of bachelor degree in aeronautics and certificate of successfully completed Basic ATCO Training. This process of training is supervised by CCAA . Students are required to take nine subjects before involving in practical part of training: introduction, aviation law, air traffic management, meteorology, navigation, aircraft, human factors, equipment and systems and professional environment when attending modular program. Nevertheless, when attending undergraduate program students take many more subject and they get outside the box picture. The practical part of the basic training is performed on the Micro Nav Ltd. BEST Radar ATC Simulator operated by the Faculty of Transport and Traffic Sciences. Instructors who train and lead students through practical training during practical simulator training are licensed, air traffic controllers and ATC OJT (on-the-job) instructors, part-time associates of the Faculty of Transport and Traffic Sciences. Using ATC simulator students should develop skills in accordance with the ATC operational procedures and perform several skills at the same time as required in a simple air traffic control exercise. Also, student-controllers should execute operational tasks at the workload, defined in terms of complexity, density and quantity in a basic simulator exercise, demonstrate performance within the designated area of responsibility on the simulator and apply the operational procedures in a consistent and reliable manner. Due to the nature of basic training, in particular to the organization of the work position with a single person, the workload should enable the student to perform the listed tasks without being affected by inappropriate overload. The number of aircraft in the simulator exercise will allow students to demonstrate basic ATC skills and to solve a maximum number of three separation problems, but only one problem at a time. The complexity of the simulation run requires several duties to be performed simultaneously. After successful passing of basic training, student-controllers are being sent to the other air traffic control training organizations in Europe to get all prerequisites for student ATCO license to allow start of Unit training in Croatian Air navigation service provider.

NEW MODEL OF ATCO TRAINING IN CROATIA

Department of Aeronautics at the Faculty of Traffic and Transport Sciences (FPZ), University of Zagreb and Croatia Control Ltd. (CROCONTROL) started collaboration on a research study in order to define the training model for air traffic controllers in Croatia. The research study shall describe all the competencies required for the controller's job and clearly define learning outcomes in accordance with the European Qualifications Framework. In addition, the following elements shall be defined and clearly explained in the study:

- Detection of trends and provision of overview of the existing modelof the air traffic controllers training
- investigation and comparison of training models according to the valid national and European regulations for the air traffic controllers training,
- proposal of detailed elaboration model of education that combines the needs of CROCONTROL and possibilities of the FPZ level of Initial Training (Basic + Rating) based on the previous analysis
- definition of the competencies of graduate students according to the needs of CROCONTROL and job standards
- definition of time limits for certain levels of training
- conduction of a simulation study of the proposed model
- conduction of cost-benefit analysis of the proposed training model

In the context of current European regulations, Department of Aeronautics gained experience by successfully providing education for civil and military pilots for more than 20 years back. That experience has been applied for the air traffic controllers training model.

The proposed model is shown in the Figure 2:

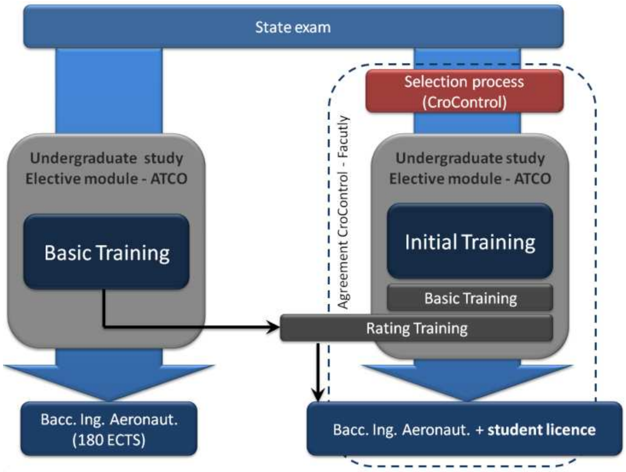

Figure 2 Proposed model

The model includes two modes of study at the undergraduate program at the Department of Aeronautics, air traffic control course. The first model has been applied since 2009 at the Faculty. This university study program has been certified by the Croatian Civil Aviation Authority in accordance with legislative requirements specified (see in II. Regulation on ATCO Training). Completing the program, students acquire the bachelor degree title (bacc.ing.aeronaut.) and a certificate of the completion of the Air Traffic Control Basic Training. This mode of study is not directly related to the CROCONTROL and graduating students at the announcement for the position for air traffic control apply individually. After the job tender and selection of candidates by the CROCONTROL, students who have completed the specified module at the Faculty, do not have to go through that part of education again, as opposed to other candidates.

The second model is outside the university study program of Aeronautics, air traffic control course. Basic Training can be carried out through a public tender announced by the CROCONTROL, but it is still organized at the Faculty through the modular training. In the past four occasions Basic training was conducted in the way of second model.

The new model of air traffic control education is proposed according to mutual interests to rationalize resources invested in the education of students. After the state exam, candidates for the admission to the university study program at the Faculty, air traffic control course, have to pass an additional test of English proficiency, as well the selection process in the responsibility of the CROCONTROL. The selection process is constituent part of the criteria for the students' admission which is regulated by the Croatian Agency for Higher Education and is officially announced as one of the additional conditions.

After the selection, candidates who have met the criteria are register in the Information System of Higher Education Institutions (ISVU) and enrolled in the first year of study. It is important to mention that the aeronautics module of the university program course is selected upon enrolment, while the other study programs courses are chosen by entering the third year of study. This means that the air traffic control students immediately begin attending professional courses which are also defined by the CCAA. In addition, because of the character of university study, students attend other general courses (mathematics, physics, electrical engineering, etc.). This subject are not related to the CCAA, as well as the traffic and transport technology subjects, such as traffic and transport geography, traffic, traffic engineering, transport technology, logistics, etc. This makes the extra value of the university study program because students provide a useful baseline for understanding the transport processes and technology. So, in addition to general and specialized courses, all professional courses that make Basic Training are integrated in the university study program in significantly increased hourly rate than those defined by regulation.

Part of Rating Training, which makes the extension of Basic Training, is also integrated into the program of study through practicum (aerodrome, approach and area control simulator). Practicum is conducted on the BEST Radar ATC Simulator owned by the FPZ and is located in the Laboratory for Control of Air Navigation and HUSK. Attending the practicum, as well as all other courses students acquire certain ECTS credits or necessary conditions for the recognition of courses taken. Attending specialized courses within the program is defined by the regulation and for a passing grade student shall meet 75% correct answers. Also written exams make documentation for a certain level of training, which is defined by the HUSK Operational Manual and accepted by the CCAA. After such university study program for three academic years, students complete their studies with the title of bacc.ing.aeronaut. and student license. With the title and the license they are ready for on-the-job training (OJT) in the CROCONTROL.

Other students who have not passed or access the selection process, but meet the conditions for admission to the air traffic control program according to the number of open positions attend regular study. That study program is integrated into the Basic Training program. Towards these students CROCONTROL has no contractual or other obligations and they cannot guarantee employment in the field. Each of these students has the possibility to have basic training, through practicum and to choose Rating Training, but such training is regulated by the special agreement. Regardless, each of the successful graduates achieved 180 credits and a minimum of Basic Training. The advantage of this model of education is the great flexibility that is provided to students during study, and clearly defined competences that are proven by the certificate of completion of the Basic Training or the appropriate student license.

Interested ANSP has the option of selecting the candidates according to their own criteria and needs, and their continuous monitoring during the study and training. In addition, there is possibility of additionally scholarships for students who have demonstrated excellent results, but who are studying at air traffic control beyond the contract with Croatia Control. However, the most important element of the proposed model is a timeline of 36 months in which students acquire academic education at bachelor's level and training for a student license (initial training). This timeline guarantee the systematic adoption and logical upgrade of general and specialist knowledge, competence and skill development needed for the manifestation of air traffic control operations.

Proposed model optimally meets the needs of the ANSP's who want to ensure development orientation and achieve future competitiveness as they work closely with the academic community. So in that way the new research, methods and technologies are directly implement to (all or some) sectors, which are of the interest for the development of the ANSP's. Furthermore, systematic air traffic control studies over the proposed model provides a Highly educated staff consists of qualified individuals for the position of the air traffic controller - individuals who can in the future easily and simply adopt new technology and upcoming challenges of the Single European Sky, and will be adaptable to changes in the best possible.

Conclusion

In air traffic management system, ATCO education and training are critical for provision of safe, orderly and expeditious air traffic. A novel model of air traffic control education is proposed in order to rationalize resources invested in the education of students. This model is focused on higher education and optimally meets the needs of the ANSP's. It also ensures development orientation and achieves future competitiveness as they work closely with the academic community.

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LONG TERM AIRPORT PLANNING ISSUES

Prof. Antonín Kazda
Air Transport Department, University of Žilina, Slovakia
kazda@fpedas.uniza.sk

Dr. Ján Pitor
Air Transport Department, University of Žilina, Slovakia
jan.pitor@fpedas.uniza.sk

Dr. Milan Stacho
Department of Quantitative Methods and Economic Informatics, University of Žilina, Slovakia
milan.stacho@fpedas.uniza.sk

Abstract *–The paper focuses on problems and conflicts during the development of airports. Former practice however, still used in many states, to plan an airport system expansion in 20-30-year horizons – so called 'long term' plans – is confronted with the experience from the Slovak Republic of airport planning for very distant or 'unlimited future'. The principles of land expropriation in public interest, definition of public interest and the socio-political factors influencing the 'ideal' planning period are discussed. Planning for 'unlimited future' could be practical in countries with high Human Development Index, high Democracy Index, high ranking in Worldwide Governance Indicators and in high population density regions. Research results are presented.*

Key words – 'long term' plans, expropriation, public interest,

Motto: *Historical examples provide the best kind of proof in the empirical science. This is particularly true of the art of war.*

Ries, A. Trout, J.: Marketing Warfare, , McGraw-Hill, Inc.; ISBN 0-07-052730-X; 1986

BACGROUND

Development of transport infrastructure after wars and conflicts always required radical decisions and prompt planning which were, in those circumstances, appropriate. In those circumstances the improvements of road, rail and airport infrastructure were highly welcomed by public. However, throughout decades opinions and attitudes of public gradually changed and negative image of expanding infrastructures on the communities shifted to the forefront. Air transport and airports became an easy target of neighbouring communities and pressure groups.

This leads to a question whether practices of land use and planning of transport infrastructures and airports in particular changed in the Europe to reflect the increasing participation of civil society in the public domain. Are current practices different from those of post World War II or those from the 1960-ties?

LAND USE AND COMPATIBILITY PLANNING

The most important tool for mitigation of environmental problems caused by airport expansion has always been land use and compatibility planning.

The basic documents for long term planning of any large-scale projects were (depending on different state practices) the 'Large Areas Development Plans' prepared on a 'regional' level. The principal features of airport Master Plans had to be incorporated into the Large Areas Development Plans. However, the practice to plan airport system about 20 - 30 years ahead resulted in a gradual airport growth and 'rapprochement' of airports and neighbouring communities. This was (and still is) a permanent source of conflicts.

Different practice was adopted in 1992 in the Slovak republic. Slovakia approved the ECAC Strategy for the 1990s - Relieving Congestion In & Around Airports adopted by the ECAC Transport Ministers in 1992. The overall objective of this strategy was to improve the potential throughput of the European airports and their surrounding airspace while maintaining safety and respecting the environment. With regard to the airport infrastructure, Slovakia aimed at the following, sometimes neglected, objectives:

- To define **the ultimate limits** (in a very distant future) for expansion of every **public airport** respecting the future 'environmental capacity'
- To define the **bottlenecks** which can limit the airport system capacity in the future.

The created legal frame allowed long term airport planning for so called 'unlimited future'. Subsequently long term land use plans and Master Plans were prepared for three Slovak principal airports – Bratislava, Košice and Poprad – Tatry.

EXPROPRIATION AND AIRPORT DEVELOPMENT

Development of each state brings contradictions between public and private interests [22]. The biggest problems are usually connected with building line infrastructures, which are generally defined as motorways, railways and airports, as for these constructions it is necessary to acquire large pieces of land. The process of land acquiring should be quick and effective. The interests of the state are to minimise costs, time and also to eliminate 'political losses'. The interests of the private owner are to minimise troubles with state and possibly to sell property but at a fair price.

Expropriation refers to confiscation of private property. Depending on the regime it can be politically motivated, it can result in forceful redistribution of private property and many times it can be characterized by confiscation of the foreign asset, for a pittance payment [17].

Also the Constitution of the Slovak Republic [22], the present Civil Aviation Law [23], and the Building Act [20] include provisions on expropriation[40] of land in public interest and an Article on the 'limitation of the proprietor's rights'. According to this Article the rights of the proprietor could be limited:

- in inevitable extent
- in the public interest
- in line with a law
- for appropriate compensation
- and all conditions must be fulfilled simultaneously.

Unfortunately, unlike other types of infrastructure, a runway or an airport are not directly defined as a public interest infrastructure in the Slovak legislation. To use the land expropriation in case of airport development it is necessary to prove public interest. This could be supported by an approved Airport Master Plan or Airport Land Use Study during a public hearing process as a part of a General City Plan, incorporated in the Concept of a General Plan of Slovakia or General Regional Plan where airport development has a 'public interest building activity' status. Expropriation can take place only when an agreement with the proprietor could not be reached by negotiation. Additionally, there is still the problem of defining the 'right price', which should be a market price of the property determined by an authorized expert. The whole process is usually very lengthy, as expropriation can take place only after agreement between the state and the proprietor was not reached. The proprietor can also use all legal tools to protect his rights which, going through all levels of courts, could take years. In one case in the Czech Republic, which has in practice the same legislation frame on expropriation as Slovakia, the agreement between the state and a farmer who refused to sell her land for a motorway construction was reached after 17 years [13]. Usually, right-wing governments are reluctant to use expropriation tool in these cases.

Provisions on land expropriation could be found in the legal systems of most states. In the ***Ireland*** it could be applied for a so-called key infrastructure, which comprises also airport infrastructure. There is a special system in the Republic of Ireland where it is not necessary to go through a public consultation, but the decision passes through an independent body (called 'An Bord Planeala') which rules on its acceptance. This body measures the need, the public upheaval involved and the economics of the proposed work, and rules on it. If it rules positively, the only way to appeal against the decision is through the 'High' Court. This speeds up whole process considerably. All other planning goes through the County or City Councils where a planner will decide on its acceptance based on the county / city plan. This plan is drawn up by the County Manager acting with planning specialists, architects, civil engineers etc. [18], [11].

Public Utility and land expropriation are defined by the basic principles in ***France***. Public interest is defined by a declaration from the ministry or prefect level in the form of a decree. The declaration must precisely define date by which the expropriation must be accomplished.

The proprietors can appeal against the administration up to two months after the decree was published to object against:

- the excess of the force of law
- in front of the state council in case the proprietor objects against the public contribution of the project or the procedure was not regular [12].

For projects after the 2-nd March 2002 the expropriation becomes effective one year the latest after preliminary enquiry was closed. A year after the declaration of public interest was announced the proprietor can ask the expropriator by a formal notice to purchase his/her property.

The best known case of forceful expropriation is the ***Narita Airport*** development. In July 1966 the Japanese government officially designated the Sanrizuka - Narita region of Chiba prefecture as an official site for new Tokyo International Airport. The rapid postwar development of Tokyo caused a shortage of available flat land in the Kantō region, so the only feasible location for the airport was in rural Chiba prefecture. Eminent domain power had rarely been used in Japan up to that point. Traditionally, the Japanese government would offer to relocate homeowners in regions suggested for expropriation, rather than condemn their property and pay compensation as provided by law. In the case of Narita Airport this type of cooperative expropriation did not occur: some residents went as far as using terror by threatening to burn down new homes of anyone who would voluntarily move out [4]. On September 16, 1971 during final government drive to expropriate the land from its recalcitrant owners, three policemen were murdered and a many were injured in riot rides supported by left wing student groups [2]. While primarily revolving around the issue of the right of the government to expropriate private property, the Narita case was much more complex, many-sided event that for a variety of reasons may be considered historically important. During the 'phase one' of the conflict between February 22 and March 25, 1971 fought against each other 25 000 police corps and over 20 000 Narita farmers and their allies from student activists and left-wing political parties which formed a popular resistance group known as the Sanrizuka-Shibayama Union to Oppose the Airport.

[40] In some states called Eminent Domain or Compulsory Purchase

Although the airport did open, it opened under a level of security unprecedented in Japan. The airfield was surrounded by metal fencing and controlled by guard towers staffed with riot police. Passengers arriving at the airport were (and still are) subject to baggage and travel document searches before even entering the terminal, in an attempt to keep anti-airport activists and terrorists out of the facility. The last anti-airport riot, orchestrated by left wing militants known as Chukaku-ha, took place in 1985 [8].

IDEAL PLANNING HORIZON?

Left wing governments might be more willing to use different forms of eminent domain to enforce projects under public interests. However, a necessary balance must be found between the pace of infrastructure projects construction, expropriation of private property, ‘fair price’ compensations and political loses. The process of airport privatisation also raises the question if private airport development, in particular terminal areas and airport ground access [21], could be defined as a project in public interest. Private property confiscation gives a strong signal to foreign investors who may give priority to a different country with a more predictable regime which respects more private property. The lawsuits related to private property expropriations are long lasting and often stretch over a number of generations. With this perspective land expropriation in democratic states is used as an extreme and the last option, more likely as a ‘threat’ to those who were reluctant to sell their property than as a real tool.

Long-established practice of airport planning with Master Plans defining airport expansion in 20-30 years time horizons, or so-called ‘long term’ development, might be appropriate in some states but could be a serious hurdle to airport expansion in countries where the planning process is ‘complicated’ by public hearing with active neighbouring communities and action groups involved. For example, it took 23 years to get the final building permission for Munich Airport, while just 7 years were needed for airport construction and commencement of operations. Some airport administrations with visionary architects secured the future airport expansion by purchase of large areas in period when it was possible, e.g. Paris-Charles de Gaulle Airport[41]. In other states further airport growth can be blocked even by the government. Planning for very long period ahead should be practical in Britain. The London Mayor´s Thames Estuary Steering Group, which is chaired by Sir David King and includes two members of parliament, said in a recent report: ‘It is necessary to create a vision and a framework which will inform planning policy and decisions over next 30 years’ [4]. But, we are afraid, the 30 years time horizon is insufficient in UK conditions. A new report published by the UK Government Department for Transport expects to delay building any new runways until beyond 2050 [16]. On the other hand, it would be useless to plan an airport development for 30 years or more in unstable states or regions where fundamental changes in situation, regime or policy may occur within a course of months.

Planning for very distant future is still not a norm and it is not yet recommended in any of airport planning manuals. However, would it be possible to propose an optimum planning horizon for an airport? Engineers would love to have a formula in the Airport Planning Manual defining optimum planning period with unambiguously determined parameters something like:

$$Y_I = A_{PAX} \, . \, GDP \, ...x.y$$

Where:

Y_I is ideal planning period (years)

A_{PAX} is maximum airport throughput in millions of PAX.

Unfortunately, nothing like that is possible and ‘the ideal planning period’ doesn´t exists. It depends on number of variables which are unique for each state and scope of their leverage can vary considerably.

The resistance again airport development will be typically higher in states with higher standard of living where residents usually value the quality of their lives and object airport expansion with environmental problems, pollution and generated traffic. On the other hand, investors may claim economic benefits for the municipality and residents may benefit from improved air transport connections and new jobs creation.

To specify airport optimum planning period number of indicators could be used. One of the best could be ***Human Development Index (HDI)***, an international measure of development. HDI is linked with GDP per capita and it combines measures of life expectancy, education, and a decent standard of living, in an attempt to quantify the options available to individuals within a given society [25].

The HDI is used by the United Nations Development Programme in their Human Development Report [7]. However, the HDI does not include ecological aspects and is focusing exclusively on national performance ranking. Nevertheless, future constraints on the airport operation and development could also have an environmental basis [24].

The level of human development is often, though not always, related to the level of democracy, which can be measured, for example, by the ***Democracy Index (DI)*** [5]. However, it is important to remember that a high HDI rank not always corresponds with a high DI rank: in some countries a high degree of economic and human development is accompanied by an authoritarian regime (Saudi Arabia), while on the other hand democratic principles are respected in some poor countries (India). DI is based on 60 indicators grouped in five different categories: electoral process and pluralism, civil liberties, functioning of government, political participation and political culture.

Nevertheless, successful airport development depends on many other criteria like ***political stability, voice and accountability, government effectiveness, regulatory quality, rule of law and control of corruption.*** Those all are specified by ***Worldwide Governance Indicators (WGI)*** [10] and it is possible to weigh them in any particular country or region.

[41] Charles de Gaulle Airport extends over 32.38 km^2 of land. This vast area was acquired by limited number of potential relocations and expropriations and the possibility to further expand the airport in the future [9]. The planning of CDG and its construction began in 1966.

The last but not the least important factor is country stability, which is usually influenced by internal factors like levels of violence and crime within the country, and factors in a country's external relations, such as military expenditure and wars [6]. This could be measured by the ***Global Peace Index (GPI).***

In general in countries with very high HDI (over 0.889) and high DI (full democracies 8 to 10) it will be an advantage to plan airport development to its final limits (unlimited future) defined by the 'interest area' environmental limitations. Similarly, the length of planning period should be dependent on the other two above mentioned factors: WGI and GPI. A higher ranking in those indices – reflecting better governance and an internal and external stability/peacefulness – should be reflected in an extension of the planning period. Another significant parameter is the population density in the region, which is, however, strongly linked not only with all the above factors, but also with country cultural differences.

RESEARCH

To test the hypothesis of long term airport planning necessity it was decided to conduct research aimed at the widest possible range of respondents. The online research included a single question (in addition to respondent's identification parameters - sex, age, nationality and the highest education):

Imagine that you are attending the presentation ***of an*** airport development plan in a locality near the place where you live. What would be the time horizon for the beginning of the project for which you would think***:*** '***That's so*** far ahead that I do not mind ***what is being proposed'***

Respondents had options to select one of three answers:

A/ Tick ***number of years between 5 and 200+***
B/ Tick answer ***'I would always be against projects like that'***
C/ Tick answer ***'I don't know'***

RESULTS

We received almost one thousand responses to the questioner. After data cleaning it was possible to process 952 questioners from 52 countries. No respondent has selected options B or C. We tried to find any data dependences i.e. between the time horizon and sex/ age/ nationality and education but there are none. For example there were no significant differences between answers of respondents from the old and the new EU member states.

The most important dependence can therefore be regarded the percentage of respondents opting for a certain time horizon (see Figure 1). The most respondents opted for the 'traditional' time horizons from 10 to 30 years (with average 25.43 years). This may tempt us to conclude that the current planning horizon, 30 years for airports, is correct.

However, what is surprising is relatively high number of responses with long time horizons i.e. 80 years and more that go beyond the average life expectancy. Total number of these responses 6.62 % is meaningful and could not be neglected. It could be assumed that these respondents would object airport development planned during their life. Because of their high education (more than 55 % of respondents have bachelor or master degree) they would be able to form, express and defend their opinion and thus hinder airport development plans. This problem, in fact, are now facing most European airports.

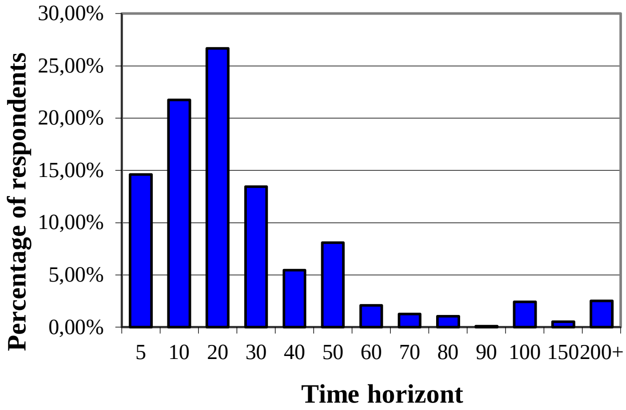

Figure 1 – Percentage of respondents in particular time horizons

CONCLUSION

In countries with high levels of democracy it is practically impossible to use eminent domain for airport development projects, as the process would be very lengthy with uncertain results. The experience of the Slovak Republic to plan an airport development by defining ***the ultimate limits*** (in a very distant future) of airport expansion and respecting the future 'environmental capacity' is positive and we were able to guarantee space for most of our airports expansion. Our airport planners were usually confronted with a tough opposition at the beginning, but proposals were gradually accepted by public and included in long term regional urban development plans. It would not be possible to accomplish the same results by planning of airport expansion step by step in 'long term' stages.

On the contrary, there are states where long term planning would be 'unproductive', and some where it is even possible to build an airport without building permission.

Although the long-term airport planning could ease future development problems it can not affect current operational restrictions at big airports resulting mainly from insufficient runway capacity. Airports, which have failed to develop adequate land reserve in the past have limited opportunities for growth nowadays and if so at substantial financial and 'political' costs.

Hence an 'ideal' planning period doesn't exist and must be assessed on a case by case basis using different tools and indicators, sometimes with getting uncertain results. As Albert Einstein said, 'not everything that can be counted counts, and not everything that counts can be counted'.

In our future work we would like to continue our research focusing on developing states (with not full democracies) which were in our research inadequately represented.

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MODERN RESEARCH AND DEVELOPMENT IN AIR TRANSPORT

Activities of the MAD Group

Ing. Jakub Kraus
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
kraus@fd.cvut.cz

Ing. Tomáš Duša
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
t.dusa@sh.cvut.cz

Ing. Vladimír Plos
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
plosvlad@fd.cvut.cz

Ing. Peter Vittek
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
vittek@fd.cvut.cz

Abstract – *This article introduces some contemporary research activities in the area of air transport performed by a MAD Group team at a Department of Air Transport, CTU in Prague. Main domains such as Aviation Safety, Aviation Security, CNS/ATM and GNSS are considered here. All four domains create a synergic whole with a main goal to improve air transport, especially in the area of General Aviation.*

Research in the GNSS domain is oriented towards implementation of the GNSS approach procedures using EGNOS and future Galileo signal, especially in applications with highest added-value i.e. airports without extensive navaid equipments. New operation procedures require better ATS services in order to maintain equal or better safety level. Better ATS could be achieved either by implementing new CNS systems or new operation procedures. Research of the new CNS systems is performed within the CNS/ATM domain. Safety domain examines new procedures by safety analysis and implementing new performance indicators into safety assessment process. Last but not least security aspects of the GNSS signal has to be taken into consideration. This is absolutely necessary when GNSS signal is being used as a primary navigation means. Research activities eliminating impact of jamming and spoofing are performed within the security domain.

Key words – GNSS, CNS/ATM, safety, security, MAD Group

I. INTRODUCTION

MAD Group is an official name of a team of several postgraduate students formed under the Department of air transport at Faculty of Transportation Sciences of the Czech Technical University in Prague. The main common goal of the group is cooperative research, knowledge sharing and publication in various academic journals. The group is focused on four independent domains within aviation – GNSS, Safety, Security and CNS, however its work is integrated by a common topic - the safety. The group has a wide knowledge of aviation safety topics, keeping its research aligned with actual trends in the world, to stay on with a very precipitously evolving subject as aviation safety undeniably is. The group cooperates with Czech NAA, trying to adapt modern safety challenges into national environment.

Importantly, none of the investigated areas can exist by itself - all complement each other. Their relationship is depicted on Figure 1.

$$\frac{\left[\underline{GNSS}\ \text{as enabling technology} \rightarrow \underline{CNS/ATM}\right]\underline{Safety}}{\underline{Security}}$$

Figure 1 *– Four parts of aviation to enable air transport*

GNSS is enabling technology for CNS/ATM systems. This relationship (presented by the arrow in the figure) must ensure an adequate level of safety. Finaly, every part has to be treated in terms of security.

II. GNSS

The current requirement for the implementation of satellite navigation is publishing GNSS approach to now non-instrument aerodromes. GNSS in this case acts as a starting point and therefore enables the introduction of instrument approach at small aerodromes. This possible growth of General Aviation must be approached comprehensively from ideas to change legislation and approach implementation.

In this process, there are several obstacles to overcome. Among the major changes is the necessity for the presence of the ATC service at IFR airports. In the Czech Republic this issue is resolved by certified AFIS since mid-2013. Another change, which must be done, is permit IFR flights in uncontrolled airspace and to ensure their safety. For the implementation of IFR approach to VFR aerodrome is also needed to establish cooperation between the aerodrome, supervising authority and approved body for the design of approach procedures. In the situation that some changes in legislation and regulations will be needed, they must be consulted with the competent governmental body. But, the most important is to find a subject that will have expert knowledge of the issue and make, negotiate and process every change needed. In fact there is a need of facilitator, while state authorities are overloaded with work, and therefore cannot guarantee rapid progress in the issue.

Two solutions

For the implementation of the IFR approach it is always possible to choose from several options. Since the current airspace around VFR aerodromes, labelled as ATZ, is small (radius 3 NM, height 4000 ft AMSL), it is necessary to define a new airspace. This can be either using class F or the use of Nordic design with Traffic Information Zone (TIZ). Using one or other solution depends on the agreement of stakeholders, but it is necessary to process safety study for both of them.

Even when choosing the type of approach there is several options of RNP APCH minima (LNAV, LNAV / VNAV, LPV minima), while the better approach system is implemented, the greater demands on aircraft avionics are placed. By default, in the design of GNSS approach is proposed more than one type of minima, making it possible to fly with a different avionics. Selecting only LPV minima, which ensure the greatest accuracy through the use of EGNOS, may be a good argument for reducing the requirements for ground infrastructure, primarily lighting systems.

It is therefore appropriate for each aerodrome, where it is intended to introduce GNSS approach, to create safety study that will include a complete overview of the risks and determine whether the risks are low enough as required by legislation.

III. CNS/ATM

For small aerodrome is also necessary to solve the question of their capacity. At present time it is almost certain that the airspace around small aerodromes will still be uncontrolled in the future. But this includes the possibility that the airspace around aerodromes will get increasingly overcrowded by planes and AFIS Officer (AFISO) will not be able to provide accurate information about the surrounding traffic. The answer to this challenge is two areas of CNS / ATM research that we deal with; the automatic control of the maximum number of aircraft in a defined area around the aerodrome and providing surveillance information for AFISO.

Management of Maximum Number of Aircraft

The basic idea of managing the maximum number of aircraft in a given airspace is very primitive, and this procedure is carried out continuously in controlled airspace. However, if we consider uncontrolled airspace, the situation changes. In uncontrolled airspace has pilot full responsibility for the aircraft, also for maintaining separation and preventing incidents. Management of this airspace therefore faces the obstacle, to incorporate a clause into the legislation that in uncontrolled airspace can exists a system that can give commands and pilots must obey.

A model situation may look like this: In the vicinity of the aerodrome is twenty aircraft and AFISO starts to have significant problems with their management. Another two aircraft approaches the ATZ with the intention of landing. When reporting to them AFISO could say that ATZ is full and ask them to hold for five minutes, but the pilots do not have to respect, therefore the number of aircraft is increased, AFISO can no longer provide complete information about the surrounding traffic and the risk of accidents increases into intolerable extent.

Given this model situation, it is clear that the possibility of capacity management is a good safety measure, but when output should be passed by AFISO to pilots, the time period required for this broadcast occupies some transmission time. For this reason and defined position of AFISO in legislation it is necessary that this system of controlling the maximum number of aircraft must work automatically. The basic model is shown in Figure 3, where the input is the number of known aircraft (reported by the radio, seen on the "radar") and output prohibiting flights into ATZ, noise in this model is the number of unidentified aircraft.

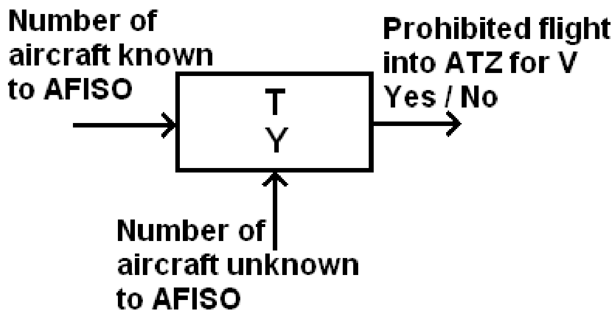

Figure 3 – *Basic model*

Surveillance Information for AFISO

With the continuous increase of AFIS responsibility, thanks to allowing IFR operations, there is an effort to compensate this theoretical decline in safety with new technologies. The best solution is the introduction of surveillance information for AFIS Officer, which adds him an accurate overview of the situation in the vicinity of the airport, and therefore AFISO could contribute to solving unsafe situations with very precise information.

We identify multilateration in combination with ADS-B based on "low-cost" ADS-B receivers as a good solution for this system. The basis is deployment of several receivers in the vicinity of the airport, synchronizing their time and subsequent evaluation of aircraft positions.

Similarly as controlling the maximum number of aircraft, the surveillance information is currently also dependent on aircraft equipment with ADS-B/Mode S transponder and will therefore be continuously improved with the equipping of more aircraft.

IV. SMS

The current situation in aviation safety calls for necessity of Safety management System implementation to all airlines, maintenance organisations and other aviation companies. This fact is supported by releasing of new Annex 19, which will be directly related to SMS and summarizes the requests on the company's functionality of SMS.

The principle of effective functionality of the safety management system lies in the so-called closed-loop safety processes, which is in fact ongoing hazard identification, risk assessment, implementation mitigation measures and subsequent control of the effectiveness of these measures. This whole process is constantly repeated. The implementation of safety indicators greatly helps to control the effectiveness of SMS. Within our research activities we are inspired by other sectors, which are referred to as high-risk sectors. As an example, chemical, or nuclear power plants. In these sectors the development of safety indicators is running since the eighties.

Safety indicators allow us to evaluate and compare the level of safety achieved by individual organizations thanks to the unified methodology. Indicators should be selected systematically in relation to the area for which they are introduced. In some types of aviation organizations is easy to establish a system of reactive indicators thanks to already established system of safety incidents monitoring. This system exists for several years in various forms. Annex 13 defines the conditions for the investigation of air accidents. The first form is therefore information on accidents and incidents. Other forms are relating to the assessment of safety events by organizations themselves. In the case that the organization evaluate the safety impacts of the critical steps of the operational processes, we move to so-called leading indicators. The organization focuses on the initialization of situations which, under certain circumstances, may lead to an incident or accident. The system of safety indicators already provide warnings when the number of safety events increases, what could act as trigger for a chain of events leading up to the creation of an incident or accident. By monitoring of critical processes and noting anomalies in them it is possible to evaluate these processes and to adopt such remedial measures to prevent the establishment of the operational deviations when the procedures commonly performed by employees differ from those for which were designed.

Finally, the third form of safety indicators are early warning indicators. According to the concept of "flexible" organization they are based on the monitoring of the eight contributory factors of successful crisis solution.

Usage of safety indicators in practice

Based on the improving of safety indicator values, whether reactive or leading, we cannot say that the organization becomes safer. Rather, we can say that it should be prepared for the situations leading to the accident: company can recognize under what circumstances (bad weather, time press, the absence of the instructor) and which processes (solo flights pupils with low seeding) are more susceptible to accidents and incidents and is able to respond appropriately to them (flight delay, widespread land preparation).

Equally, important consequence of the introduction of safety systems in general, and thus indicators, is the increased communication flow on the subject of safety and a feeling among employers that safety issues are present in the organization and they need to be taken into account. An important role in this aspect plays a supervisory authority which gives out a clear position that safety is reflected in the whole sector, and especially then serve as a motivating factor for organizations inoperative on their own initiative to improvement (organizations with a low level of safety culture).

Evaluation of indicators is based on the comparison between projected results against reality. Conclusion of safety monitoring could be even the failure to achieve these results. This could serve as a feedback for the safety manager and company management. For the management this feedback can mean a lack of coverage of risk issues and the need for additional investment. Experienced safety manager should find simple, smart and inexpensive solutions of safety problems. Simple for not being overcame intentionally by employers due to excessive delay from the primary activity or misunderstanding. Smartness is necessary for the best way to be more efficient and to affect several aspects of safety at the same time. And finally cheap means that resources dedicated to safety was adequate, but do not jeopardize the functioning of the organization economically.

Current Activities of The laboratory of aviation safety on the field of safety indicators

There are requirements for safety performance across the three main groups of indicators for European air navigation service providers. The first is EoSM (Effectiveness of Safety Management), which is used to evaluate the effectiveness of implementation of processes and tools of SMS. Another indicator is the RAT (Risk Analysis Tool). Monitoring of this indicator will give an overview of the use of risk analysis for individual safety events. The result should be a motivation for the introduction of risk assessment and analysis to a wider range of events. The third is the Just Culture indicator that assesses the level of safety culture of an open hearing in investigation of safety incidents and the use of voluntary reporting. A recent trend in the theory of safety (bearer of the ICAO and EUROCONTROL) is to try to eliminate the attribution of guilt and penalties in order to obtain a complete list of errors that could led to a safety incident.

A working group was established to solve all issues relating to safety indicators and the first phase of the research - information gathering and analysis of the current state-of-the-art has been completed. Thanks to this know-how, we have successfully started to cooperate with the Ministry of Transport already, the Civil Aviation Authority and Air Navigation Services of the Czech Republic.

Based on theoretical knowledge about safety indicators in nuclear power plants and chemical plants our project team has presented pilot project for study the safety indicators in air transport at Vaclav Havel Airport Prague (LKPR). After subsequent examination of the provided materials and data of experience, we are working already on the concept of the use of safety indicators to determine the safety performance of the original structure of the data collection. For the year 2014 an analysis of safety event database data structure and its optimization for easier evaluation of safety indicators is planned. Result of the optimization should be also enhancing the resolution level of safety indicators and thus find more detailed context of risk realization.

Creating safety indicators for general aviation is very problematic due to lack of safety data. The project team therefore primarily focused on establishing mechanisms for their collection. The primary source is the number of accidents and incidents. Other sources such as mandatory and voluntary reporting systems are connected with the necessity of improving the safety culture, which is achievable only in case of effective SMS functionality, implementation of mandatory safety targets and compliance with accepted principles of safety policy. SMS for this part of aviation cannot be too robust from a process point of view, structure of collected data and their evaluation must be simple and indicators should have enough information value. In the case of the high cost and complexity of maintaining of this system, therefore we focus on the creation of sufficiently sensitive and variable implementation plan.

The existence of a safety campaign "Přemýšlej doletíš!" meant for a Czech general aviation great service not only in terms of accident prevention. This activity creates a respected source of information and a tool for introducing advanced safety indicators that allow evaluating the resistance of general aviation organizations to realize safety risks.

V. Security

The ACARE Research Agenda identifies challenges and goals for aviation security based on three pillars: airport-, airborne- and ATM security. Activities of our security research are in line with ACARE Program. The program explains the need of abandonment of the classical (aircraft cantered) aviation security concept towards the new holistic understanding.

With respect to the GNSS, nowadays the attackers is not worth attacking GNSS signal, because it is not the only means of navigation for aircraft guidance and it is possible to use other navigation aids when GNSS signal is disturbed. On the other hand, attackers are looking at such assets that are perceived to be less protected or more vulnerable. This may be the case of the GNSS if security issues are underestimated.

Within this activity the MAD Group tries to set up new operational and technical procedures for eliminating security issues of GNSS safety critical applications. Most of the actual research in Europe has similar point of view. To prevent problems caused by signal interference, they propose to use filters, electromagnetic screens, encryption or increase robustness. Deviating from this, MAD Group’s research is oriented to using data fusion tools (DF). The primary objective is to confirm or disprove a hypothesis that data fusion tool could be used to enhance security issues of GNSS safety critical applications, e.g. 4D navigation based on GNSS signal, especially during final approach.

We believe that collecting large amount of data and information, which may go beyond current perceptions of GNSS security, could contribute in enhancing overall security. In our current project we are exploring the idea of new data sources that could be used in DF. Precise selection of parameters and key parameters has to be done, their margins and/or possible values and methods for their monitoring set-up. It might be data, that are not present in the everyday environment, but once they are detected and monitored, the mere data turn into valuable information which can increase the likelihood of early detection of degradation of security of applications using GNSS.

Finally, as a qualitative tool assessing the performance of the system using data fusion we have chosen ROC curve, which has been adapted to our needs.

VI. Conclusion

Continuous development and implementation of new technologies in aviation is essential for sustainability of air transport as a leading transport means in competitive environment of other transport means (e.g. high-speed railway especially in continental Europe).

Many technologies are already developed but, unfortunately, their implementation in civil aviation is tangled up, very complex and time consuming. One example of all – the GNSS and its usage for precision approach onto uncontrolled aerodromes. In compliance with the equation presented on the figure 1 we have promoted research activities in the area of GNSS implementation into ATM systems of small airports. The safety issues of such implementation and security domain of navigational signal disturbance is being investigated. As the MAD Group focuses its activities onto four main pillars of aviation it covers the most significant areas of modern research topics.

Acknowledgements

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THE SYSTEMS AND INFORMATIONS SYSTEMS ON THE AIRPLANE

František Martinec
Department of Air transport, Faculty of Engineering, VŠB – Technical University of Ostrava
frantisek.martinec@vsb.cz

Abstract. *The article is focused on the application of systems information on the airplane where use integration betwen systems and airplane.*

Keywords. integration systems of airplane, hardware, software, system informations, information technology.

I. INTRODUCTION

Historical development of the information system used that from 7 basic informtion in 1920 to a few thousands information 2013. Number of information change construction canbin too. From 3-5 devices in 1920, to modern airplanes used 3-6 modern devices – display - Multifunction Display (MFD) 2013.

II. Solution Of Information Systems On The Airplane

The systems keep on the airplanes progres digital processing all information and all aiplane systems new airplanes work on the base computes. When airplans started use elektronics on the board elektric equpment was names Avionics.

Avionics are the electronic systems used on aircraft, artificial satellites, and spacecraft. Avionic systems include communications, navigation, the display and management of multiple systems, and the hundreds of systems that are fitted to aircraft to perform individual functions Fig.1.

Avionics modern aiplanes makes integrated systém with modern change informations among systéms of aiplane and systéms airplane and pilot too. This gives occasion optima solve all problems on the airplane.

Using various sensors (such as GPS and INS often backed up by radionavigation) to determine the aircraft's position, the FMS can guide the aircraft along the flight plan. From the cockpit, the FMS is normally controlled through a Control Display Unit (CDU) which incorporates a small screen and keyboard or touchscreen. The FMS sends the flight plan for display on the EFIS, Navigation Display (ND) or Multifunction Display (MFD).

III. PHILOSOPHY OF INFORMATION SYSTEMS OF AIRPLANES

Basic of the information system of the new airplane is Fligt Management Systém (FMS). Essentially, the FMS accepts information, processes that information to provide two basic problems:

- Performance advisory functions
- Full flight management

In the advisory role, the system advises the flight crew as to the optimum settings to use in order to obtain the optimum performance. The flight crew must manipulate the controls in order to maximise the available benefits. Most early FMS units were restricted to this role.

In the ‘flight management’ role, the FMS is interfaced with the engine ‘Power Management Control’ (PMC) and the Automatic Flight.

This isolates the flight crew from the control loop and allows the FMS to act in a totally integrated fashion providing optimum control of engine power and total flight path control.

Modern FMS units can operate in the advisory role but are capable of providing a full flight management. Indeed, their primary functions are to manage four basic problems:

- Aeroplane performance
- Flight planning
- Navigation
- Three-dimensional guidance

The advisory role is a secondary function.

IV. SOFTWARE OF INFORMATION TECHNOLOGY ON THE AIRPLANE

Avionic Systems new airplanes work on the base computes using software. Software work on the airplane must answer high safety.

Software for real – time operating systéme use Standard software – systéme ARINC (Aeronautical Radio, Incorporated). Avionics Application Standard Software Interface series 600 to 900 they can use for diffrend aplications.

First basic safety requirements was published by RTCA, Incorporated, and development was a joint effort with EUROCAE, (European Organisation for Civil Aviation Equipment) who publish the document as ED-12B. DO-178B, Software Considerations in Airborne Systems and Equipment Certification is a document dealing with the safety of software used in airborne systems. The FAA applies DO-178B as the document it uses for guidance to determine if the software will perform reliably in an airborne environment,when specified by the Technical Standard Order (TSO) for which certification is sought.

The Design Assurance Level (DAL) is determined from the safety assessment process and hazard analysis by examining the effects of a failure condition in the system. The failure conditions are categorized by their effects on the aircraft, crew, and passengers Table 1.

V. FUTURE OF INFORMATION TECHNOLOGY ON THE AIRPLANE

Future information technology on the airplane is Integrated Modular Avionics (IMA) and full performance VNAV or Vertical Navigation. INA represent real - time computer network airborne systems.

The VNAV profile that the FMC commands, if not modified by the pilot, is a climb with climb thrust at the airspeed limit associated with the origin airport until above the limit altitude, then climb at economy speed to the entered cruise altitude.

The IMA concept proposes an integrated architecture with application software portable across an assembly of common hardware modules. An IMA architecture imposes multiple requirements on the underlying Operating System. Sophisticated aircraft, generally airliners have full performance VNAV or Vertical Navigation.

The purpose of VNAV is to predict and optimize the vertical path. Guidance includes control of the pitch axis and control of the throttle. In order to have the information necessary to accomplish this, the FMS must have a detailed flight and engine model. With this information, the function can build a predicted vertical path along the lateral flight planof airplane.

VI. COCLUSION

Information systems and Information technology on the airplane with cabina with clasical instrument - analog, analog systems was operate to the begining 70 yers last century. Start new technological methods and materials (after 70 years) evolution of pilot cabin and ergonomic cabim started evolute to the digitál version – glass cocpit.

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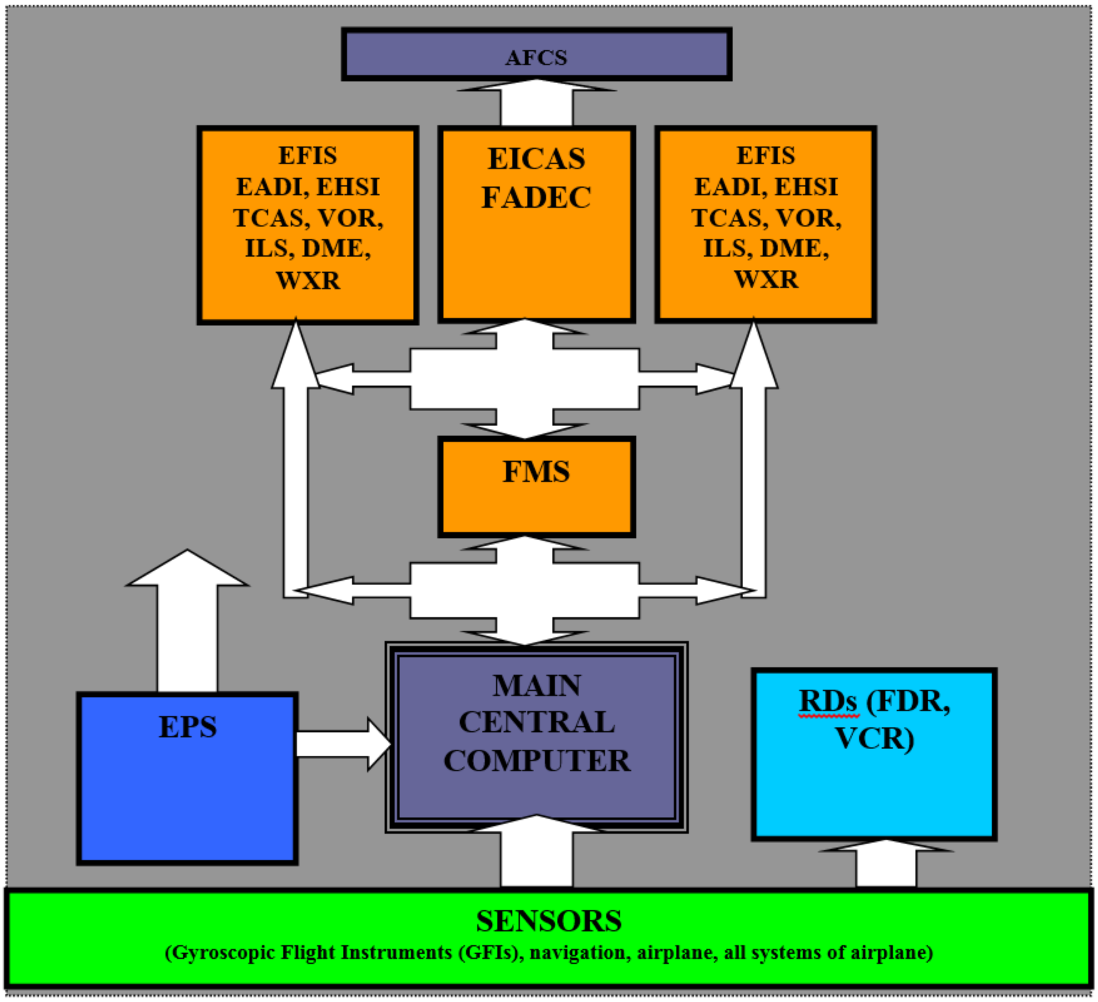


EFIF	- Electronic Flight Instrument Systems
FMS	- Flight Management Systems
EADI	- Electronic Attitude Director Indicator
EHSI	- Electronic Horizontal Situation Indicator
TCAS	- Traffic Collision Avoidance System
FADEC	- Power Computation and Thrust Control
EICAS / ECAM	- The Engine Instruments, Indication and Crew Alerting System
AFCS	- Automatic Flight Control Systém
RDs	- Recording Devices, Flight (FDR), Voise(VDR)
EPS	- Electric Power Systém
VOR	- VHF Omnidirectional Radio range
ILS	- Instrument Landing Systém
DME	- Distance Measuring Equipment)
WXR	- Weather radar

Fig. 1. Information technology new modern airplanes.

Table 1.

Catastrophic	Hazardous	Major	Minor	No Effect
Failure may cause a crash. Error or loss of critical function required to safely fly and land aircraft.	Failure has a large negative impact on safety or performance, or reduces the ability of the crew to operate the aircraft due to physical distress or a higher workload, or causes serious or fatal injuries among the passengers. (Safety-significant)	Failure is significant, but has a lesser impact than a Hazardous failure (for example, leads to passenger discomfort rather than injuries) or significantly increases crew workload (safety related)	Failure is noticeable, but has a lesser impact than a Major failure (for example, causing passenger inconvenience or a routine flight plan change)	Fai lure has no impact on safety, aircraft operation, or crew workload.

THE EXHAUST EMISSION VERIFICATION FOR ZLIN–142 M AIRCRAFT IN STATIONARYTESTS RESEARCH

Prof. dr hab. inż. Jerzy MERKISZ
Poznań University of Technology, Poznań, Poland
Jerzy.merkisz@put.poznan.pl

dr inż. Jarosław MARKOWSKI
Poznań University of Technology, Poznań, Poland
Jaroslaw.markowski@put.poznan.pl

dr hab. inż. Jacek PIELECHA
Poznań University of Technology, Poznań, Poland
Jacek.pielecha@put.poznan.pl

mgr inż. Marta GALANT
Poznań University of Technology, Poznań, Poland
Marta.m.galant@doctorate.put.poznan.pl

mgr inż. Dominik KARPIŃSKI
Poznań University of Technology, Poznań, Poland
Dominik.p.kaprinski@doctorate.put.poznan.pl

***Abstract** – Due to a rapid development of air transport there is a need for assessment of real environmental perils related to the aircraft operation. The main environmental risks are the products of incomplete combustion contained in the exhaust gases. The paper presents the results of the emission tests of a Zlin–142 M under the stationary test conditions.*

Key words – exhaust pollutants, exhaust emissions, research, piston aircraft engine

INTRODUCTION

The problems in attempting to obtain high engine overall efficiency and low fuel consumption also exist in the aviation sector. Particular attention is devoted to turbine engines used in turbo jet, turbo fan and helicopter powertrains. For most of these engines the applicable emission standards are those included in Amendment 16 'Environment Protection' of the Chicago Convention, ICAO. The emission standards do not cover piston aviation engines and turbine engines of the power output up to 2 MW and thrust to 26,7 kN. This action resulted in a slower development of piston aviation engines in the aspect of their negative impact on the natural environment. The omission of this group of powertrains in the ecological standards resulted in a reduction of the manufacturers' capital expenditure on the development of new designs. An additional reason for little advancement in this direction is the need of certification of an aviation engine, which also generates substantial costs for the manufacturers (turns out important in the case of low number of manufactured units) [5–7]. This number is tightly related to the number of new planes supplied to the general aviation sector. General aviation in the world is defined as a sector comprising all aircraft except government and commercial airplanes. Hence, general aviation covers all aircraft from balloons to private jet planes or planes used in business enterprises. The largest group of aircraft in general aviation is small and medium planes propelled with piston or turbine engines. The production of these planes is tightly related to the market demand (Fig. 1).

Current forecasts in the production of aircraft dedicated to general aviation indicate that within three years the annual production will reach that of 2006 and the share of planes fitted with piston engines will reach 45%. It is also forecasted that this status quo will remain until at least 2020 and the number of planes manufactured annually will amount to approximately 6000 units, 35% of which will be planes fitted with piston engines. The statistics assume that the technical advancement of piston aviation engines will remain on the current level, which, with the accumulated number of planes fitted with piston engines from 1994 to 2012 in the amount of approximately 30 000 units may constitute a serious peril for the natural environment.

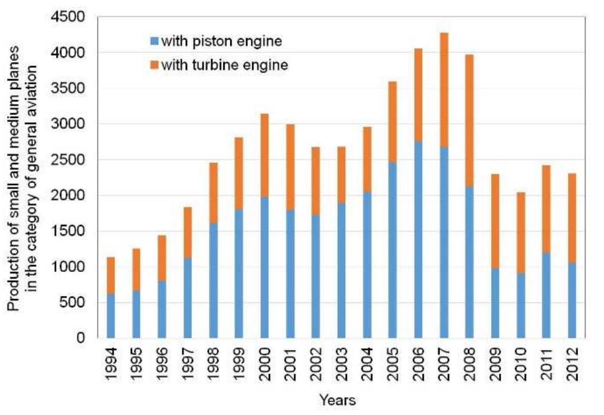


Figure 1 – Production of small and medium planes in the category of general aviation worldwide in the years 1994-2012

Current level of measurement technology related to the testing of exhaust emissions allows a performance of the said test under real operating conditions of the tested objects [1–7]. Such tests allow determining of the level of exhaust emissions of individual exhaust components under real operating conditions. Besides, they allow an assessment of the specificity of operation of a given means of transport in terms of time density of engine loads. Such information allows determining of the operation states of the drivetrain along with their share in the total operation time. The possibilities of usage of portable testing devices become particularly important in the tests of small aircraft under real operating conditions. Unfortunately, it is not possible for all the small aircraft cases. The mass of the admissible load that the plane can lift and the cargo space are decisive here. That is why it is vital that a testing procedure be developed for small aircraft that will allow an evaluation of the exhaust emission of aircraft in a stationary test performed on the runway.

TESTING METHODOLOGY

TESTED OBJECT

The exhaust emissions tests were carried out for a Zlin–142 M (fig. 2) aircraft fitted with Avia M 337 AK supercharged (fig. 3). The Zlin–142 M aircraft parameters have been listed in table 1. A significant meaning for the exhaust emissions measurement from aircraft engines has the engine design, its technological level, quality of workmanship, let alone the engine wear. The tested Zlin–142 M was fitted with a 5.970 dm^3, air-cooled, flat 6-cylinder spark ignition piston engine - Avia M 337 AK supercharged (M 337 C).

Figure 2 – Zlin 142 M [8]

Figure 3 – The engine - Avia M 337 AK supercharged (M 337 C) [10]

Table 1 – Technical specifications Zlin–142 M [9]

Version	Zlin–142 M
Wingspan	9.16 m
Length	7.33 m
Height	2.75 m
Wing area	13.30 m^2
Max. take-off weight	1 090 kg
Engine	Avia M 337 AK supercharged (M 337 C)
Engine power	156 kW / 3000 rpm
Maximum speed	230 km/h
Cruising speed	215 km/h
Minimum velocity	102 km/h
Propeller	Avia V-500A two bladed constant speed

For the needs of the exhaust emissions tests the exhaust system was extended by 4 meters. This enabled the measurement to be realized in a spot where the measuring probe could be easily fitted (fig. 4).

Figure 4 – The fitting location of the measuring probe

MEASUREMENT EQUIPMENT

The aim of the tests was to evaluate the exhaust emissions from the aircraft as it was stationary on the runway under conditions closest to the real operating ones. For the measurement of the concentrations of the exhaust components a portable analyzer SEMTECH DS by SENSOR was used (fig. 5).

a)

b)

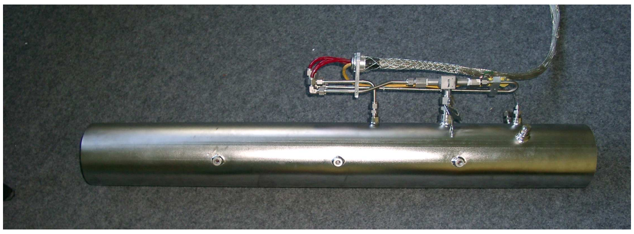


Figure 5. The view of the exhaust emission analyzer (a) and the measuring probe for mass exhaust flow (b)

Table 2 - The characteristics of the portable analyzer SEMTECH DS

Parameter	Measurement method	Accuracy
CO	NDIR – non-dispersive (infrared) range 0–10%	±3%
HC	FID – flame ionization range 0–10 000 ppm	±2,5%
NO_x = (NO + NO_2)	NDUV – non-dispersive (ultraviolet) range 0–3000 ppm	±3%
CO_2	NDIR – non-dispersive (infrared) range 0–20%	±3%
O_2	Electrochemical range 0–20%	±1%

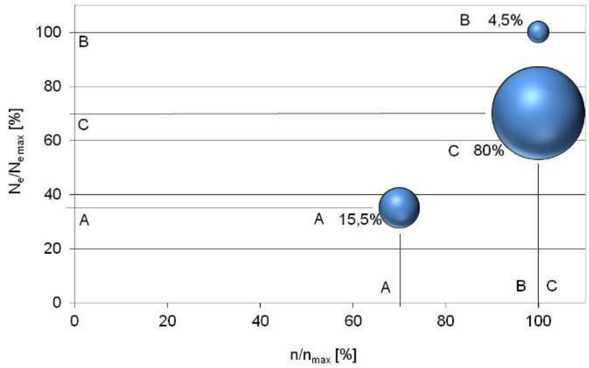
The analyzer measures the concentrations of exhaust components (table 2) at the same time measuring the mass exhaust flow. The exhaust gases are introduced into the analyzer through a probe that maintains the temperature of 191°C (fig. 5) and then they are filtered out of the particulate matter (diesel engines only) and the measurement of hydrocarbons takes place in the flame ionizing detector. The exhaust gases are then cooled down to the temperature of 4°C and the concentrations of nitric oxides (non-dispersive ultraviolet – measures nitric monoxide and nitric dioxide), carbon monoxide, carbon dioxide (non-dispersive infrared) and oxygen (electrochemical analyzer) are measured [1–4, 8–10]. To the central processing unit of the analyzer we can connect data links from the OBD and GPS systems, which, however, was not necessary in the tests presented in this paper.

THE RESULTS OF THE MEASUREMENTS

The measurements of the exhaust emissions from the Avia M 337 AK supercharged (M 337 C) engine fitted in Zlin–142 M were performed at an airport in a stationary test. In the standard course of the flight of the aircraft we can distinguish several phases. These are: taxi, takeoff, climb, steady flight phase, approach to landing, landing and taxi. Depending on the performed task the time share of individual flight phases in the flight differs. For the realization of the tests in the stationary conditions three test phases were selected: A – startup, taxi, B – takeoff, C – cruise/steady flight (the settings of the engine and propellers were as under real flight operating conditions) (fig. 6 and table 3). Additionally, the exhaust emissions during engine startup were measured. The obtained results have been presented on graphs (fig. 7 – 11) and table 4.

Table 3 – *Phases distributions and weight for the test emission*

Test phase	n/n_{max} [%]	$N_e/N_{e\,max}$ [%]	Test phase share
A	70	35	0.155
B	100	100	0.045
C	100	70	0.800



Fiure 6. Phases distributions and weight for the test emission

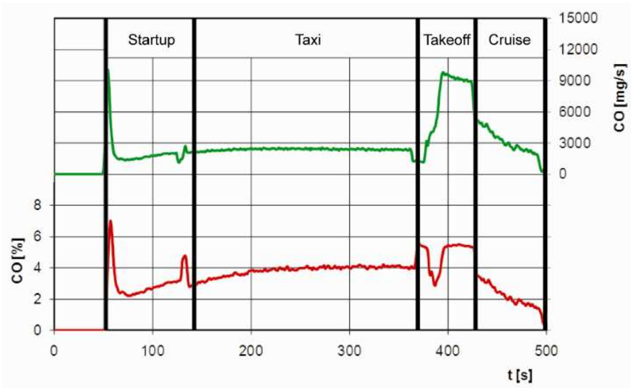


Figure 7. – The measurement of CO during the test

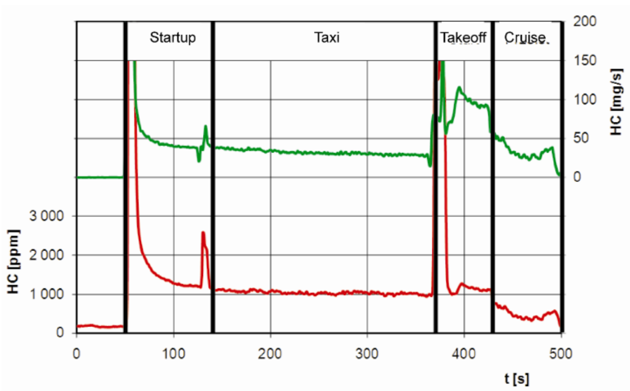


Figure 8.– The measurement of HC during the test

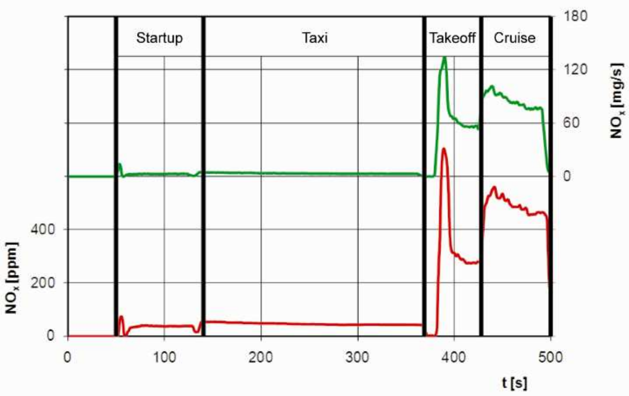


Figure 9. –The measurement of NO_x during the test

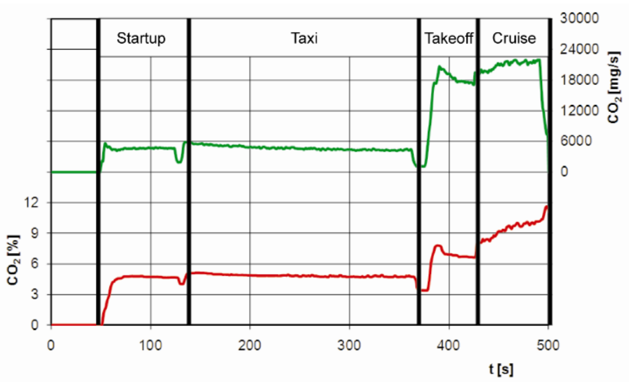


Figure 10. –The measurement of CO_2 during the test

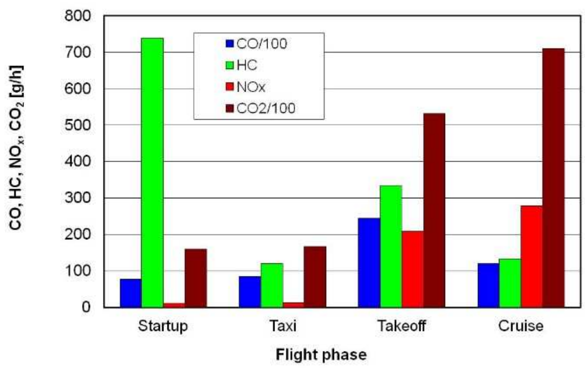


Figure 11.– The average hourly emissions of the exhaust components

Table 4 - The The measurement results of the exhaust emissions from the Avia M 337 AK supercharged (M 337 C) engine

Parameter	Flight phase			
	Startup	Taxi	Takeoff	Cruise
Speed [rpm]	–	1200	2600	2400
Duration [s]	80	240	52	78
Average concentration				
CO [%]	3.20	4.21	5.50	2.57
HC [ppm]	3897	1144	2116	524
NO_x [ppm]	26.6	34.0	216	337
CO_2 [%]	4.65	5.24	7.14	10.5
Emissions [g]				
CO	169	560	352	258
HC	16.42	7.94	4.82	2.87
NO_x	0.24	0.83	3.00	6.03
CO_2	353	1115	768	1539
Hourly emissions [g/h]				
CO	7622	8405	24374	11923
HC	739	119	334	133
NO_x	10.9	12.4	207	278
CO_2	15901	16728	53144	71031

The assessment of the exhaust emissions from the Zlin-142M aircraft can be performed based on the proposed test. The analysis was carried out based on the concentrations of the exhaust components in the exhaust gases, recorded during flight trials and the average hourly emissions determined in the predefined operation phases. The comparison of the exhaust emissions from engines of different design parameters is possible with the use of the measured quantities subsequently related to the engine power output. Hence, the comparative quantity adopted for the validation of the test is the unit emissions of the individual exhaust components expressed in g/kWh. The operation phases ‘startup’ and ‘taxi’ are within category A of the test phase. Hence, the values of the hourly exhaust emissions from the phases were averaged and the obtained value was ascribed to phase A. Knowing the characteristics of the Avia M 337 AK engine the values of the engine power output were determined in the individual test phases. In the next step, based on the power output ascribed to a given phase and the value of the hourly emission of the individual exhaust components unit Emission was determined (tab. 5).

Table 5- Results of the hourly and unit exhaust emissions measurements from the Zlin-142 M engine

Parameter	Test phase		
	A	B	C
Engine power output [kW]	65	185	130
Hourly emission [g/h]			
CO	11824	24374	11923
HC	798	334	133
NO_x	17.1	207	278
CO_2	24265	53144	71031
Unit emission [g/kWh]			

CO	182	132	91.7
HC	12.3	1.81	1.02
NO_x	0.26	1.12	2.14
CO_2	373	287	546

The obtained values of the unit emissions in the individual test phases were multiplied by the coefficients of phase share in the test as given in the formula:

$$e_j = \sum \left(e_{ji} \cdot u_i\right) \qquad \text{[g/kWh]} \qquad (1)$$

where:
e_{ji} – unit emission in the individual test phase [g/kWh],
u_i – coefficient of phase share in the test [–];

thus, obtaining the unit emission in the proposed test (tab. 6).

Table 6- The values of the unit exhaust emissions for the Zlin-142M aircraft in the proposed exhaust emissions tests

Aircraft	Test phase area	A	B	C
	$N_e/N_{e\ max}$ [%]	35	100	70
	Test phase share	0.115	0.045	0.800
	Unit emission determined based on the test [g/kWh]			
Zlin-142M	CO	100		
	HC	2.31		
	NO_x	1.79		
	CO_2	493		

The realization of the exhaust emissions test according to a preset procedure may be used for the evaluation of the aircraft condition and its exhaust emissions.

Conclusions

The performed investigations and the analysis of the obtained results confirm the significant influence of many parameters related to the ideas of fuelling of piston aircraft engines on the exhaust emissions. The paper indicates great dependence of the concentrations of the exhaust components on the operating conditions of the engine, which are tightly related to the operating conditions of the plane, realized plane trajectory, pilot's driving style, his skills and particularly the appropriate selection of the fuel air mixture. The composition of the air fuel mixture significantly affects the exhaust emissions as it directly influences the course of combustion in the cylinder, thus generating mutual relations between the emission of hydrocarbons and nitric oxides. These relations are particularly visible on the example of emissions of these components in the takeoff and cruise phases.

The performed investigations are to be treated as preliminary of an explorative nature. The analysis of the obtained results indicates a serious issue of an increased concentration of carbon monoxide and hydrocarbons in the whole range of the engine operation. These results should be correlated with the results obtained for the aircraft of the same type but fitted with an engine of a newer generation.

The obtained information could be used to develop and validate testing procedures for small aircraft that do not have sufficient cargo capacity to be fitted with specialized, full-sized measuring devices. Eventually, the realization of this type of tests could help develop universal testing procedures for the measurement of the emission level of small aircraft and their impact on the natural environment.

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DESIGN OF AN AB-INITIO PILOT SELECTION PROCESS WITH REDUCED CULTURAL AND LANGUAGE BIAS

(*AB-INITIO PILOT = TRAINING PILOTS FROM THE BEGINNING, 0 FLYING HOURS)

Karina Mesarosova MSc, BSc (Hons), MBPsS, MIEHF, MEAAP
KM Flight Research and Training
km@flightresearch.eu

Abstract *– With the rapid globalization of aviation many non-European airlines are sending their nationals for flight training based on European designed selection processes, with minimal scientific validation (for different cultures) or adapted for those with English as a second language (ESL). There is a need to ensure that the Airline selects candidates who have the ability to succeed with minimum training risk; to achieve this aim, the fairness and effectiveness of the selection process must be proven and this leads to major questions from the rapidly expanding aviation markets of the Middle East and Asia.*

To address the cultural & language differences, participants of different nationalities (EU & Arabic) and languages (English, other than English within EU & Arabic) were identified. Language barriers were addressed through participants undergoing mathematics and physics testing in English and Arabic, the pilot aptitude assessment (PILAPT®) was aided with a Gulf Arabic translation brochure.

The effect of language was very evident in both the PILAPT® IP task, with a significant positive correlation with English language ability (IELTS) listening score ($r=.408$, $p<.05$) and the significant improved results in the mathematics and physics test that was conducted in their native language (Arabic). The cultural difference was identified in the PILAPT® comparison between nationalities; Gulf participants achieved the lowest scores, this was consistent throughout the PILAPT® tests (2D,3D,IP and SA) indicating that the raw score from PILAPT® testing using European based norms is not a reliable predictor for ab-initio pilot potential. This study identified a cultural correction to the raw PILAPT® data of 2 units for the Gulf candidates. Considering the risk, cost and time involved in the training of ab-initio pilots (circa 100 000 Euro per pilot), it is crucial to make sure that the selection process is effective, fair and rigorous.

Key words – selection process, ab-initio cadets, language, culture

INTRODUCTION

PILOT SELECTION IN THE COMMERCIAL SECTOR

The Commercial aviation sector had relied on a constant supply of well trained and proven ex-military pilots; thus there was felt to be no need for a selection process as an ex-military pilot had already undergone a robust military selection process. Sadly for the airlines, the reduction in defence spending and subsequent smaller pool of ex-military pilots entering the commercial aviation market is driving a need to change (Carretta and Ree, 2003). In 1997 pilots with a military background accounted for 75% of the new hire in commercial aviation (Hansen and Oster, 1997). At the predicted expansion of the worldwide airline business, it is expected that 498,000 new pilots will be needed in the next 20 years (e.g. Boeing Commercial Outlook, 2013), this demand cannot be met by experienced pilots due to a range of factors, e.g. fewer pilots entering from military and mandatory retirement age (e.g. Suarez et al, 1994, Hunter, 1998 as cited in Carretta and Ree, 2003). Flight International's David Learmount (2010) sums this up as follows *"the golden days in which the airlines could rely upon a supply of virtually free high-level piloting skills have gone forever"*.

The military pilot selection process is aimed at young individuals with no previous flying experience (*ab-initio*) (Martinussen and Hunter, 2009), and *ab-initio* ("*from beginning*") training has become a growing requirement for commercial aviation, but is far from popular with air carriers as it is associated with a high cost (Carretta and Ree, 2003).

Ab-initio flight training is a comprehensive step by step process – the selection process starts with a large amount of applicants that have passed the baseline criteria, i.e. healthy individuals with a medical certificate, clean police record, set education requirement (includes maths & physics). These applicants are tested with range of psychological tests and more extensive medical examinations; in most cases only 10 % of the applicants are accepted into the training programme (Martinussen and Hunter, 2009). Thus the success of the selection process is dependent on correctly identifying and deploying the right method to determine the skills and abilities needed to be a successful professional pilot.

BAD PEOPLE IN A GOOD SYSTEM OR GOOD PEOPLE IN A BAD SYSTEM.

As aircraft design and reliability improved, combined with the major leaps in ergonomic cockpit design and standardisation of instrumentation, safety was clearly seen to improve with a major reduction in the number of accidents, this trend continued to the early 1990's. Unfortunately, this improvement has stagnated; there has been no improvement in the number of fatal accidents since the year 2000. Further accidents in the year 2009 clearly highlighted that the flight crew failed to manage situations that was expected to be within the normal skills level of a professional pilot and "Major airlines worldwide have also begun to appreciate that flight crew who meet legal pilot licensing minima with little or nothing in reserve are not good enough to be able to cope reliably with high workloads generated by anything from system failures to approaches in marginal weather conditions" (Learmount, 2010). Pilot error (human error) to a layman suggests that the pilot is to blame, however this view is simplistic, after an accident with the benefit of hindsight, most errors seems preventable (Dekker et al, 2007), we are left to wonder how we can cope with the marked unreliability of the human factor. On the other side is the system, greater automation and system complexity have in turn led to new areas of risk, pilot confusion and the problem of automation deficit; systems are not safe by themselves but are vulnerable to operator efficiency. Operators (pilots) of complex systems learn about the vulnerabilities of the system and the aircraft they fly, they are trained to cope with stress and the challenges of modern aviation and thus investigators can either blame the system or the operator; 70% of recent accidents are identified as human error (Wiegmann and Shappell, 2003). The demands of the global market and the changes post cold war have led to a reduction in the supply of ex-military pilots into the airline market, further most European airlines have stopped funding ab-initio pilot training, despite this the need for pilots worldwide has increased and this has led to the creation of a self-selected and funded professional pilot who often is trained to the minimum legal standard.

How to measure cadets handling skills, spatial abilities, situational awareness and workload capacity?

The most obvious answer would be to utilise an aircraft simulator, however this is not feasible with ab-initio pilots for numerous reasons (need training to use it, high cost per hour). There are several computer-based instruments (e.g. PILAPT®, CogScreen, Compass) that can assess information processing and psychomotor function. These have proven to have an acceptable validity and offer substantial savings to the simulator option.

Computer Based Pilot Testing Batteries.

The development of computer based testing from the late 1980's allowed incorporation of the old style pencil and paper tests, complex psychomotor testing with new designed testing that took advantage of the capabilities computers brought, such as latency (time to respond) and the ability to record inappropriate responses. The military quickly took advantage of this and a variety of systems were developed such as; MICROPAT (MICRO computerised Personnel Aptitude Tester) used by the British Military (Army & Navy), TBAS (Test of Basic Aviation Skills) used by the USAF measure of psychomotor and cognitive skills and PILAPT (Pilot Aptitude) widely used by military forces world-wide. The concept that all of these systems use is very similar, PILAPT is relatively unique in that it is one of the few systems that has been modified and adopted as a standard for civil pilot selection and it is based on job analysis survey results framework design by Fleishman (Kokorian, 2004).

PILAPT®.

PILAPT® is a computer based assessment for selecting military and civilian pilots (selection of ab-initio and experienced pilots). PILAPT® - covers handling skills (i.e. basic pilot aptitude) and human factor (HF) competencies (e.g. situational awareness (SA) and capacity). It aims to provide a comprehensive assessment of key skills; Co-ordination, information processing, spatial ability, workload capacity.

PILAPT® does not require any prior knowledge of flying, however it identifies key pilot performance factors and the design allows for differences in candidates i.e. those with greater experience in video games (Kokorian and Valser, 2006), as prior "hands-on" flight experience and computer gaming experience alters performance measure in psychomotor tests and even may explain a 27% of variance in test performance (e.g. Lang-Ree and Martinussen, 2008, Martinussen and Tornjussen, 2004). PILAPT® has been validate across a range of different languages (Italian, Portuguese, English and Spanish) and in different locations (Chile, Italy Portugal, United Kingdom) (Kokorian,Valser,Tobair and Ribeiro, 2004), although to date only a small set of norms has been gathered from a sample of Arabian Gulf nations and testing was conducted in English.

Does the Western style of ab-initio selection process disadvantage the Gulf ab-initio cadets?

Language and validity of a Selection Process

The western style approach to ab-initio selection may have affect upon the results, as it omits two important factors language and cultural differences. With the growth of aviation training worldwide and the need for selection processes to be exported internationally, a demand for tests validated and constructed in one language and the need to use them in another language (and possibly culture) has grown. Factors that may alter selection scoring include; culture and language, standard of education, wealth, standard of living and motivation across national groups (Hambleton and Patsula, 1998). We require language abilities to develop the ability for mathematical reasoning, language competencies are necessary for success in mathematics (Cambel, Adams and Davies, 2007) especially for students with English as second language (ESL). As the mother tongue acts as a mediator between the mathematical structure and the mental processes and experience and concept, therefore a certain linguistic competency is required to make a transition between languages and subsequently mathematical concepts and meanings. ESL deal with multiple language factors at the same time when attempting a mathematical problem leading to an increased cognitive demand (Cambel et al, 2007).

Culture and the selection process

The globalisation of the aviation industry combined with an increase in demand for pilots worldwide has led to a greater interest in human factors and cultural impact. The new multi-cultural flight decks has led to greater human factor issues and have been identified by aviation psychologists as a threat. Aircrew that come from countries recognised for their individualistic culture (e.g. Great Britain) will respond differently to a given situation in comparison to a member of highly collectivistic culture (e.g. Saudi Arabia) (Mjos, 2004). This concept is important because it extends beyond the traditional research and shows a much wider scope of factors that are implicated in human factors related accidents or incidents and that "*the active failure of a crew may be a symptom rather than a cause*" (Mjos, 2004). "*The national cultures arise largely out of shared values; organizational cultures are shaped mainly by shared practices*" (Reason 1997, as cited in Mjos, 2004).

To see a person as a whole we must consider their bio-psychological characteristics (the very foundations of behaviour, emotions, and mental processes) and also their nature, the software that is acquired during their first years of life as well as education and their life experience.

Human factors are determined by the bio-psychological features i.e. spatial ability, visual capacity, body rhythm and general fitness. Soeters and Boer (2000) have related these capabilities as the hardware of human factors, but for these to function properly we need the software (the mind), this can be related to the individuals culture, their very own tool kit of skills, which gives us the basic abilities to construct strategies of action. This software is regarded as an indicator of culture; every culture bestows a certain degree of influence on how the individual will function in different situations (e.g. social adaptation, leadership or followership).

Aviation training-performance prediction.

Selection procedures are mainly derived from the predictive validation approach where performance is tracked over the whole period of the flight training and the initial selection test results are compared with actual flight performance and ground school results; establishing such a predictive relationship is the basis for selection system development (Duke, 1994). In 1994 a Pilot Candidate Selection Method (PCSM) score was used to predict the number of flying hours required by United States Air Force (USAF) ab-initio cadet pilots (Duke, 1994). A sample of 1082 cadets revealed a correlation between the PCSM score and extra flying hours(over syllabus), the higher the candidate's PCMS score resulted in fewer extra training hours to complete training. This demonstrated the empirical relationship of PCSM and flying training hours, allowing estimation of future training costs based on initial selection results. The ability to draw such conclusions has major implications for the airline recruitment system as it may lead to considerable savings; average training cost incurred as a result of failure during ab-initio training was estimated at 50 000 Euro in 2004 (Goeters and Maschke, 2004).

The interest in future performance is mainly based on the future cost that the employer will encounter with cadets and their long term performance within the airline, both in training and operating safely on the line (normal passenger flying). The interview is a selection method that is considered very poor in predictive validity, especially in unstructured interviews. Such interviews are considered more beneficial for the applicant rather than the interviewer, as the applicant gets to ask questions about the company from the representatives themselves (Martinussen and Hunter 2009). Much better results are recorded with structured interviews where the questions are not random, these are more costly to construct but are considerably more valid (Schmidt and Hunter, 1998). Yet another type of predictor is the work sample test, where candidates are required to perform a task similar to a task that would be part of their job. There is usually a standardized scoring system and according to Schmidt and Hunter (1998), this method has a high validity (Figure 05). Another method to predict performance is through using psychological tests (ability and personality tests), are most readily (often) used in aviation selection processes primarily for pilots and air traffic controllers, as they have been developed particularly with these groups in mind (Martinussen and Hunter, 2009).

Pilot Selection, the Cost Rationale.

Pilot selection is driven by cost; today the traveller wants to fly at lower cost, this can be seen with the growth in low cost carriers (LCC), Ryanair, Easyjet, Wizzair, Air Arabia, Jazeera Airways etc. The first conclusion would be to achieve a reduction through cutting selection and training; the reality is for an airline to save in the long term, pilot selection and training must be strengthened. The old cliché "*if you think training is expensive, try an accident*" is a recurring comment in the industry (Daly, 2009), the Spanair crash in Madrid in August 2009, was a Human Factors (HF) related accident that "*cost SAS the parent company between $50-60 million*". Thus pilot ability and competence have long term consequences beyond the selection process, ab-initio training, type rating and line flying are costly for the company but at the end, any airline recruiting that does not aim for a pilot that can safely fly in all circumstances is making an error that may prove costly. If there was any uncertainty over either the need for a selection process before training, or the argument that it will become evident during training if the person is suitable or not (Goeters and Maschke, 2004) clearly shows a lack of awareness of the cost of training.

An effective selection process offers several advantages for the organization (Goeters and Maschke, 2004):

- Decreased rate of failure
- Low rate of additional training
- Improved reliability of planning long term employment
- Improved safety standard

And also for the individual:

- Minimizing the risk of false personal investment (time, effort, money)
- Increase in socio economic status with prospective long term employment

Aims and objective of the study

The major focus of this study was to provide a Gulf National major airline with a new selection process that would reduce the failure rate during training and predict the amount of extra training required to reach the required standard. Thus from the review of the literature as discussed, a revised selection process can be designed based on assessment of English language ability, graded on the International English Language Testing System (IELTS), this is necessary to identify the level of English of the candidates in relation to the international requirements for aviation training and therefore is an essential tool in the selection process. The job task analysis has identified the significance of these abilities, assessment of speech recognition and written comprehension that further underline its importance for ESL cadets. Written tests in mathematics and physics that consider the language barrier and the increase in information processing required for students with ESL (Finley and Neal, 2008), lead to the need to develop test papers that measure mathematics and physics performance in English and Arabic. Further identified by the pilot job analysis, psychomotor, sensory and cognitive abilities that are necessary for a pilot must be assessed, this assessment tool must be correctly based on the requirements for normal airline pilots and be suitably predictive of the potential to aid the airline in cost versus training risk and the future risk to the airline. Previous research indicated the psychomotor test (PCSM) relationship with the requirement for extra flying hours (Duke, 1994), thus the commercial version of the PILAPT battery test was chosen to establish the relationship of PILAPT ® and the extra flying training hours on two types of aircraft, normally used in ab-initio flying training; the Piper Seneca twin-engine aircraft and Piper Warrior single-engine aircraft, with the aim to set an objective cut-off in the selection process for the client airline. A structured panel interview to identify motivation, time management, leadership/followship, communication skills and if the candidate fits the airline's "image".

The proposed adjusted selection process for the Gulf area selection of ab-initio pilots

- English testing (reading comprehension, listening comprehension, grammar, speaking and writing ability.
- Mathematics, physics (in Arabic and English)
- Aptitude test-PILAPT® (with Arabic translation booklet)
- Interview (structured interview).

Further, this research concentrated on the cultural differences that could lead to candidate bias, establishing whether there are differences in selection criteria compared to the European based selection processes, Arabian Gulf nationals and other Lebanese Arab nationals. To date there is limited literature referring specifically to cultural differences in the pilot selection process, but there are some "red flags" to the differences.

Method

Design

Experimental design: mixed design.

To address the cultural & language differences in the selection process results, participants of different nationalities (EU & Arabic) and languages (English, other than English within EU & Arabic) are identified. Language barriers in terms of non-native English speakers are addressed in mathematics and physics tests, participants perform the tests in English and Arabic and in PILAPT® assessment aided with an Arabic translation brochure.

In the first task the comparison of Gulf cadets (within subject design) performance in mathematics and physics test in two condition English version of the test and Arabic version of the test is tested. The dependent measure was the score achieved from the tests.

Second task the Gulf cadets were split into two conditions, cadets who performed better in the Arabic version of the mathematical and physical test and cadets who performed better in the English version of the mathematical and physical test (between participant design). Their IELTS score from the listening test was compared with their information processing (IP) PILAPT® score.

In the third task the cadets were split into four conditions (between subject design) EU-English first language, EU-English second language, Lebanese and Gulf candidates, their PILAPT® scores(2D,3D,IS,SA and overall PILAPT®) across the test were compared. The dependant measure was the scores achieved by the cadets in the PILAPT® test.

Fourthly, all EU and Lebanese cadets and five PILAPT ® conditions (2D, 3D, IP, SA and overall PILAPT ®) scores were tested. The dependant measure was the overfly hours on Seneca and Warrior.

Participants

Comprised of 44 Gulf candidates with average age of 20 (19.93) (range from 17-25 years of age).

The second sample consisted of participants from a major European flying training organization (that was selected to conduct the successful Gulf candidates training), that had successfully completed flight training, with an average age of 24 (range 18-39 years old). The data was supplied in a raw format, de-identified by the organization itself (221 cadets).

Results

Q1: Does the Arabic version of Math and Physics improve cadet's performance in mathematics and physics test results?

The effect of language on the mathematics and physics test was compared using related T-test (repeated measure design). Candidates achieved significantly better results in the mathematics and physics test (Figure 01) that was conducted in their native language (Arabic) ($M = 54.25$, $SE\ 20.16$) in comparison to the math and physics test in English ($M = 50.86$, $SE = 21.51$) $t(43) = 17.85$; $p < 0.05$, with a large effect size $r = 0.93$.

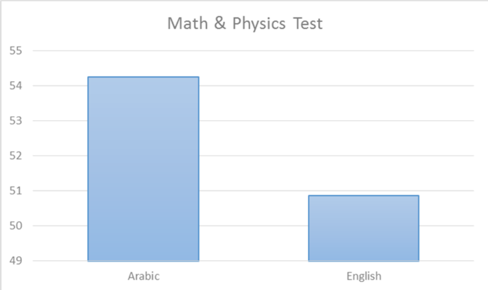

Figure 01: Comparison of math and physics test results of the test conducted in English & Arabic (Gulf candidates)

Q2: Does a higher IELTS listening score result in better performance in PILAPT® Information Processing?

Three correlations were used to investigate the dependence between listening and information processing (IP) PILAPT® score achieved by Gulf candidates as follows, overall (N=44), for the group who performed best in Arabic mathematics and physics tests (N=20) and the group who performed best in English Mathematics and Physics tests.

The IELTS score for listening significantly correlated with IP r=.408, p<.05 for the all candidate group. The IELTS listening score also significantly correlated with IP for the group with the best results in maths and physics in Arabic r=.598, p<.05. However, for the candidate group who scored best in the Mathematics & Physics test in English the results did not correlate r=.132, p>.05.

Q3: Are there differences in PILAPT® score among the different nationalities?

The difference in results in the PILAPT® score between EU (English first language and English second language) Lebanese and Gulf candidates (Figure 2)was compared using ANOVA.

The best results in 2D tracking were achieved by EU candidates with English as second language (M=5.58,SE =1.50), followed by EU candidates English as first language(M=5.49,SE=1.73), then by Lebanese candidates results in 2D tracking PILAPT® test was (M =4.30, SE = 2.13), followed by Gulf candidates results in 2D PILAPT® test (M= 3.25, SE = 1.53), the overall difference was significant *F* (3,261) = 5.15, p< .00 with a medium effect size r = .45

In 3D tracking the best results were achieved by the EU English first language candidates (M =6.76, SE = 1.42), followed by EU English as second language candidates (M =6.11, SE = 1.15), then Lebanese candidates results (M =5.2, SE = 1.33) and with the lowest test score, the Gulf candidates (M= 4.20, SE = 1.55). The overall difference was significant F (3, 261) = 21.59, p< 0.05 with a large effect size r = .58.

In Information Processing the best results were once again achieved by the EU English first language candidates (M =6.62, SE = 2.00), followed by EU candidates with English as second language (M =6.53, SE = 2.29), followed by Lebanese candidates (M =6.03, SE = 1.92) and with the lowest score the Gulf candidates (M= 3.18, SE = 1.35). The difference was significant F (3, 261) = 43.64, p< 0.05 with a large effect size r = .55.

In Selective Attention the best results were again achieved by the EU English first language candidates (M =6.85, SE = 1.87), followed by EU English as second language candidates (M =6.53, SE = 1.50), the Lebanese candidates (M =5.43, SE = 1.77) and with the lowest test score, the Gulf candidates (M= 3.66, SE = 1.68). The difference was significant F (3, 261) = 37.72, p< 0.05 with a large effect size r = .55.

In the Overall PILAPT® test the best results were achieved by the EU English first language candidates (M =6.92, SE = 1.50), followed by EU English as second language candidates (M =6.42, SE = 1.26), followed by Lebanese candidates (M =5.15, SE = 1.40) and finally Gulf candidates (M= 3.18, SE = 1.26); the difference was significant F (3, 261) = 38.47, p< 0.05 with a large effect size r = .70

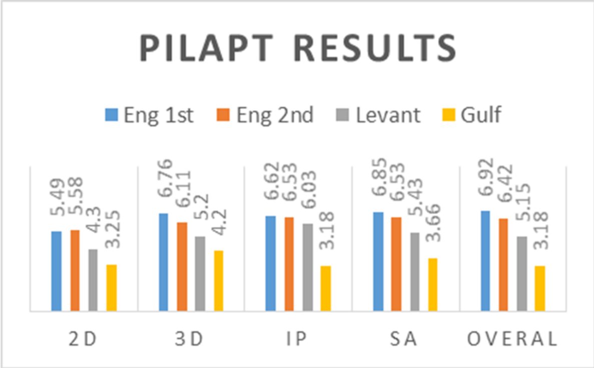

Figure 02: Comparison of PILAPT® score across different nationalities

Q4: Does PILAPT® score correlate with the overfly hours on Seneca and Warrior aircraft?

A simple correlation was used to indicate whether the PILAPT® score correlates with the overfly hours on Seneca and Warrior aircraft. There was a significant negative relationship of the PILAPT ®score and the overfly hours on the WARRIOR r= -.190, p<.01 and a significant negative relationship of the PILAPT® score and the overfly hours on SENECA r= -.225, p<.01. This indicates that the lower the PILAPT® score the more over fly hours are necessary.

Q5: Which specific PILAPT ®predictors are best in identifying the Warrior and Seneca overfly?

To establish the factors most indicative of the overfly hours on the Seneca and Warrior aircraft a multiple regression was used.

Five predictors in overfly hours were used (PILAPT®s individual contributors): 2D, 3D, Information Processing, Situational awareness, Overall PILAPT® score

WARRIORS (single engine) overfly predictors:

Multiple regression, sample size 221, with 5 predictors, overall the model accounts for only 6.8% of the variance in overfly hours on Warrior single engine aircraft but it is a significant fit (F= (5,215) = 3.12, p≤ 0.01).

Overfly on the Warrior was significantly (p < 0.05) predicted by 2D PILAPT ® results, it is a negative relationship indicating that the higher score on 2D PILAPT ® the lower overfly hours required.

SENECA (single engine) overfly predictors:

Multiple regressions, sample size 221, with 5 predictors, overall the model accounts for only 7.5% of the variance in overfly hours on Seneca twin engine aircraft, however it is not a significant fit (F= (5,215) = 3.50, p>0.01).

Overfly for the Seneca was not significantly (p < .05) predicted by any of the PILAPT ® score results. However the 3D and Overall PILAPT® indicates a negative relationship between the score and overfly hours.

None of the PILAPT® predictors seems to significantly predict the Seneca overfly.

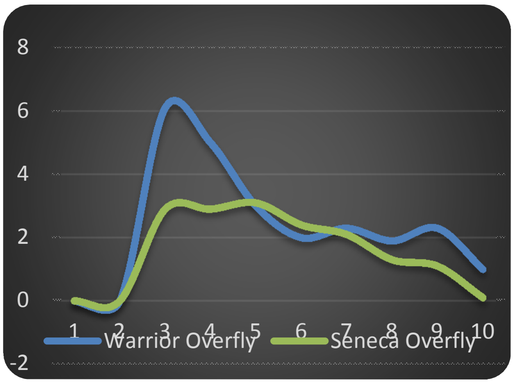

Figure 03: Overall PILAPT® score and Warrior and Seneca overfly

Q6: Which specific PILAPT ®predictors are best in identifying the Warrior and Seneca overfly for EU and non EU cadets?

To establish the factors most indicative of the overfly hours on the Seneca and Warrior aircraft for the NON EU cadets, a multiple regression was used.

Five predictors in overfly hours were used (PILAPT®s individual contributors): 2D, 3D, Information Processing, Situational awareness, Overall PILAPT® score

NON EU cadets -WARRIORS (single engine) overfly predictors:

Multiple regression, sample size 40, with 5 predictors, overall the model accounts for 25.2% of the variance in overfly hours for the Warrior single engine aircraft and it is not a significant fit (F= (5,34) = 2.29, p> 0.01).

Overfly on the Warrior was not significantly (p < 0.05) predicted by any of the PILAPT ® factors (2D,3D,IP,SA, overall), however the negative relationship between the 2D,3D and overall PILAPT® indicates that the higher score on 2D, overall PILAPT® the lower overfly hours required.

NON EU cadets -SENECA (single engine) overfly predictors:

Multiple regressions, sample size 40, with 5 predictors, overall the model accounts for only 9.8% of the variance in overfly hours on Seneca twin engine aircraft, however it is not a significant fit (F= (5,34) =.73, p>0.01).

Overfly for the Seneca was not significantly (p < .05) predicted by any of the PILAPT® tests (2D, 3D, IP, SA). However, the Overall PILAPT® score had a negative relationship with the overfly hours.

EU cadets -WARRIORS (single engine) overfly predictors:

Multiple regression, sample size 181, with 5 predictors, overall the model accounts for 3.1% of the variance in overfly hours on Warrior single engine aircraft and it is not a significant fit (F= (5,175) = 1.10, p> 0.01).

Overfly on the Warrior was not significantly (p < 0.05) predicted by any of the PILAPT ® test results, however the negative relationship between the 2D,3D and overall PILAPT® and overfly indicates that the higher score on 2D,3D and overall PILAPT® the lower overfly hours required.

EU cadets -SENECA (single engine) overfly predictors:

Multiple regressions, sample size 181, with 5 predictors, overall the model accounts for only 7.4% of the variance in overfly hours on Seneca twin engine aircraft, however it is a significant fit (F= (5,175) =2.8, p<0.05).

Overfly for the Seneca was not significantly (p < .05) predicted by any of the PILAPT ® parts (2D, 3D, IP, SA). However the Overall PILAPT® score was found to have a negative relationship with the overfly hours, the higher the 3D and PILAPT® overall scores resulted in a reduction of overfly on Seneca.

Discussion

The focus of this study was to develop a culturally robust selection process by developing and adapting the selection process validated in a European based pilot training facility. The discussion about language bias and culture robustness in the selection process, formed the key argument *"can we use the same selection process and techniques within Gulf ab-initio pilot selection*"? The findings would clearly seem to support major differences between EU cadet pilots and the Gulf candidates and this would seem to be due to both cultural and language driven bias.

Language is a major factor identified in the selection process results; the mathematics and physics testing clearly showed that candidates performed better in their native language (Arabic). However, it needs to be noted that there were a number of candidates that performed better in tests in the English language. This anomaly, upon closer examination is explained by the effect of the candidate's educational exposure, those that attended International schools with all lessons in English. This finding is in line with other research findings, Cambell et al 2007 highlighted the *"increased cognitive demands for students of English as a second language";* this increased cognitive loading is clearly indicated in the difference in performance between the English and Arabic mathematics and physics testing.

Although there is an argument that a certain standard of mathematics (and physics) should be achieved in English prior to selection, whilst this holds true, considering that many candidates have experienced limited exposure to cognitive processing biased to English, if they are able to pass an Arabic based mathematics test to the required standard, the further English and foundation in both mathematics and physics (in English) would reconcile the language differences. Thus the main reason for adapting testing to both English and the native language is to give a fair and equal opportunity to all candidates (Hambleton and Patsula, 1998).

The effect of language was very evident in the PILAPT® IP task, with a significant positive correlation with IELTS score; this is to be expected as the IP task requires the candidate to process audio information as part of the task, thus the Gulf candidates would be at a major disadvantage in terms of cognitive workload as previously identified and this handicap must be addressed by the application of an artificial correction to the raw score.

A comparison of the Gulf candidates and Lebanese cadets was made, purely on account of the perceived common language of

Arabic, in general the written forms are classic Arabic (the language of the Quran), Modern Standard Arabic (published books), these are not spoken, the day to day Arabic is the colloquial form and varies markedly between regions (Holes, 2004), the differences can be so great as to be mutually incomprehensible between each other. Further, the Lebanese cadets completed the selection process entirely in the English language; compare to the gulf candidates who benefited from the mixed design (Arabic and English). The results of both groups PILAPT® were compared and surprisingly the Lebanese cadets performed significantly better in all tests (PILAPT: 2D, 3D, information processing, situational awareness) despite the alleged language disadvantage. This may be an indicator of an underlying cultural bias, in general it was noted that the Lebanese cadets performance was closer to that to the EU cadets, perhaps this is related to the long history of trade, migration etc. between the Levant and Europe with modern Lebanese society and life being closer to European lifestyle, education and business approach than the more conservative Gulf Nations. Finlay & Neal (2008), highlighted how the conservative " root of Arab power" (Ali, 1995) is linked to the skills for desert survival leading to the typical "*sheikocracy*" with power devolved to one person and shared by familial association, this leads to success through connections rather than via qualification or ability. In comparison, Lebanon has a "European" approach (Finlay & Neal, 2008) and this may be the hidden cultural bias leading the Lebanese cadets' performance to be similar to the EU cadets, thus the relative poor performance of the Gulf candidates.

Such results raise questions not just about the importance of language (and translation), whilst the Lebanese cadets had successfully completed their training (professional licence issue) the true progress and success of the Gulf cadets will only be revealed upon completion of the 18 month training program (English, foundation and the Frozen ATPL course), thus revealing the full implications that this comparison may have on their results.

Martinussen and Hunter (2009), hypotheses of the validities of the selection process for professional pilots may not be valid between different ethnic groups with educational institutional experience and motivation the major factors. This perceived cultural variance in mean overall PILAPT® score between the Lebanese (5.15) and Gulf (3.18) nationals of 2 units, has been taken and added to the selection process model to create an adjusted PILAPT® result to create a fairer selection system and address the cultural bias.

Further comparison of the regression model of Warrior overfly and PILAPT® predictors for the EU cadets and non EU cadets, revealed for the EU cadets (N=181) a negative relationship between 2D, 3D and overall PILAPT® scores and the overfly hours despite being non significant. The model for NON EU cadets (accounted for 25.5% of variance) and again 2D and overall PILAPT® scores show a negative relationship, nevertheless it was not significant.

The model of Seneca overfly and PILAPT® predictors for the EU cadets (model valid predictive validity = 7.4%) also indicates a negative relationship between the 3D and overall PILAPT® scores and Seneca overfly, once again this was not significant. The model for non EU cadets and Seneca overfly (accounted for 9.8% of variance) and in this model only the overall PILAPT® score had a negative relationship with overfly although it was not significant. Despite the lack of statistical significance in these results for the model for both EU and NON EU cadets, they revealed a common aspect and that is the overall PILAPT® score is a predictor with a constant negative relationship for overfly on both the Warrior and the Seneca. For the Warrior overfly the negative relationship is indicated by the 2D predictor and that is common for both the EU and non EU cadets. The overall PILAPT® score was predictive (regression model) of the overfly of EU and non EU cadets (N=221) pilots cadets, the lower overall PILAPT® score the more over fly hours that are necessary (e.g. as in Duke, 1994). This was true for both types of aircraft, the single engine Warrior and the twin engine Seneca, (which is more complex to fly). However, a closer investigation of the PILAPT® predictors (model valid, but low predictive validity = 6.8%) and the overfly hours on the Warrior, only the 2D PILAPT® was a significant predictor of the Warrior overfly. This supports the hypothesis that the higher PILAPT® score the lower overfly hours required and this was also true for the IP and Overall score, however, this was not a significant result.

These results are not surprising considering the Warrior is a simple, single engine aircraft, used for the more basic stages of training where the 2D capability of the student pilot would play a significant role. The Seneca overfly (model valid, low predictive validity 7.5%), did not achieve significance for any of the PILAPT® test predictors, despite the lack of statistical significance we should highlight the identified negative relationship between the Seneca overfly and 3D score (i.e. the higher the 3D score the lower overfly required), also for the Seneca overfly and overall PILAPT® score. As the Seneca is considered a more complex aircraft (two engines, variable pitch propellers, retractable undercarriage and higher speed) in comparison to the Warrior, is used at the later stages of the training involving more complex tasks (Instrument flying, airways etc.), that add a greater cognitive load to the student pilot, the 3D PILAPT® test should afford a more accurate identifier of potential performance.

The Arabic booklet that was used as an aid in PILAPT® screening, where possible language confounds could be expected for the Gulf participants did not seem to improve the PILAPT® test results. Overall the score for Gulf participants was lower on every PILAPT® predictor (2D, 3D, IP, SA and overall PILAPT®) in comparison to Lebanese cadets (the difference was between 1 to 2.85). This requires further research to identify what level of language ability is required to effectively undergo PILAPT® testing.

Prior to this work, the airline sponsor had not considered the use of any pilot aptitude test, thus an important part of this research was to meaningfully validate the use of such testing for Gulf nationals. The data indicates that an overall low PILAPT® score is associated with higher overfly hours. The 2D regression model is a significant predictive factor for the Warrior overfly, whilst the 3D result shows a significant correlation with the Seneca overfly. A simple prediction table was established to enable the sponsor to set the maximum extra spend i.e. overfly and thus set the minimum required standard for the ab-initio airline pilot selection for their airline. The model will be continued to be adjusted with time as the first batch progress and graduate from the flight training, to ensure that the airline achieve the best initial selection process for their national cadet pilots.

To validate the conclusions currently made and to support the decisions taken in the selection process will require following the participants progress through flying training and comparing the actual overfly against the predictive model. Further, to gain a more rapid insight into the validity for selection of Gulf nationals it is planned to take a small number (n=6) of the selected candidates and carry out Elementary Flight Grading (EFG), this is a modification of the UK Royal Air Force programme and will involve seven hours of flying in a Warrior aircraft per candidate. EFG is an assessment tool of trainability; it involves no actual flight training but rather focuses on a candidate being able to repeat an exercise demonstrated by a trained EFG assessor. The actual assessment of flying potential will be compared with the PILAPT® data to provide confirmation that the selection was made on a valid hypothesis. Further comparisons need to be expanded to more Gulf countries to increase the numbers involved in this research. Most Gulf nations are small with a relatively small population and thus pool of potential pilot applicants, cultural perception of the airline pilot profession is markedly different to that of the western world with many nationals electing management positions within state run industry or government as the preferred role. These factors may result in a reduction in the quality of candidate and thus resultant test performance rather than a pure cultural factor driven degradation.

Conclusion

Cultural effects in selection processes are not fully comprehended and their effects need to be further explored. This research has identified the need to monitor the progress during and after training to fully allow the formation of a coherent picture of the possible interference of culture and the learning approach of the training organization. Cultural influence must not be disregarded, as the comparison of the Lebanese and Gulf cadets clearly indicates a major difference between Arab nationals, however there is a need to establish a clearer link, to find a meaningful baseline that could allow better and more complete comparisons (i.e. gender). For now, we need to observe and monitor the progress of the Gulf cadets that have started their training in Europe and are due to complete the training in May 2011. As part of the ongoing process to refine the selection process, this group of cadets will be re-tested with PILAPT® after completion of advanced English training(IELTS 5.5), mathematics and physics foundation. This should reduce the language and educational issues and the results will be compared with their initial selection results, to provide a clearer indication as to the adjustment needed to raw PILAPT® results.

Throughout this research valuable information was acquired, that may benefit future research into this area. We have learned that the Gulf cadets are quite different to the "norms" studied and used as a basis to validate selection processes and that in depth knowledge of the region is important before embarking on the design of a selection process. Language is a major factor and it is essential that the selector fully identifies the candidate's language bias and avoids assumptions that the Arabic language is always preferred. This research highlights the need for both airlines and training providers to adapt the selection criteria, being cultural sensitive if they wish to succeed in the new global training market.

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RUNWAY SAFETY - EVERYONE'S RESPONSIBILITY

Ing. Mária Mrázová
Air Transport Department, University of Žilina, Slovakia
maria.mrazova@fpedas.uniza.sk

Abstract *– This paper deals with runway safety. Runway incursions are a serious safety concern. Because of the considerable number of runway incursions across the European region and worldwide, including actual collisions with a significant loss of life, it is considered necessary to focus attention on this issue. It is also needed to work together on a series of concrete measures to minimize the risks of runway incursions, runway excursions and other events linked to runway safety by establishing, promoting and enhancing multi-disciplinary runway safety teams at individual airports.*

Key words – runway safety, runway incursions, vehicle / pedestrian deviations, FOD strikes.

INTRODUCTION

Runway Safety is a significant challenge and a top priority for everyone in aviation. Accordingly, ICAO has been called upon by the international civil aviation community to exercise leadership in the effort to reduce the number of runway-related accidents and incidents worldwide.

Both runway incursions and excursions have many casual or contributing factors and reducing the risk involves a concerted effort from the aviation industry. Flight crew, Air Traffic Controllers and aerodrome operations personnel can all play a part in helping to reduce the human factor elements that contribute to an accident. By developing runway safety training and outreach initiatives, hundreds of thousands of people working in air travel can develop good work practices for maintaining an extraordinary level of safety. Along with continued situational awareness, these practices will continue to reduce the rate and severity of runway incursions.

Major progress has been made recently in the area of runway safety. In 2012, there was a significant reduction in runway safety-related accidents, with a decrease of 21 %. In addition, the global accident rate involving scheduled commercial operations for 2012 decreased significantly to 3.2 accidents per million departures. [1]

RUNWAY INCURSION OVERVIEW

The risk of a runway incursion event that could kill hundreds of people in a single accident is serious problem. Fortunately, this problem has been exhaustively studied by dozens of experts, and mitigations have been devised that can greatly lessen the risk inherent with ground operations today.

Many operational staff have experienced a runway incursion and have contributed to the future prevention of runway incursions through incident reports. The result is that the majority of contributory and causal factors are concerned with communication breakdown, ground navigation errors due to inadequate or ambiguous signs, markings and relevant information needed in the cockpit. Frankly, communication is again a priority for runway incursion prevention, with new emphasis on visibility and tracking of traffic.

OPERATIONAL AND HUMAN FACTORS INVOLVED IN RUNWAY INCURSIONS

Approximately three runway incursions occur each day at towered airports. The potential that these numbers present for a catastrophic accident is unacceptable. According to the ICAO, a runway incursion is *"Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft."*

On the other hand, statistics show that most runway incursions occur in visual meteorological conditions during daylight hours; however, most accidents occur in low visibility or at night. All runway incursions should be reported and analysed, whether or not another aircraft or vehicle is present at the time of the occurrence. [4]

Other common factors that cause runway incursions are shown in **Figure 1.**

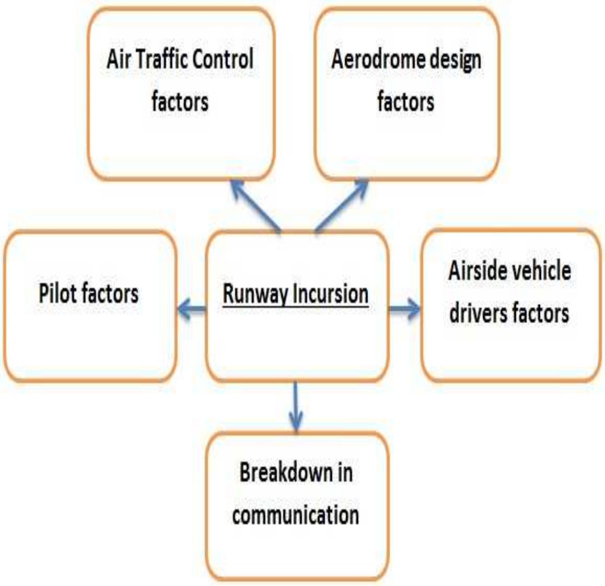


Figure 1 – The diagram of common factors that cause Runway Incursion

Nowadays, we categorize incursions as one of three types:

1. *Vehicle/pedestrian deviation (V/PD)* – when a vehicle or person causes the incursion
2. *Operational error (OE)* – a mistake by ATC and
3. *Pilot deviation (PD)* – when the pilot is at fault.

For instance, **Table 1** shows breakdown of runway incursions during 2011-2012 time period according to mentioned types.

Table 1 – Runway Incursions Total in 2009-2012 time periods

	YEAR			
Category	2009	2010	2011	2012
A	9	4	5	7
B	3	2	2	11
C	343	386	361	491
D	595	574	586	640
E	1	0	0	1
Total	951	966	954	1150
Operational Deviation	39	29	27	15
Operational Incident	114	127	151	211
Pilot Deviation	599	629	593	722
Vehicle/Pedestrian Deviation	199	181	183	200

The FAA further categorizes runway incursion events by severity, as shown below **(Figure 2).**

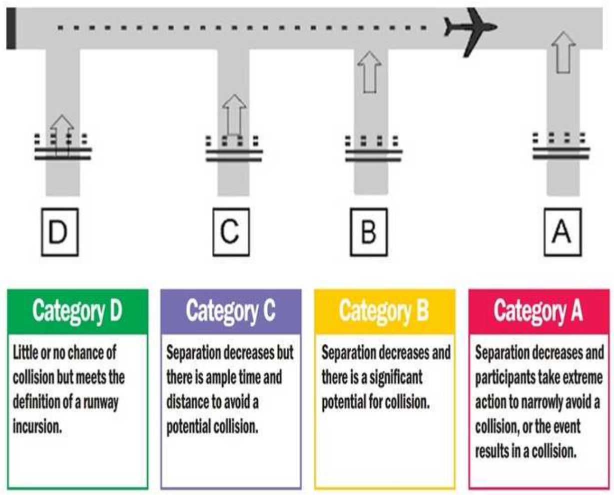


Figure 2 – Illustration of runway incursion severities

Runway incursions are not new. In fact, the worst disaster in aviation history happened on the ground, when 583 people died in the collision of 2 Boeing 747s on the island of Tenerife in 1977 (2 aircrafts, 1 runway). The tragedy happened when the captain of a KLM B747 initiated take-off without a clearance and collided head-on with a Pan Am 747 back-taxiing on the same runway.

The growth in volume of commercial scheduled flights seen in 2010 continued in 2011 at the rate of 3, 5%. The number of accidents grew by 4.1% and the global accident rate for 2011 remains unchanged at approximately four accidents per million departures. Moreover, the number of fatalities has decreased by 41.4%, making 2011 the safest year with regard to fatalities since 2004. Improved runway safety was a key element for this decrease with no fatal runway safety accidents occurring in 2011, as can be seen in **Table 2**. [10]

Table 2 – Accident statistics 2011 time period

	Accidents			
REGION	Traffic (thousands)	Number	Rate	Fatal accidents
Africa	891	7	7.9	3
Asia	7,561	22	2.9	3
Europe	7,143	39	5.5	4
Latin America and the Caribbean	2,625	15	5.7	4
North America	10,979	38	3.5	0
Oceania	855	4	4.7	2
World	30,053	126	4.2	16

Anyway, a lot of serious incidents we can see in the past, and for instance, analysis of data from 71 runway-incursion occurrences (aircraft-aircraft) worldwide shows the following:

1. **70 % involved crew deviations** from standard operating procedures and **46 %** involved failure **by an ATC** to provide separation
2. **34 %** occurred in **darkness or twilight**, implying a risk 2-times higher than conditions of daylight (25 % of occurrences)
3. **23 %** of occurrences were in visibility **less than** reported runway visual range of **1,200 ft.** [6]

Runway incursion occurrences happened most frequently in the scenarios shown in **Figure 3**.

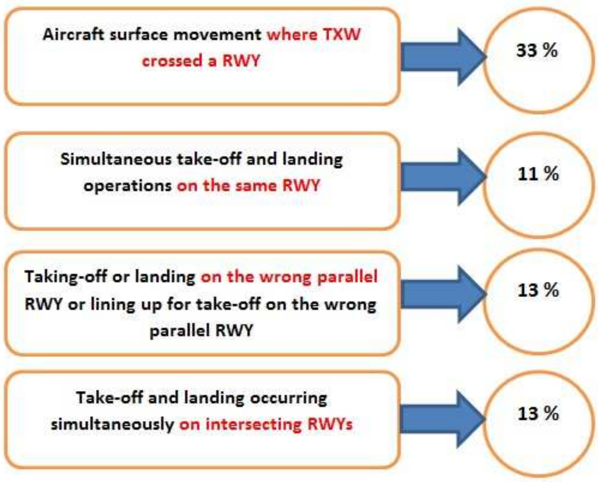


Figure 3 – Illustration of most following scenarios runway incursions

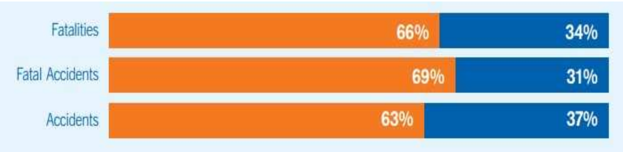
HIGH-RISK ACCIDENT OCCURRENCE CATEGORIES

Runway incursions are the consequence of multiple operational and/or environmental factors. One major contributing factor for runway incursions is the crew lack of situational awareness during airport surface operations, induced by weather considerations, by complex airport factors or by crew technique itself.

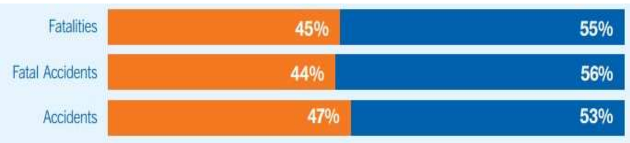
Based on an analysis of accident data covering the 2006-2011 time periods, ICAO identified 3 high-risk accidents occurrence categories:

1. ***Runway safety-related events*** (include abnormal RWY contact, Bird Strikes, Ground Collision, Ground Handling, Runway Incursion/Excursion, Loss of Control on Ground, Collision with Obstacle)
2. ***Loss of control in-flight***
3. ***Controlled flight into terrain***

As indicated in the first chart below, these 3 categories represented 63 % of the total number of accidents, 69 % of the total number of accidents, 69 % of fatal accidents and 66 % of all facilities in period 2006-2011. (The orange colour represents High-risk categories, the blue others).



In 2012, high-risk accident categories accounted for less than 50 % of accidents, fatal accidents and fatalities.



Besides, the percentage of runway safety-related accidents was reduced significantly **(Year 2012),** representing 43 % of all accidents, accounting for only **11 % of all fatal accidents,** and **1 % of all related fatalities.** It shows us a major decrease from the 2006-2011 baseline periods. The percentage of all accidents is shown in **Figure 4.** [10]

Figure 4 – Illustration of All Accidents in 2006-2012 time periods

Anyway, the number of accidents (as defined in ICAO Annex 13) decreased by 21 % and the global accident rate involving scheduled commercial operations for 2012 has decreased significantly to 3.2 accidents per million departures. Compared to 2011, the number of fatalities decreased by 10 % making 2012 the safest year with regard to fatalities since 2004. [1] [2]

ILLUSTRATION OF RUNWAY SAFETY AT SELECTED AIRPORT

Runway Safety is a vital component of aviation safety as a whole: with the expected growth of air traffic, sheer numbers of incidents are bound to rise, unless held in check by pragmatic, sensible solutions. On the other hand, you can never anticipate all the ways even the simplest action can go wrong. It is indispensable that improvements come from attention to detail. That's why, we will look at example of airport that has a complex of runway system and it makes many dangerous spots.

At Zurich airport runway 10/28 crosses runway 16/34. The location of runway 28, between the north and south aprons, is also critical, as we can see at **Figure 5**. This layout means that taxiing aircraft often cross runways. The fact that apron control is divided into north and south sectors also means that frequency changes are common. Thus, anyone operating a vehicle at Zurich Airport must therefore always be on the alert.

Figure 5 – Illustration of Zurich airport runways

For instance, let's take look at an example of an accident that happened in 2002. Flight XY received the clearance to taxi from the "G-Stands" via taxiways E and A to the holding point RWY 28. On its way to RWY 28 the aircraft XY crossed RWY 28 on taxiway E without clearance and the crew realised this only once they were crossing the RWY. As one can expect the investigation revealed a chain of errors and several contributing factors. Nevertheless, at the crossing of taxiway E and RWY 28 a "RED STOP BAR „is installed and was activated. This should have been a last line of defence and considered by the crew of XY as a wall of concrete. [7]

The next **Figure 6** shows runway incursions (2008-2010) by type. Anyway, in view of the vital importance of clarifying the reasons for every runway incursion which occurs, it must be concluded that the number of vehicle and pedestrian deviation runway incursions has increased at Zurich Airport in the past three years.

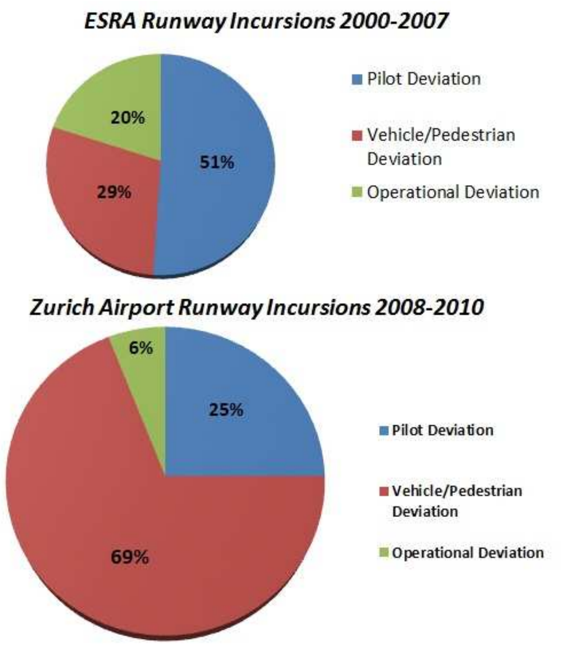


Figure 6 – Runway incursions occurred at LSZH by type

As **Figure 6** shows, the incident data for the past three years show a clear increase in the number of *vehicle and pedestrian deviation* runway incursions at Zurich Airport. The individuals involved in the vehicle and pedestrian deviation runway incursions reported are varied, and range from airfield, maintenance staff to airport authority and planning personnel, employees from an outside company and emergency services personnel. [7]

MAJOR CAUSES RELATED TO RUNWAY INCIDENTS AND ACCIDENTS

To prevent large accidents and to drive continued improvements in aviation safety, one needs to look not at the accidents themselves, but at the myriad much smaller and less consequential precursor to those accidents. Runway safety cannot be understood without addressing FOD.

Foreign Object Debris (FOD) is a term used to describe all of loose bits and pieces that can be found lying around any airport operating surface, however mostly this debris is harmless. The most expensive parts to repair are engines, with even very minor engine imbalances can lead to major efficiency losses. Engines operating blades with uncorrected damage may suffer a 1, 5 % fuel efficiency loss, costing up to $108 per flight. Of course, this drives airline fuel consumption and overtime costs mount. In addition to engine damage, FOD damage means tires need to be replaced at the airport due to tears, punctures or gouges. On top of those active replacements, fully 4 % of tires that seemed to be in otherwise good condition fail re-tread due to embedded FOD. *Goodyear* data suggest that the cost of embedded FOD come to $7.350 per aircraft per year for a typical wide body jet. [3]

Let's take a look at the *Concorde aircraft*. It had been the safest working passenger airliner in the world according to passenger deaths per distance travelled. In addition, its crash at Charles de Gaulle International Airport on 25 July 2000 was caused by FOD; in this case a piece of titanium debris on the runway which had been part of a thrust reverser which fell off from a DC 10 that had taken off about 4 minutes earlier. All 100 passengers and 9 crew on board the flight, as well as 4 people on the ground, were killed. [5]

Figure 7 – Illustration of the Concorde crash

A second important category is **bird strikes**. Like FOD, most bird strikes are innocuous. A large airport suffers one bird strike every 3 days. Most strikes (92 %) cause no damage, but the average cost still comes to $22.741 per strike. Although birds are usually thought of as an in-air problem, data shows that a bit less than half (41 %) of all bird strikes occur on the runway. Of these, up to 50 % are caused by birds actually sitting on runway rather than simply flying past.

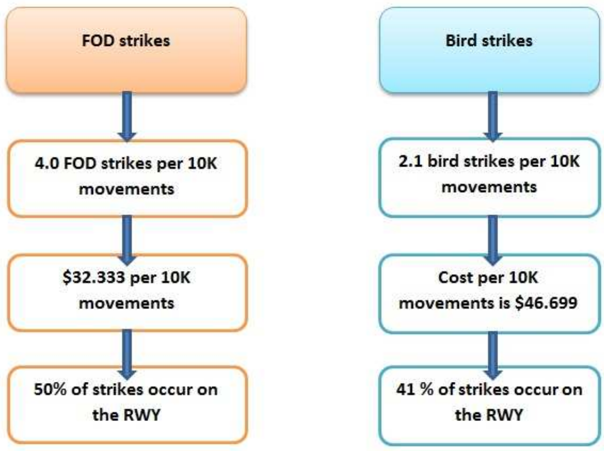


Figure 8 – Illustration of the data related to FOD and Bird strikes

Anyway, looking specifically at Runway fatalities, the already low numbers are cut even further, for many countries by about 80%. The particular combination of circumstances required to cause a large scale fatal crash on the runway calls for such an unlikely combination of factors that accidents are all but impossible to predict. The lesson is that the past has become a poor predictor of the future. This is why every fatal accident always seems to come as a "surprise". It also means that basing future safety policy on past accidents is non-productive. Finally, we have to realize that the future is not about spending money, but about saving money to save lives by predicting accidents. [3]

IDENTIFICATION OF HOT SPOTS – KEY ROLE IN RUNWAY SAFETY

A hot spot is defined as a location on an airport movement area with a history of potential risk of collision or runway incursion, and where heightened attention by pilots and drivers is necessary. By identifying hot spots, it is easier for users of an airport to plan the safest possible path of movement. Hot spots also call attention to potentially confusing airport areas so pilots can exercise extra care. (See Hot Spots in **Figure 9**).

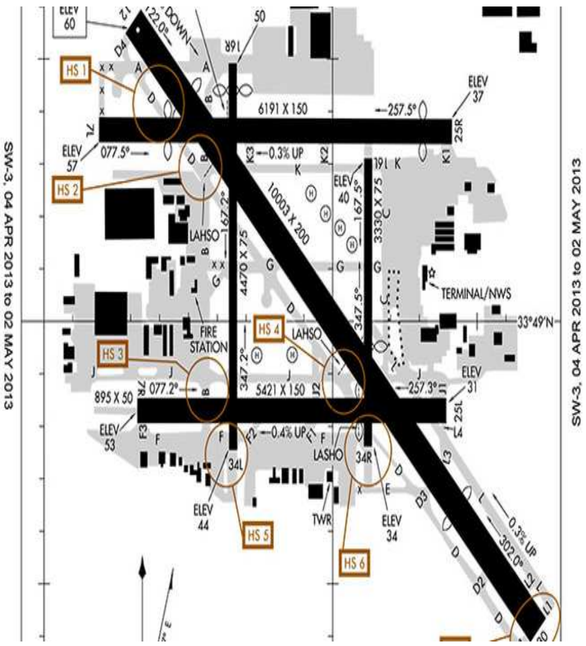


Figure 9 – Airport Diagram Hot Spots

Of course, the runway incursion problem is difficult to solve. One of the important challenges is that pilots and drivers on a runway without a valid ATC clearance believe they have permission to be there. Communication is again a priority for runway incursion prevention, with new emphasis on visibility and tracking of traffic. Anyway, runway safety is a priority, because safe flying starts and ends on the ground. In this case it is necessary to cooperate with airports and regulators. The **Figure 12** shows the ways of reducing runway incursion risks. [9]

Figure 12 – Diagram of the ways reducing RWY incursion

Constantly reducing the likelihood of airplanes colliding with obstructions on airport runways – whether they are other aircraft, vehicles, individuals, or wildlife – is the primary objective of the Runway Safety. To accomplish this, we must focus our limited resources on the causal factors with the highest risk of contributing to the likelihood of significant safety events.

CONCLUSIONS

Runway safety is a major concern for the aviation industry. The reduction in runway incursion incidents represents an opportunity to enhance runway safety. To move to the next level of safety, the safety metrics and analysis capabilities must continue to evolve and provide predictive indicators of potentially adverse situations, and it must continue to work aggressively to correct problems and mitigate risk. Moreover, in high-reliability industries such as air transportation, safety risk and safety performance cannot be solely measured by the absence of fatalities or by traditional methods that rely on counting the numbers of observed precursor incidents.

It is clear that aircraft and flight crews operate in complex airport environments every day. They fly in all types of adverse weather and often in limited visibility conditions. They complete the demanding tasks of safe landing and take-off over and over. We have to realize that all of these tasks demand vigilance and high situational awareness. It is really important, because the risk for runway incursions in aviation is constantly increasing, although many of the initiatives implemented are already providing a positive impact on runway safety.

Briefly, runway safety is an ongoing effort and we are committed to finding ways of making a safe system even safer. In addition to current runway safety initiatives, the following efforts will further the progress of increasing runway safety over the next several years - because safety is making every journey better.

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Európska únia

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ASSESSING THE IMPACT OF A CONSTRAINED AIRPORT ON THE CAPACITY OF AN AIRPORT NETWORK WITH SIMULATION TECHNIQUES

Miguel Mujica Mota
Aviation Academy, Amsterdam University of Applied Sciences, The Netherlands
Weesperzijde 190 | 1097 DZ Amsterdam
m.mujica.mota@hva.nl

Geert Boosten
Aviation Academy, Amsterdam University of Applied Sciences, The Netherlands
Weesperzijde 190 | 1097 DZ Amsterdam
g.boosten@hva.nl

Abstract *– The current article deals with the problem of assessing the practical capacity of an airport network. This problem is approached using simulation techniques taking into account not only the variables that currently limit the capacity but also other ones that affect the capacity such as the stochastic behaviour of the system, the current traffic mix, environmental limitations and the interrelationships among the airports that compose the system. The article put focus on the North Holland region which is a good example of a system that struggles for allocating the growing traffic in the coming years.*

Key words – Simulation, airport network, capacity

INTRODUCTION

Nowadays the main airports throughout the world are suffering because their capacity are getting close to saturation due to the air traffic which is still increasing besides the economic and oil prices. These levels of high saturation can be perceived as more and more aircrafts put in holding trajectories, lack of gates when they have landed and increasing delays in airside or terminal sections in the airport. Several options appear for alleviating the congestion problem in the airports of the main capitals of the world. The traditional approach is just increasing the facilities which means the investment of important quantities of money. When the physical, economic or political restrictions impede the expansion of the facilities different approaches have to be considered by the airport managers. This efforts range from optimizing current facilities using simulation and optimization techniques [4][5]to the development of novel ways to manage the incoming and outgoing traffic through the development of systems of airports [3].

In order to increase the transport capacity within a region, it is necessary to consider holistic visions that evaluate not only the efficient management of current resources of individual airports, but also an integrated view of ATM systems for the different airports that participate in the system.

MULTI-AIRPORT SYSTEMS

A multi-airport system is the set of significant airports that serve commercial transport in a metropolitan region, without regard to ownership or political control of the individual airports [2]. The main characteristics of these kind of systems are:

- They focus on commercial aviation.
- They focus in a metropolitan region rather than a city.
- They are market-oriented thus they leave aside the ownership of the airports.
- Normally there is one main airport with secondary ones that relieve traffic from it.

The case of London, New York, San Francisco are just some of examples of regions that use airport systems for managing the air traffic. Other European capitals such as Amsterdam is struggling nowadays for changing the management model from a single airport to a system of airports in order to accommodate hub-related and non-hub related growth of aviation in the Netherlands [7].

SCHIPHOL AND THE DUTCH REGION

The case of Schiphol Airport is of special interest because it not only serves a region which comprehends some of the most important urban and technological centres in the Netherlands but also because is one of the main Hubs in Europe, mainly operated by AF/KLM. The KLM hub provides the Netherlands with crucial connectivity for the Dutch economy to many destinations worldwide [7].

Schiphol currently performs 423,000 operations which corresponds to an 83% of saturation considering the declared capacity of 510,000 ATM. Table 1 presents the information concerning the number of passengers transported and the number of operations performed in 2012 by Schiphol. If we put focus on this information it is important to notice that Schiphol is getting to a level of saturation where a small disruption would cause a chain effect in the whole system which would be translated in delays and queues not only in the terminal airspace sector but also in the airfield (taxiways,runways, head runways etc.).

Table 1– Key figures Schiphol Airport 2012 (source Schiphol traffic data)

Airport Name	Schiphol Airport
ATM	510,000
Current ATM	423,407
Saturation Level	83%
Millions of Passengers (2012)	50,976
Originating Passengers	30,101
Transfer Passengers	20,875
Operating Hours	24
Airside Infrastructure	5 RWY - Deicing - RFFS Cat 10 - cargo facilities

These delays would impact in the whole system at different levels, not only at the quality of service provided but also at the economy in the actors that participate in the system (airlines, airports, passengers, business in the region, etc.)

On the other hand the growth rate in terms of passengers transported is expected to continue during the coming years. Figure 2 illustrates this situation, it can be seen that the only perceived reductions in the number of passengers were during S11 and during the economic crisis of 2008 [6].

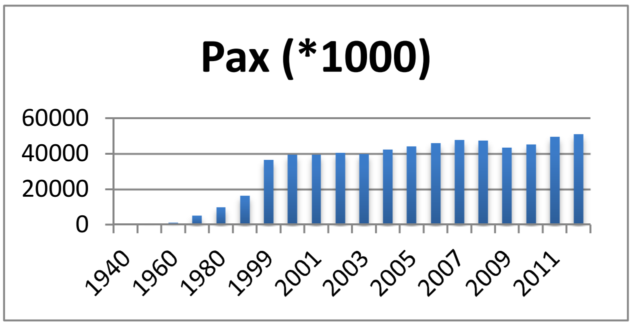

Figure 2- Growth rate of passengers in Schiphol

In the case of cargo operations the behaviour is quite similar. As it can be appreciated in Figure 3 the amount of tons has been stable during this and the previous decades but due to the developments and the type of products transported to and from the region Schiphol is servicing it would be considered that the value of these cargo has increased.

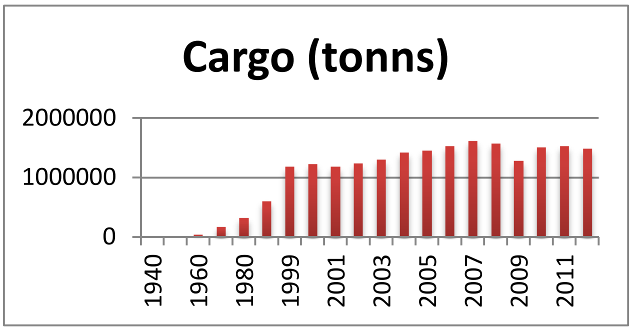

Figure 3- Cargo Growth

The case of air trafic movements (ATM) which sometimes is the one that illustrates in the best way the level of saturation of an airport shows that the current ATM operations (423k) are growing towards the declared capacity of 510,000 ATM. In the coming years the saturation and the consequences of it already are and will remain a big issue in the Dutch agenda.

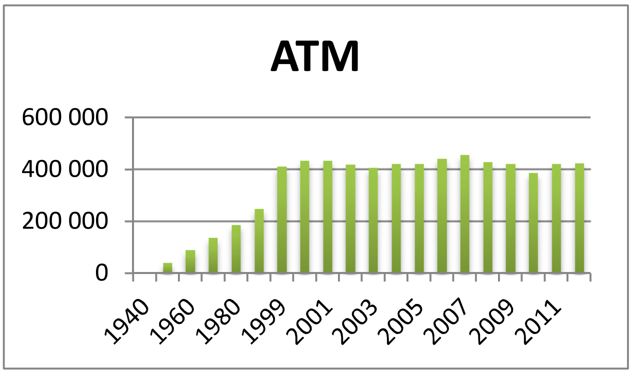

Figure 4- ATM growth in Schiphol

For all these reasons the national government is interested in developing a system of airports that serve for the purpose of the region [7]. The airports involved in the forthcoming project are Schiphol (as the main one), Rotterdam (already saturated with business, VFR and charter traffic), Eindhoven which currently has only some low-cost-carriers and Lelystad which currently is not serving any commercial ones.

Figure 5 illustrates the level of saturation in the different airports in the region of The Netherlands. In the case of Lelystad it illustrates its current capacity which is calculated for the general aviation.

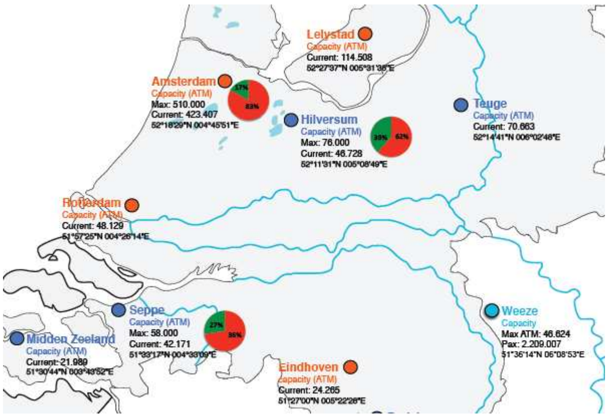

Figure 5- The map of North Holland Region

As it has been previously mentioned, Schiphol has a level of saturation of 83%; this level of saturation reflects the problem Europe is facing nowadays as it has been stated by EUROCONTROL [8]. The Dutch politicians have estimated that with proper investment in Lelystad and Eindhoven the level of operations of Schiphol (implementing the airport system) could be increased to 580,000 ATM. The previous scenario might be achieved through the management of the traffic between Schiphol as the main airport serving and the use of 3 secondary ones, in this case the question that arises is which type of traffic should be diverted to which airport?. A secondary question is what the impact of the new airport system is on the use of the airport capacity of the other secondary and tertiary airports in the Netherlands (inclusive the border region with Germany and Belgium). It is important to assess whether or not current GA-traffic at Lelystad and Eindhoven can be diverted to other regional airports (a knock on effect of the new airport system).

Montreal, San Francisco among others are examples of failed efforts for developing this airport systems [3]. Therefore planning experts have identified that in order to develop a self-sustained airport system it is necessary to have at least a minimum of 14 million of originating passengers which in the case of Schiphol this number has been reached long time ago. Based on the information presented it seems that an airport system for the Netherlands looks attractive and is an option which should be evaluated from different scopes and using diverse techniques.

REQUIREMENTS FOR A SIMULATION MODEL

In this section the methodology and requirements for assessing the performance and the assumptions for developing the airport system will be presented.

The evaluation of the airport network for the Netherlands will be performed through the development of a set of scenarios which will take into account the different characteristics of the airports that are involved in the system, namely Schiphol, Eindhoven and Lelystad. As a second step the knock on effects on the other airports in the region will be evaluated. The second step will take into account the impact on general aviation and special services for Dutch regions that are served by regional airports.

SIMULATION METHODOLOGY

Simulation is very-well known technique which has been used traditionally to evaluate systems performance through a series of experiments with the developed model. Figure 6 presents the traditional methodology for the simulation approach [1].

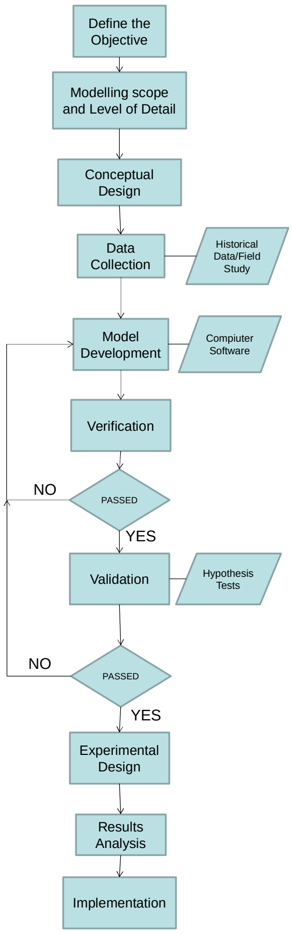

Figure 6- Simulation Methodology

This general flowchart presents the different steps that must be followed in order to analyse, validate and get a deeper understanding of the system under study. There are some key steps which must be performed properly in order to have useful and valid conclusions for the system.

The first step (objective definition) is very important because it will lead the remaining ones. Once the objective of the study is set up then it is relatively easy to define the required level of abstraction for the developed model. The level of abstraction will depend on the pursued level of insight about the system under study. Sometimes simulation models based on analytical or empirical rules are sufficient for the objective pursued while in other occasions a very high-level of detail is needed for understanding the dynamics involved in the system.

The conceptual design is a step where the modeller should have the first approach for the model and during that step the initial requirements for the data collection are defined.

Data collection should be performed according to the previous step, this phase is also very important because depending the quality of the data will be the outcome of the developed model.

The following step (model developing) is normally performed using of-the-shelf tools or developed by the modeller through a general-purpose language such as C++,VB,Java, Etc.

After the model has been developed a cycle for verification is performed, in this phase it is evaluated that the developed model behaves in accordance with the conceptual model. At this step the model cannot be considered that it represents properly the system under study therefore it makes no sense to experiment with it until the next step is performed.

Validation is the process of verifying that the developed model represent reality with sufficient level of reliability. There are several quantitative and analytical tests that can be performed in order to determine the level of confidence that can be put in the model [1]. The remaining steps are straight forward; in the experimental design, the different configurations are evaluated and some simulation runs are performed in order to obtain information for the research question.

Once the analysis of the experiments is performed, some conclusions can be taken based on the information provided by the work with the model. At this phase all the previous steps come together in order to propose some improvements to the system under study, if all the steps have been properly performed then the conclusions make sense ad the decision maker can take some actions over the original system based on the study performed with the model.

METHODOLOGY FOR THE SIMULATION OF AN AIRPORT SYSTEM

The following subsection proposes a methodology for the assessment of the future performance of an airport system using simulation techniques.

Traditional simulation techniques have been developed for the analysis of dynamic systems where there is a reasonable number of elements that interleave in a clear way. On the other hand it is typical to perform a bottom-up approach or top-down for the development of the model. Depending on the kind of approach the limits of the model must be established. The modelling and simulation of an airport system present a lot of characteristics and dependencies that make the development of a proper model a particular challenge to be faced. The following table presents some of the most important ones that must be taken into account for the development of a simulation model.

Table 2-Requirements for a simulation model

REQUIRED DATA	DESCRIPTION
Schiphol Current and Future Operation Capacity	Mill. Passengers, Ops./hour. This information will be used for validation purposes.
Environmental Restrictions	These and other restrictions will impose the limit for the future operations of the network.
Ultimate Capacity	The simulation models will be used to assess the practical capacity of Schiphol and foreseen the one for the future network.
Current Level of Service, Delay thresholds	The current level of service (level usage) and delay information is a key issue in order to determine the practical capacity of the network and the future capacity of each one of the airports that participate in the system. To be extended in second step with regional airports.
Causes of Delay	In order to propose new configurations and managerial schemas it is necessary to identify the causes of the delay which is the one that determines the practical capacity of the individual airport and it will be in the future system.
Runway Configuration	In the case of the main Airport, it will be useful to understand the current configuration and the different options that could serve for a future re-configuration of commercial transport.
Aircraft Mix (commercial Flights)	This variable is also a very important one due to the restrictions imposed depending od the type of aircraft using the runway.
ATM policy in the Netherlands	This restriction might affect the actual and future capacity of the system.
Breakdown of IFR or VFR operations	This information will be useful for validation purposes and it will determine the distributions of operations throughout the year.

Assumptions and Limitations

The simulation model will be performed making use of a two-layer approach. Layer A will be a top one which will take into account identified dependencies and high-level relationships resulting from the interaction of the simulation models at a lower-level. Layer B will be composed of different models, mainly the different models of the three airports that compose the system. Figure 7 illustrates the hierarchal representation of the simulation model. The next step will be to define the layers for the regional airports that are involved because of the knock on effects due to the forming of the Airport System.

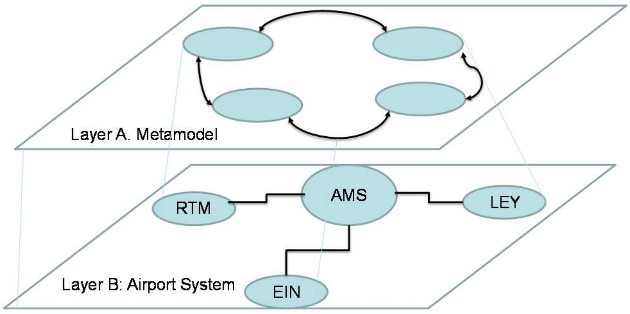

Figure 7 – Two-layered approach for the simulation of an Airport System

Conclusions

The simulation of an airport system is a challenging process that has not been addressed performing an approach that uses simulation models at different abstraction levels. In this article the initial approach for a simulation model of these characteristics is presented. This model will be developed for the evaluation of a problem of general concern in the Dutch region that involves the main airport in Holland and three secondary airports, two currently in operation of low-cost carriers and another one which currently is used for general aviation. Simulation approach is considered a suitable one for these kinds of problems. Furthermore the model will enable decision makers evaluate beforehand the problems and practical capacity of the future network.

Acknowledgments

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MEASURING INTERFERENCE GNSS WITH VERTICAL GUIDANCE

Prof. Ing. Andrej Novák, PhD.
Department of Air Transport, University of Žilina, Slovak Republic
Andrej.Novak@fpedas.uniza.sk

Abstract *– This paper describes the consistent preview of the testing and measuring parameters interference of GNSS signal with vertical guidance. The Global Navigation Satellite System (GNSS), as a source of position information available worldwide is considered as a key enabler to future navigation.*

Key words – GNSS, GPS, Galileo, GLONASS, SBAS, GBAS

INTRODUCTION

The potential for interference exists to various extent in all radio navigation bands. As with any navigation system, the users of GNSS signals must be protected from harmful interference resulting in the degradation of achieved navigation performance. Current satellite navigation systems provide weak received signal power – meaning that an interference signal can cause loss of service at a lower receiver power level than with current terrestrial navigation systems. Interference exist wherever the GNSS signal is authorized for use. GNSS is however, more resistant to misleading navigation errors from interference signals than current terrestrial radio navigation systems. [1]

Spectrum allocations. Both current core satellite constellations, GPS, Galileo and GLONASS, operate using the radio frequency (RF) spectrum allocated by the International Telecommunications Union (ITU). States authorizing GPS, Galileo or GLONASS based operations have an obligation to ensure that their national frequency allocations and assignments in the 1559-1610 MHz band do not cause interference to GPS, Galileo or GLONASS aviation users. Similarly, services operating in the adjacent bands should not generate harmful interference to GPS, Galileo or GLONASS. GPS, Galileo and GLONASS operate using spectrum allocated to the aeronautical radio navigation service (ARNS) and radio navigation satellite services (RNSS). GPS, Galileo, GLONASS and SBAS operate in segments of the 1559-1610 MHz frequency band allocated to ARNS and RNSS. The GBAS operates in the 108-117.975 MHz band allocated to ARNS

SOURCES OF INTERFERENCE

In-band sources. A potential source of in-band harmful interference is that of fixed-service operation in certain States. There are primary or secondary allocations to the fixed-service for point-to-point microwave links in certain States in the frequency band used by GPS, Galileo and GLONASS.

It is expected that States authorizing GNSS operations endeavor to ensure that existing and future frequency assignments in the 1559-1610 MHz band with the potential to interfere with the GNSS operations be moved to other frequency bands.

Out-of-band sources. The potential sources of interference from services operating in bands outside the 1559-1610 MHz band include harmonics and spurious emissions of aeronautical VHF transmitters, VHF and UHF digital television (TV) broadcast stations, and other high-power sources. Out-of-band noise, discrete spurious products and intermodulation products (IMP) from radio services operating near the 1559-1610 MHz band can also cause interference problems.

Studies have shown that commercial VHF transmissions do not pose an operationally significant threat to GNSS users. However, further consideration should be given to this threat for specific VHF transmit antennas located in the vicinity of a runway and approach areas. The digital television stations do pose a threat to GNSS. Given current limitations on out-of-band emissions from the TV transmitters, it is feasible for a transmitter operating within specifications to radiate significant power into the GPS L1 band. Future digital TV systems or LTE network such as High Definition TV MPEG-4 or 3G cellular networks may be capable of causing significant interference to GNSS receivers. Therefore, there is a need for mitigation strategies to prevent operational impacts to GNSS aviation users operating in the airport vicinity. As the spurious emission characteristics of digital TV transmitters change over time (due to maintenance, weather conditions, etc.) there will be a need for an on-going interference mitigation strategy on the behalf of the affected air traffic service provider.

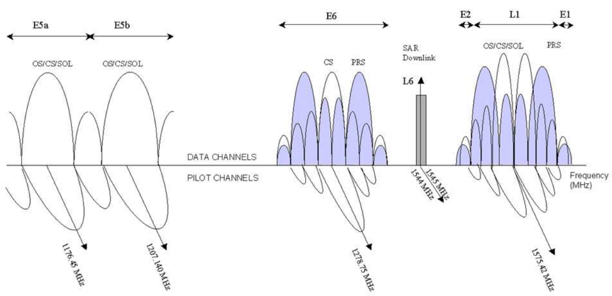

Figure 8. The navigation signals from Galileo satellites. (Source: www.easa.int) [7]

On-board sources. The potential for harmful interference to GNSS on an aircraft depends on the individual aircraft, its size, and what transmitting equipment is installed. The GNSS antenna location should take into account the possibility of on-board interference – mainly emanating from satellite communication equipment.

On large aircraft sufficient isolation between a transmitting antenna and a GNSS receiving antenna can usually be obtained to mitigate an interference problem. Transmitters of particular interest are the satellite communications equipment and VHF transmitters. The possible generation of intermodulation products on the aircraft from one transmitter with multiple carriers or multiple transmitters is controlled by a combination of transmitter filtering and frequency management. Some on-board interference could be due to harmonics generated by weathered joints and connections. It is recommended that air operators and State regulatory authorities take action to control such occurrences.

Avionics must be installed in accordance with industry standards to ensure that the equipment operates properly. These standards require testing for interference with and by other on-board systems.

The combination of appropriately shielded GNSS antenna cabling, separation of antennas and cables, and transmitter filters can solve most interference problems on-board small aircraft. Transmit equipment should be filtered within its own box or as close to the transmit-antenna port as possible. Additionally, some personal electronic devices are capable of generating sufficient in-band energy to interfere with avionics when used on-board an aircraft.

Malicious interference. Intentional malicious interference (jamming) to GNSS is also a possibility as it is to all radio navigation systems. Such unauthorized interference is illegal and should be dealt with by the appropriate state authorities (TU SR). Spoofing of GNSS receivers can be made extremely difficult with proper design of the receiver autonomous integrity monitoring (RAIM) and fault detection and exclusion (FDE) algorithms resident in aviation receiver equipment. [3,4]

REQUIREMENTS

Protection of the aeronautical radio navigation safety services spectrum is of paramount importance. International regulations state that the aeronautical radio navigation service is afforded special protection. The ITU Radio Regulation (RR) 953 states: "Members recognize that the safety aspects of radio navigation and other safety services require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies." Each State wishing to implement GNSS in support of air traffic services should ensure that regulations are in place to protect the aeronautical radio navigation spectrum allocated satellite navigation.

Interference detection, flight inspection and ground monitoring. Reliance on GNSS will require a State to re examine their respective capabilities to detect, localize and identify interference sources in order to minimize potential service disruptions in their flight information regions. This examination may result in planning efforts to investigate a need for airborne and ground-based systems for detecting and localizing potential sources of RF interference (RFI) to the GNSS signals.

In order to quickly identify and mitigate GNSS interference, a suite of systems may be required. Current technology provides RFI direction finding (DF) and localization capabilities available in four main platforms of interest – aircraft, land fixed (e.g., airport), land mobile (surface vehicle), and handheld. Cooperative efforts between the responsible regulatory organizations within a State, utilizing such a suite of systems, will provide the capability to locate and initiate measures to terminate sources of interference.

The extent of development a particular State may desire to implement should be predicated on the extent of operational services provided by GNSS and required availability for those services.

Interference is of primary concern for the approach and landing operations. States (CAA) and ATS providers have an obligation to validate the interference environment as part of the flight inspection of the approach operation. This can be carried out by a spectrum analysis of the frequency ranges of GPS, Galileo and GLONASS (and their respective augmentation signals). In this way it is possible to identify any unintentional interference that has the potential to disrupt approach operations.

GNSS receivers for approach operations, developed in accordance with guidance material in the SARPs, are required to achieve a minimum level of performance in the presence of both continuous wave (CW) and pulsed interference. To assess the potential impact of received signals, a comparison of the received spectrum with the interference masks specified in the SARPs is recommended. If no incursion of the CW interference is detected, the environment can be regarded as satisfactory. Since the interference masks are only valid for the most harmful CW interference, further (post-processing) analysis of the spectrum is necessary if broadband or pulsed signals exceed the interference mask.

To achieve the required measurement sensitivity, a suitable preamplifier and a resolution bandwidth of 10 kHz or less are required. It is desirable to analyse the frequency ranges of GPS (1575 ± 20 MHz), Galileo (1575 ± 30 MHz) and GLONASS (1598 − 20 MHz to 1604.25+20 MHz). It is recommended to use a digital signal processing (DSP) receiver rather than a spectrum analyser since only DSP-receivers allow a satisfactory sweep rate.

Extensive interference of the Galileo considerations took place in E5a/E5b concerning Distance Measuring Equipment (DME), the Tactical Air Navigation System (TACAN) and the Galileo overlay on GPS L5; in E6 concerning the mutual interference to/from radars and in E2-L1-E1 frequencies with regard to the Galileo overlay on GPS L1.

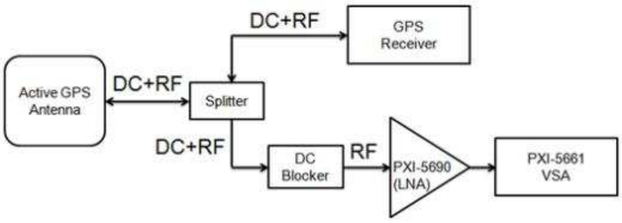

Figure 9. Measuring and analysing GPS Signal with PXI – 5661 Signal analyser.

If the primary aim is just to detect interference, a GPS or GPS/Galileo/GLONASS antenna with an appropriate pre-amplifier can be used. If a location of the interference source is to determined, a direction finding antenna or a multi-channel DSP receiver with direction finding capability should be used. The extent of the required interference monitoring equipment depends on the extent of operational services provided by GNSS and the required availability for those services. At airports with very high traffic that rely on GNSS as the navigation means for approach, it may be desirable to deploy a permanent interference monitoring station. In this way a timely notification to ATC of the threat of interference can be performed. Even with a flight inspection there is no full guarantee that all interference sources have been identified. For example, some sources may be intermittent transmitters or may come from mobile transmitters.

Therefore it is recommended aircraft are equipped with interference sensors (GNSS receivers with interference detection capability producing automatic reports). In this way the ATC operator can collect and analyse reports to obtain information on the spatial distribution of interference events.

In addition to the analysis of the spectrum, a GNSS receiver should be used to determine the impact of interference to the GNSS data.

Conclusion

The interference from unintentional or intentional sources can present a risk to the safe use of GNSS, noticeably for precision approach and landing operations. This is due to the fact that GNSS signals are of a low power when received by a user receiver. However, there are many steps that can be taken to overcome the influence of interference – technically, institutionally and operationally. From a technical perspective, judicious sitting of the aircraft GNSS antenna well away from satellite communications antennas and other high effective radiated power systems will provide mitigation from on-board interference sources. At the same time, consideration should be given to sitting the antenna to optimize airframe shielding from ground-based interference. Adaptive antennas, notch filters and INS coupling all provide increasing levels of protection from interference effectively negating the threat altogether.

Flight inspection of GNSS approaches for interference combined with the use of ground-based monitoring and the provision of timely status information to ATC will act to protect the users of GNSS. At an institutional level, both ATS providers and States must take all necessary steps to protect users of radio navigation satellite services by ensuring proper policing of the GNSS spectrum and strict application of the ITU Radio Regulations.

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THE APPROACH TO AIR LAW IN EU AND COMPARISON OF THE LEGAL SYSTEMS OF SLOVAKIA AND CROATIA

JUDr. Ing. Alena Novák Sedláčková, PhD.
Air Transport Department, Faculty of Operation and Economics of Transport and Communication, University of Žilina, Slovakia
alena.sedlackova@fpedas.uniza.sk

Abstract *– This paper is focused on the field of air law and its specific characterization in the way of comparison of legal systems of two Member States of EU and their approach to implementation of EU legislation.*

Key words – air law, space law, EU law, institutions,

INTRODUCTION

Air Law is a very specific system of law and the state or some international organization has the legal power to control observance of it. Air law is firmly entrenched in the principle of sovereignty of states; a state may lay claims to rights over the airspace above its territory. [1] The legal and philosophical bases of space law are the antithesis of those applicable to air law in that space law is grounded on the principle that outer space is the common heritage of the mankind. This means that, while the implementation of air law is heavily influenced by municipal law, space law is solely grounded on legal principles binding on the community of nations. In terms of jurisprudence, space law represents the Idealist school which supports community interest over national interest, while air law represents the Realist school which advocates that national interests are pre-eminent considerations for all purposes. [2]

AIR LAW VERSUS SPACE LAW

Space law is one of the most recent additions to international jurisprudence. It pertains to one of the most highly technology-intensive activities is an incontrovertible fact and was made evident with the successful launch of the space shuttle Columbia on the 12-th of April 1981, when the world entered a new age of space exploitation, leaving behind the period of space exploration which seemingly started in 1957 with the launch of the Russian Sputnik. The emergent philosophical problem posed by space law, in its offer to mankind of a new dimension of transport law and property law. [2]

The basic principle of space law is the common interest principle which emerged as a result of the first specific resolution on space law of the United Nations General Assembly in 1958. [3] The common interest principle has been incorporated in subsequent multilateral treaties, particularly the Outer Space Treaty of 1967. [4] The next very important treaty is The Moon Agreement of 1979 provides that, in the exploration and use of the moon, states parties shall take measures inter alia to avoid harmfully affecting the environment of the Earth through the introduction of extra-terrestial matter or otherwise. [5]

Air law is in different position. In this way the critical role is played by air traffic management which is not regulated by international convention owing to the permeating influence of the principles of state sovereignty. Therefore responsibility of states for their air traffic management rests heavily on the concept of sovereignty upon which air law has built its formation. Air law is based entirely on the concept of state sovereignty in air space and is essentially related to land. The concept dates back to early Roman times when :States claimed, held, and in fact exercised sovereignty in the air space above their national territories…and therefore the recognition of an existing territorial airspace of States by Paris Convention of 1919 was well founded in law and history. [2] [6]

The civil aviation is mainly international and there are development trends to consolidation / unification/. There is very strong relation between international air law, national air law and EU law, but sometimes someone declares that Air law Air law is fundamental only for pilots, it covers the origins of aviation law and the practical elements of the rules of air, personnel licensing, and operational aspects of Air Law as they affect the Airline Transport Pilot. [7]

SOURCES OF AIR LAW IN THE EU

The development of European ideals and the government of the problems of contemporary Europe are realized almost exclusive through EU law. After the accession to the convention of EU is EU law for our country very important and we have to implement EU legislation to our national legislation and the same case with the Air law.

Most EU law-making is carried out within the community pillar. Central types of legal instrument in Community law are: regulations, directives, decisions, recommendations and opinions. Regulations shall have general application. It shall be binding in its entirety and directly applicable in all Member States, they are mostly centralizing of all Community instruments and are used wherever there is a need for uniformity. From the date they are automatically incorporated into domestic legal order of each member state and require no further transposition. Directives are binding as to the result to be achieved. It leaves the choice as to form and methods used to implement it to the discretion of Member States. Usually 18 or 24 months after publication - by which Member States must transpose its obligations into national law. Decisions shall be binding in its entirety upon those to whom it is addressed. Recommendations and opinions shall have no binding force. [8]

The most important European civil aviation organization is EASA - European Aviation Safety Agency. It is the centerpiece of the European Union's strategy for aviation safety. Our mission is to promote the highest common standards of safety and environmental protection in civil aviation. Air transport is one of the safest forms of travel. As air traffic continues to grow a common initiative is needed at the European level to keep air transport safe and sustainable. The Agency develops common safety and environmental rules at the European level.

It monitors the implementation of standards through inspections in the Member States and provides the necessary technical expertise, training and research. The Agency works hand in hand with the national authorities, which continue to carry out many operational tasks, such as certification of individual aircraft or licensing of pilots.

It is interesting to compare of two legal systems in the field of Air Law. At this moment in the year when entered into force on accession treaty between the Republic of Croatia and EU we can simply compare application of international and EU principles of Air law of two states of EU: Croatia and Slovakia.

Slovak Republic is a member state of the International Civil Aviation Organization- ICAO since 1993, only one year after Croatia, which means that both countries are applying international regulations and standards for approximately twenty years. Both of the countries are members of EU. Slovakia has been a member since 2004 and Croatia became a member in summer 2013. At this moment there are still changing some regulations in aviation. For example, some changes need to be done related to pilot and staff certification. That means there are still some differences between these two countries.

Sources of Air Law in the Slovak Republic

In the Slovak Republic (SR) there are legislative which powers the National Slovak Council, the Government, the Ministry, and the Councils of self-governing regions.

Act No. 143/1998Coll. on the civil aviation and on amendment and supplement of some other legislation is the basic Slovak civil aviation legal act.

This Act regulates civil aviation, the operations of civil aircraft in the airspace of the Slovak Republic, competence and certification of aviation personnel of aircraft and other aeronautical products, the register of aircraft, installation and operation of airports and aviation ground equipment, conduct of air transport, aerial work and other businesses in civil aviation, civil aviation, the competence of state administration and penalties. This Act also applies to the operation of civil aircraft registered in the register of the Slovak Republic (referred to as "aircraft register"), which are temporarily outside the territory of the Slovak Republic. Slovakia has complete and exclusive sovereignty over its airspace.

The authorization for Ministry of Transport, Construction and Regional Development of the Slovak Republic is issued by law and by the national standards. The background of Act No. 143/1998Coll., on the civil aviation is in the Chicago Convention. The Convention on International Civil Aviation, also known as the Chicago Convention, established the ICAO in 1944. ICAO standards and other provisions are developed in the following forms: Standards and Recommended Practices - collectively referred to as SARPs; Procedures for Air Navigation Services - called PANS; Regional Supplementary Procedures - referred to as SUPPs; and Guidance Material in several formats.

In 1998 was established by Ministry of Transport the Civil Aviation Authority of Slovak republic. Description of its function is given on the official website of Civil aviation authority as: "The Aviation Authority is an organization that provides for execution of the State administration, professional state supervision in the civil aviation and the fulfillment of other tasks in civil aviation arising from the Aviation Act, other generally binding legal regulations of the Slovak Republic, of legally binding acts of the European Union, as well as international treaties by which the Slovak Republic is bound." [9] CAA is led by general director.

The next important institution in the field of civil aviation is the Aviation and Maritime Investigation Authority, which is an accident and incident investigation authority of Slovak republic for aviation and nautical matters. It is an independent part of the Ministry of Transport, Construction, and Regional Development of SR.

Sources of Air Law in the Republic of Croatia

In Croatia, organizations in charge of civil aviation are Ministry of traffic, Croatian Civil Aviation Agency and Agency for accident investigation. Croatia became a member of ICAO in 1992. The air traffic act NN 69/09,84/11 is a group of regulations determined by Croatian parliament. Civil aviation agency and Agency for accident investigations must obey that act. The next important part of national legislation:

- Regulations on the conditions and methods of providing air navigation services
- Regulation on the provision of ground handling services
- Regulation of airports
- Regulations on airports on the water
- Regulations on heliports
- Regulation on rescue-fire protection at the airport
- Rules on emergency medical services at the airport
- Airports Act

The air traffic act consists of these basic provisions and scopes:

1. The provisions of this Act shall apply to all civil aviation activities carried out in the territory and airspace of the Republic of Croatia
2. The provisions of this Act shall also apply outside the territory and airspace of the Republic of Croatia to aircraft registered in the Republic of Croatia.
3. Unless this Act provides otherwise, its provisions shall apply to all aircraft used by Croatian airspace, including foreign aircraft, in accordance with international agreements binding on the Republic of Croatia.
4. The Croatian air space is the space above the land and the Croatian territorial waters.
5. Activities in civil aviation to be performed in the territory and airspace of the Republic of Croatia in accordance with the provisions of this Act, the Convention on International Civil Aviation (referred to as the Chicago Convention), with all the extras of a multilateral agreement on the establishment of a European Common Aviation Area (referred to as the ECAA Agreement) and other international agreements binding on the Republic of Croatia.
6. In the air transport may be used an aircraft that meets the requirements of this Act, regulations made under this Act and in accordance with the relevant regulations of the European Union (referred to as the relevant EU regulations).
7. The provisions of this Act shall apply to military airfields and civil aircraft as provided in this Act.

Ministry of traffic is in charge of civil aviation politics, future development, representing Croatia in international organizations like ECAA, signing contracts and agreements with other countries or organizations, proposing new laws and regulations, ensuring application of all international agreements, supervision of civil aviation agency and agency for accident investigation, and providing strategic decisions in air traffic, except security decisions.

Civil aviation agency was established by Republic of Croatia in 2007. This decision was made by the parliament. Agency should perform all tasks in accordance with national and international law. In charge of the work of Agency is Croatian government. Agency's activities include work related to air safety, especially certification, supervision and inspection to ensure continued compliance with the requirements for the performance of air transportation and other air transport services.

The agency, as part of its activities, in collaboration with the Ministry, is participating in international activities, including negotiating processes at the conclusion of international agreements, meetings organized by the International Civil Aviation Organization (ICAO) and other international organizations and institutions in the field of air transport, taking part in the work of their professional bodies and working groups, and works with international bodies in charge of civil aviation. There is a council providing leadership for agency. Agency Council consists of five members. Members are recommended by minister, and appointed by the government for the term of four years. After that they could be appointed again. President and vice president of the council are chosen and appointed by government. Council members cannot be employees of the agency.

Agency for accident investigation performs investigation of accidents and serious incidents, as well as activities of interest of Republic of Croatia. Same as Civil aviation agency, Agency for accident investigations was founded by Republic of Croatia. [10]

Conclusion

Both of countries are members of EU and must apply all rules and regulations that EU requires, so we won't be focused on these laws. The same principles in accordance with EASA regulations are applied in Croatia as in Slovakia and legal institutions are similar.

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FLIGHT SIMULATION TRAINING DEVICE IMAGE GENERATORS REQUIREMENTS

Ing. Ján Pitor, PhD.
Air transport department, University of Žilina, Slovakia
janpitor@fpedas.uniza.sk

Vidor Czvedler
Air transport department, University of Žilina, Slovakia
czvedler@gmail.com

Abstract *– This paper provides overview of historical flight simulation training device (FSTD) visual systems development, actual levels of FSTD under FAA and EASA regulatory framework and discusses the possibility to construct a universal full flight simulator certifiable under both regulatory system from image generator perspective.*

Key words – flight simulation, image generators, training.

INTRODUCTION

Air Transport Department of the University of Zilina cooperates with Virtual Reality Media, a.s. company on project " The research on virtual reality elements application: the significant improvement of simulator performance characteristics " (CODE: 26220220167).

In scope of this project Air Transport Department will engage bachelors and masters degree students into activities connected with real world helicopter data collection and identification of flight model parameters using software.

In addition to these activities, students will be engaged in studies of the necessary standards and regulations for flight simulation with an emphasis on visual systems and further processing of such information. Based on the previous analyses, image generator requirements will be set, together with measurement methodologies. Influence of new image generators parameters on human factor will be also assessed, as well as experimentally verified.

This paper will publish initial outcomes of the project concerning full flight simulator regulatory requirements in the field of image generators, accompanied by historical background of visual systems evolution.

HISTORICAL BACKGROUND OF IMAGE GENERATORS EVOLUTION

One of the first simulators was constructed in 1910 as the Sanders Teacher. It was a modified aircraft mounted on a hinge connected to the ground. The students learned how to manipulate the controls and to maintain equilibrium by balancing in strong winds.

When the world war came, a necessity arose to teach to fly as much people as possible in the shortest possible time. Because of this there was a strong growth of accident rate, leading to tests of coordination and reaction times.

In these times it was believed that the vestibular system works in the air the same as on the ground. Later it vas recognized that it is not true. On the basis of this knowledge a new device was constructed in 1917, called Ruggles Orientator. This device consisted of a seat mounted in a gimbals hinge which enabled rotation of the student in all three axes.

Figure 1 *– Amelia Earhart riding Ruggles Orientator* (1)

The next step in flight simulation evolution was the „Link trainer“, called also „Blue Box, which was constructed in years 1927 to 1929. It was a device used for teaching of flight in reduced visibility and bad meteorological conditions. This device was widely used mainly during the Second World War by nations of both sides.

Link trainer was at first a device without visual system. Later models were upgraded by inclusion of a scenery painted on walls of the training room where the device was positioned. In 1939 Link created a simulator featuring a dome with depiction of stars. The stars could be positioned according to given time and aircraft position. This device was used mainly for night flight training.

The first visual systems are dated to late 50s. A small physical model of terrain was used. This terrain was lit and a camera moved above the terrain according to the movement of aircraft. The terrain was limited to the vicinity of one or more airfields. The extent of terrain was enlarged in military applications in order to simulate low level flights and attacks. These models were later substituted by digital image generators

In 1948 Curtiss-Wright developed the first cockpit simulator for Boeing 377 Stratocruiser of Pan American airlines. It was also the first type-specific cockpit flight simulator. It didn`t contain any visual or motion system, but it was able to simulate operational procedures on exact copy of the cockpit layout.

The occurrence of digital computers in 1960s led to digital visual models, providing much greater diversity. In 1972 Singer-Link company created a display accommodating collimating lences, providing the possibility to extend focal length to any distance.

The first systems able to generate image were developed by General Electric Company for space usage. The first versions produced so called „ground plane“. Later systems incorporated the third dimension even without any defined 3d model of the terrain.

The next step by E&S company was a complex simulation system for military as well as commercial usage. This system encompassed simulation in the air, on the ground and in the water. It was up to the costumer what tasks were trained on these devices.

In 1980s Defence Advanced Research Projects Agency started with development of a network of great extent called SIMNET. This network was designed so that hundreds of simulators (tanks, airplanes, etc.) could send their position, health or other attributes in a mutual simulated environment. It was used for example by US army when training for deployment in Persian gulf in 1991.

As the image generators evolved, there were two more major problems to solve:

- Restricted display design - Singer-Link displays from 1972 had horizontal visual field of view only around 28 degrees. In 1976 a series of new models with greater field of view was introduced. The field of view reached values of 35 degrees and the new units were called WAC Windows (Wide Angle Collimated Windows). Several of these devices had to be installed into the simulator in order to achieve a field of view sufficient for the pilot in training. Single pilot simulators usually consisted of three units (left, centre and right), providing a field of view of 100 degrees horizontally and 25 to 30 degrees vertically.
- Viewing angle – a disadvantage of all these displays is too narrow viewing angle. This posed no problem if the device is a single pilot simulator, but for multi pilot simulators if one pilot looked into the second pilots display, he saw very distorted image. Because of this phenomenon, it was necessary to develop a system providing much greater field of view in order to enable a clear sight without distortion to both pilots.

A breakthrough came in 1982, when a British company Rediffusion company of Crawley introduced Wide-angle Infinity Display Equipment system.

This system used a big, curved mirror in order to observe reflected image on a homogenous surface for both pilots sitting side by side. The image was projected on a big screen situated above the cockpit. Image from this screen was then reflected thru the glass mirror. In order not to use heavy and brittle glass, a light reflexive material on a mylar sheet was utilized.

This principle is used in majority of full flight simulators of Levels C and D. Originally, the cross cockpit system consisted of three projectors providing horizontal field of view of 150 degrees and vertical field of view of 30 degrees. By extension to five projectors, the horizontal field of view increased to 240 degrees.

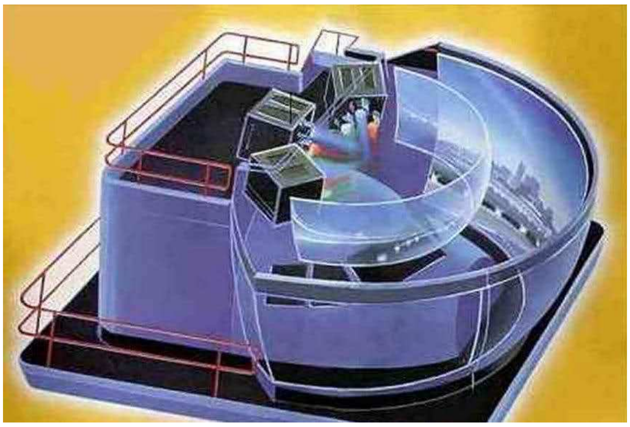

Figure 2 *– Cross-Cockpit Collimated display system* (2)

HELICOPTER FLIGHT SIMULATORS REGULATORY REQUIREMENTS

Performing standards and regulations analyses at the Air Transport Department we aimed at establishment of common requirements of EASA and FAA. This should lead in future to the possibility to construct flight simulators certifiable under both regulatory systems at the same time.

On the US side the regulatory requirements are established by 14 CFR Part 60. From this regulation, these parts deal with helicopter flight simulators:

- Appendix C to Part 60 - Qualification Performance Standards for Helicopter Full Flight Simulators
- Appendix D to Part 60 - Qualification Performance Standards for Helicopter Flight Training Devices

On the EU side the regulatory requirements are established by EASA CS-FSTD (H) - Certification Specifications for Helicopter Flight Simulation Training Devices. This regulation replaced in 2012 obsolete JAR-STD

1H dealing with FFS, JAR-STD 2H dealing with FTD and JAR-STD 3H dealing with FNPT. This action unified the regulatory requirements of the three parts and removed duplicate provisions.

I this paper we will deal with all three categories of of devices defined in CS-FSTD (H), i.e. FTD, FNPT and FFS. 14 CFR Part 60 doesn`t contain FNPT at all, however it defines more levels of FTD, from which some have characteristics close to FNPT. CS-FSTD (H) defines FTD levels 1 to 3, in contrast with 14 CFR Part 60, which defines levels 4 to 7. Levels 1 to 3 were excluded from this regulation due to coverage by other regulations. Apart from FFS the levels between FAA and EASA are not identical. The following table shows comparable levels of FTD and FNPT s with similar regulatory requirements.

Table 1 –FNPT and FTD levels comparison

FAA	FTD 1	FTD 2	FTD 3	FTD 4	FTD 5/6
EASA	FNPT I	FNPT II	FNPT III	FTD 1	FTD 2

This inconsistent levels definition does not facilitate the situation regarding establishment of common core requirements on image generators, as the allocation from the previous table is not exact. In reality, the requirements are often totally different or the regulated parameters are incomparable between the two regulations. In spite of this it is possible to design a device that could suffice requirements of both regulatory systems, as is the custom in the industry. One type of device may be modified in compliance with customer needs.

FFS Requirements

According to EASA CS – FSTD (H), a Level A FFS shall have a visual system capable of providing at least a 45 degree horizontal and 30 degree vertical field of view simultaneously for each pilot, increasing these values to 75 and 40 degrees respectively for Level B. Levels C and D shall have “Continuous”, cross-cockpit, minimum visual field of view providing each pilot with 150 degrees (level C) or 180 degrees (level D) horizontal and 40 degrees (level C) or 60 degrees (level D) vertical.

In comparison, according to 14 CFR part 60 a Level B simulator must provide a continuous field-of-view of at least 75° horizontally and 30° vertically per pilot seat, where both pilot seat visual systems must be operable simultaneously. For a Level C simulator these values are increased to 146° horizontally and 36° vertically per pilot seat. This is further increased to 176° horizontally and 56° vertically for a Level D FFS

The 14 CFR part 60 does not define requirements for Level A FFS, as there no Level A helicopter full flight simulators under FAA regulations. It can be seen that the requirements for particular levels are quite similar. It is clearly possible to construct with ease a simulator sufficing requirements of both regulation systems.

Further requirements state required scene complexity, night lighting system parameters, contrast ratios, visual cues and other parameters. However, majority of requirements under FAA regulation doesn`t have an equivalent EASA requirement and vice versa. This also provides an easy possibility to construct a unified simulator.

One of common requirements from both systems is complexity of scene content resolution, where according to EASA CS-FSTD (H) for a Level C, the FFS has to provide scene content comparable in detail with that produced by 4,000 polygons for daylight and 5000 visible light points for night and dusk scenes for the entire visual system. For Level D these figures are increased to 6000 and 7000 respectively.

According to 14 CFR part 60, for both Level C and Level D full flight simulators, total scene content must be comparable in detail to that produced by 10,000 visible textured surfaces and 6,000 visible lights with sufficient system capacity to display 16 simultaneously moving objects.

The requirement for number of polygons is much higher on the US side, with requirement for number of visible lights falls in between the two FFS levels on EASA side.

Conclusion

When combining these two regulations, we have to take the stricter criteria from both systems, meaning an FFS providing 10000 visible polygons and 7000 visible lights may be certified as either C or D level FFS in both regulatory systems. Designing of such visual system may mean more effort and resources given into the development, but provides greater flexibility of certification and availability to customer.

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

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IMPACT OF CLIMATE CHANGE ON AVIATION VULNERABILITY

Reinhard Schmitz, Michael Kreuz, Dr. Annette Temme, Dr. Thorsten Mühlhausen
Institute of Flight Guidance, DLR German Aerospace Center, Germany
reinhard.schmitz@dlr.de
michael.kreuz@dlr.de
annette.temme@dlr.de
thorsten.muehlhausen@dlr.de

Abstract *– The objective of this paper is first to identify the conditions robustness and resilience of the air transport system. Therefore, in-depth analysis on air transport mode specific disruptions and their consequences for the overall system´s performance are elaborated. In addition, a conceptual definition of the conditions robustness and resilience within the air traffic management (ATM) framework based on Gluchshenko [10] is developed aiming for a distinct differentiation and a solid basis for performance measurements. This paper aims to set up a holistic approach on how to define the interaction of robustness and resilience in the context of vulnerability in the ATM system in consideration of existing practices such as the scoring method of the weather algorithm developed by the ATM airport performance (ATMAP) group [13]. Thus, this paper intends to deliver the basis for future developments that allow a more objective evaluation of actions to enhance preparedness against disrupting weather events of the air traffic system in order to reduce vulnerability.*

Key words – climate change, aviation industry, vulnerability, resilience.

INTRODUCTION

Of all modes of transport, aviation in particular has shown high vulnerability in terms of weather phenomena, which will fostered by the climate change. Climate change leads to an increase in extreme weather events resulting in more frequent and also severe disruptions in air traffic [11]. Due to the imprecise nature of climate change forecasts, enhancing preparedness against such events is difficult. As a consequence, maintaining standards in service delivery is a great challenge and may even overcome airports capabilities as seen in total shut down at London Heathrow or Paris Charles de Gaulle in December 2010 due to heavy snow falls.

In most cases, the disruptions due to severe weather events are less serious. The severity of disruptions varies from small deviations in flight plans up to cancellations of flights for a whole region as e.g. during the volcanic eruption of Eyjafjallajökull from 14 April 2010. The airspace closures resulting from the eruption led to the disruption of some 100.000 flights and 10 million passenger journeys [15] [6]. In order to allow an estimation of the impact of such disruptions, first a conceptual definition of the conditions robustness and resilience within the air traffic management (ATM) framework based on Gluchshenko [10] is developed in section II. This gives a distinct differentiation and a solid basis to define vulnerability of the ATM system with respect to severe weather events in section III. In the following section IV, measures to cope with this vulnerability and impacts on the traffic flow are analyzed for selected examples and allocated to either the term robustness or resilience depending on the system´s reaction on these phenomena and the actions taken.

The long-term development due to climate change of the analyzed severe weather phenomena is investigated in section V, followed by proposals in section VI on how to monitor and evaluate the vulnerability of the ATM system with respect to these weather events in order to learn from the ordinary as well as occasional disruptive event.

RESILIENCE AND ROBUSTNESS

Resilience is considered as a system´s ability to recover from disruptions within a given time interval and return to the initial state. Within the ATM framework based on Gluchshenko [10] *disturbance* is defined as a factor or a phenomenon that may case stress within a system. It is relative to the specified reference state and can be categorized by parameters such as type, frequency or intensity. *Survival or lethal stress* are possible reactions of a system caused by a disturbance. The framework identifies four properties of the ATM system:

- **Robustness** is described as a system´s ability to absorb disruptions. Doing so, a system does not experience any stress since a disturbance has occurred. Changing the dedicated runway operations due to shifts in the wind direction during the day might be an example for the system´s robustness.
- **Resilience** by "transient perturbation" indicates the system´s ability to respond on a disturbance within a defined time horizon and return to the reference state.
- **"New reference state of system"** defines a state with „permanent perturbation" meaning that the deviation becomes fixed over time and a new state of the system being different from the reference state is established.

- **“Modification of system“** is caused by the system’s reaction „lethal stress” (see Figure 1). The system can or should not respond on a disturbance.

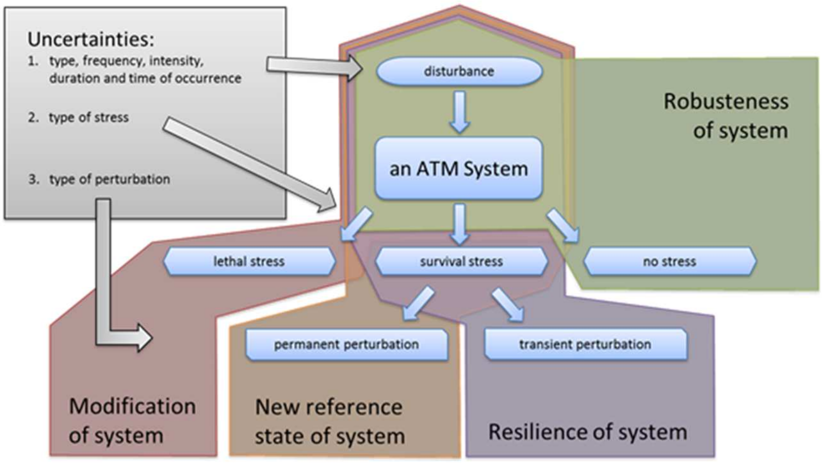

Figure 1 – State of ATM System from [10]

In the paper by Gluchshenko [10] an airport with a throughput capacity defined by its runway system is defined as the reference state and a winter season as the disturbance. If the airport manages to keep the reference state over the winter period, robustness in terms of the ability to absorb stress caused by disruptions is demonstrated. This situation is exemplary for those airports operating below their nominal capacity. If the throughput is increased and the airport is hit by lethal stress in consequence it has to be modified by e.g. substituting flight movements by trains or adapting the equipment to the challenges ahead.

Performance values of great importance in the ATM system are amongst other the airside capacity including take-offs and landings as well as the total amount of movements per time unit. Flight data such as the “OOOI data” (Off-block, Off-wheel, On-wheel, In-block) are taken as reference points for flight status. Delay assessments for average delays per take-off/landing (in minutes) for the off- to in-block period can be performed by comparing scheduled and actual times. Differences reflect the performance of an airport or off the air transport system (en-route). Additional values such the average delay of a single flight or the percentage of delayed take-off and landings at a defined airport are given in the reports by Central Office for Delay Analysis (CODA). Air Traffic Flow Management (ATFM) delays result from regulations measurement by the Central Flow Management Unit (CFMU) due to capacity shortages in the en-route sector or at airports. In consequence, affected aircraft are not allowed to take-off and stay on ground at the airport of origin.

VULNERABILITY WITH RESPECT TO SEVERE WEATHER EVENTS

Definition: Vulnerability of a person, a social group, an object, or a system in view of existent hazards, risks, crisis, stress, shocks, or damaging events that already occurred. Usually, damage in this context denotes a reduction or even inoperability of important functions [7].

The scoring method developed by the ATM Airport Performance (ATMAP) Group at the request of the Performance Review Commission (PRC) aims to support a uniform measurement of airport airside performance across European airports. Thereby, differences in airports´ infrastructure and equipment needs to be considered when evaluating their performance in bad weather conditions. But even given similar requirements differences in their performance may occur. The aim of the ATMAP weather algorithm is the separation of „bad weather days” that are used to evaluate the impact of bad weather conditions on the airport´s performance. Doing so, it assigns severity coefficients to different weather classes. Providing regular preconditions such as e.g. a defined separation of aircraft in the airspace analysis are based on METAR data being recorded every 30 minutes from 06.00am until 9.59pm. METAR is a message containing all safety critical meteorological observations for flight operations in a given airport and nearby airspace (up to 16 km from the airport).

- "Weather class" is a group of weather phenomena, i.e. single meteorological elements. The following weather classes are to be differentiated:
    - "Ceiling & Visibility",
    - "Wind",
    - "Precipitations",
    - “Freezing conditions" and

- o "Dangerous phenomena"

- "Coefficient" is a number of points being not necessarily linear to the severity of a weather class.

Coefficients of the weather classes are merged in one score for every META massage. An average of all scores of a day within a time interval of 16 hours is determined in order to be compared with a threshold value for a "bad weather day" with R >= 1,5.

Table 1 – Elements/Parameters of ATMAP - weather classes with high coefficients

Weather class	Description	Condition	Coe.
Ceiling and visibility	"Low visibility"-operations; ILS separation minima are increased leading to more complexity in the aviation system. Constraints for take-offs under CAT III conditions.	Approach CAT II – CAT III	4-5
Wind	Increasing impact of the wind on the aircraft speed over ground and in consequence on the airport´s performance. Threshold value for cross-wind component might be reached.	Wind speed > 30kt	4
Precipi-tations	Heavy precipitations require substantial equipment and complex procedures in order to provide safe take-off and landing procedures on runways.	FZxx,(+)SN	3
Freezing conditions	Heavy frost conditions even for airports in Scandinavia	T > 3°C and (+)(SH)SN, FZxxx OR T <= -15°C with visible moisture	4
Dangerous phenomena	These weather phenomena are dangerous for the safety of aircraft operations. However, their impact is not predictable.	TCU,CB and Cloud cover TCU,CB and Cloud Cover and (±)SHxx GS, FC, DS, SS, VA, SA, GR, PL, TS, +TS	3-12 4-24 18-24

As the algorithm describes the impact of extreme weather events on the actual airport operations, there is no claim to provide forecasts about the future performance of the airport. In consequence, conclusions made up based on this algorithm are limited:

- The position of the bad weather phenomena in relation to the runway system is of great importance in terms of evaluating its impact on the airport's operation performance. In the algorithm´s recent stage, this parameter is included.
- The time of the day at which the weather phenomenon occurs is not considered in the algorithm. However, this phenomenon may occur in both high traffic and low traffic phases over the day. As the traffic demand varies, this leads to different disruption patterns.
- Traffic within the night hours (10pm until 05.59am) are not considered but still can have an effect on the airport operations during the day. E.g. nightly snow falls can lead to heavy disruptions during the day or even to runway closures.
- In order to assess the impact of these even rare „dangerous phenomena" on the performance of airport operations, a description taking into account geographical position, duration, intensity and expansion would be necessary. However, their impact can be hardly foreseen as every phenomenon has its own characteristics.

Another problem is the scoring method as the scores determined do not offer any information about their meaning. Does a score of e.g. 30 mean that the runway system is about to be closed due to heavy disruptions or that countermeasures need to be taken in order to overcome possible disruptions?

Reactions to severe weather events

The impact of (extreme) weather phenomena on the performance in the air transport system can be specified depending on the demand and supply ratio as well as the type, duration and intensity of the disruptions as follows:

- (Under visual meteorological conditions Pilots take responsibility for separation between aircraft.)
- Intervention of air traffic controller on the traffic situation without any severe consequences on the performance, e.g. changing the dedicated runway operations due to shifts in the wind direction. This may lead to a temporary peak in the traffic demand with the overall demand being on a low level.
- Changes in the runway usage, e.g. prioritization of arrivals on a certain runway during fog conditions.
- Runway capacity is either reduced if weather conditions (wind, visibility) degrade or even turned to "zero rates" (temporary shutdown of a runway). In case of thunderstorms the complete runway system might be temporarily closed.
- In case of demand exceeding supply delay (ATFM, holdings) results in different characteristics (beginning from temporarily in- and outbound delay, start-up delay to extensive reactionary delays).

- Aircraft rerouting.
- Cancellations.
- Long-lasting effects over the day or with possible impact on the performance at the following day.
- Disruptions in airport related functional areas such as apron or baggage handling facilities.
- Other Impacts (e.g. on other modes of transport).
- Full-time closure of the airport.

A qualitative analysis of weather related events has been carried out based on recent reports and data collected by the Association of European Airlines (AEA) from January 2007 until March 2009 as well [2] [3] [4] [5]. Difference in the impact of these weather events can be classified in the following three groups [14]:

- Weather phenomena such as fog, wind, rain and others primarily cause disturbances at congested international and European hub airports. As a consequence of these weather events separation of aircraft has to be increased and, in terms of heavy rain falls, runway conditions as well as braking power are decreased leading to reduced runway capacity and different forms of delays or even cancellations. Changes in the runway traffic assignments (Istanbul International Airport) or runway closures when tail wind components are exceeded (Runway 18 at Frankfurt International Airport) result from these events. At London Heathrow International Airport approximately 700 flights over the period of three days were cancelled at Christmas time 2006 due to foggy conditions. Some of the 40.000 passengers were rebooked on flights from not affected airports or on other modes of transport (busses, trains). In many cases, disturbances occur due to "overlapping effects" such as weather related impacts as well as disruptions in operations. At Munich International Airport low visibility combined with freezing fog and inversion lead to 232 aircraft being delayed and 24 being cancelled in December 2007. However, returning back to the reference point within the same day is feasible if the weather events are just short-lasting (resilience).
- Long-lasting weather events such as snow falls or freezing conditions may lead to great disturbances at any airport including its complete shutdown. Multiple runway systems need to be removed from snow alternately. Freezing conditions at Frankfurt International Airport lead on a first step to massive delays for departing aircraft due to de-icing procedures and afterwards to a complete shutdown of the airport from 10:45pm for four hours (December 21st 2009). In total, 90 movements were cancelled with approximately 8000 passengers being stranded. Heavy winds or even hurricanes over a period of several days may cause disturbances affecting numerous airport related functional areas. Due to storms such as "Kyrill" (January 1st of 2007 or „Emma" March 1st 2008) some European hub airports were suffering from delays, cancellations, and daily punctuality values below 30 %. An example about the disruptions happening at Frankfurt International Airport in May 2008 due to thunderstorms and an assessment of the recovery times are given in Figure 3. Concerning events with heavy falls the airports´ preparedness to react on these events are of great importance. Vienna Schwechat International Airport was hit by 40 cm snow on January 17th leading to single runway operations from 11am to 8pm and a cancellation rate of approximately 65% of all scheduled flights for this day. Madrid Barajas International Airport was closed on January 9th due to snow fall with a recovery time of several days to return to regular operations (reference state). As a consequence, airport operations can initially be performed in a reduced mode only even though weather conditions have completely improved ("New reference state", "Modification of system").
- Weather phenomena such as strong winds at high altitudes or large-scale cumulonimbi (CB) may lead to re-routings (information provided by EUROCONTROL Area Control Center) and longer travel times.

Large-scale weather related disruptions are of great importance for the aviation industry as the problems occurring at the relevant hub airports may even have an impact on airports that have not been affected by these weather events so far. Especially the airline network over central Europe with its high density of important international hub airports seems to be prone to large-scale weather related events in particular (see Table 2).

- *Table 2 - Distances to Frankfurt International Airport*

Brussels Airport (BRU)	164 NM
Hamburg Airport (HAM)	223 NM
Munich Airport (MUC)	162 NM
Berlin Tegel Airport (TXL)	235 NM
London Heathrow Airport (LHR)	354 NM
Amsterdam Schiphol Airport (AMS)	198 NM
Paris Charles-de-Gaulle Airport (CDG)	242 NM
Vienna Schwechat Airport (VIE)	337 NM
Zurich Airport (ZRH)	154 NM

Figure 2 shows the distribution of wind intensity at selected airport over 16 years. It can be seen that there is a high divergence especially for very strong winds above 20kt between airports.

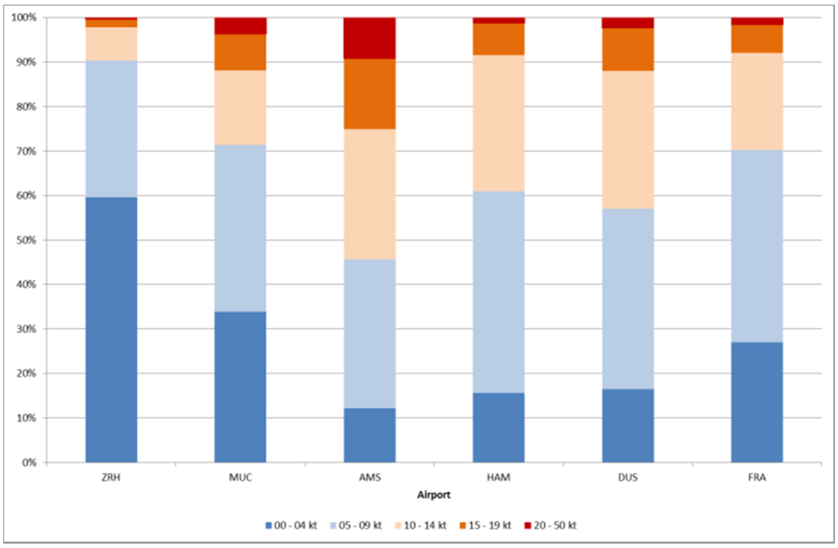

Figure 2 *– Distribution of wind intensity at selected European airports, winter season 1997-2012, 05:00 – 22:00 CET*

In the lists of the AEA there are numerous references on large-scale weather related disruptions with their consequences on the aviation industry being just partially described. These large-scale weather related disruptions (e.g. Kyrill as one example for partially active events) can be classified in regional limited ones or even those covering central Europe.

Some more severe large-scale weather conditions resulting in delays and/or flight cancellations amongst others are as follows [2] [3] [4] [5]:

- Low temperatures lead to disruptions in European air transport on January 9th 2009.
- Heavy snow falls over western Europe (January 5th 2009).
- Heavy wind and rain over the north of Europe (November 10th and 11th 2008). Snow falls and strong winds at high altitudes at leading European airports such as London, Helsinki, Dusseldorf or Vienna lead to a massive increase in the Air Traffic Flow and Capacity Management (ATFCM) delay.
- airports such as London, Helsinki, Dusseldorf or Vienna lead to a massive increase in the Air Traffic Flow and Capacity Management (ATFCM) delay
- Heavy rain showers over Great Britain (July 20th 2007) lead to massive disturbances in the baggage handling system
- Central and southern parts of England were hit by extensive flooding in July 2007 resulting in interruptions in the road and rail system.
- Low visibility and strong winds at high altitudes in England in April 2007 lead to restrictions in the arrival flow rate for up to 163 hours within 29 days of this month
- Great parts of Germany and the north of Italy on September 9th 2008 were hit by thunderstorms resulting in in- and outbound as well as reactionary delays.

Furthermore, even large-scale weather related disruptions outside of Europe have negative effects on the performance at European airports. Heavy snow fall and freezing conditions at the east cost of the United States lead to significant reactionary delays for those aircraft bound for Frankfurt International Airport. Moreover, heavy winds over the Atlantic Ocean on June 18th 2007 lead to massive delays of all flights bound for the US.

Severe Weather Events and Climate Change

Air traffic is considered to be very sensitive to weather disruptions. This is also documented by the monthly reports of the European Organisation for the Safety of Air Navigation EUROCONTROL [9]. Depending on time of the year and phenomena, weather is among the main contributors for delay. The European Aviation Safety Agency (EASA) registers weather as contributing but not as causal factor for incidents or accidents [8]. The reason for these facts can be explained by the high safety standards in aviation, which come immediately into action when weather phenomena with hazard potential appear. They initiate changes in operational procedures, which finally lead to the above mentioned delays.

Topology of aviation is characterized by single knots (airports) and not like road or rail by networks. Therefore, long term or large-scale disruptions are quite rare as destruction of infrastructure facilities occurs only punctual. But even weak weather phenomena can have an immediate impact on the traffic flow and therefore, the delay situation at airports. Due to the complex airline networks this disruption can lead to additional delays at further airports. Apart from airport disruptions also en-route traffic can be affected. Thunderstorms with cumulonimbus cause a lateral variation of trajectories. Additionally long term effects of climate change are expected. A rise of sea level may have impact on existing or planned airport facilities.

Consequences and possible protection

The European research project EWENT (Extreme weather impacts on transport systems) registered the significant phenomena for aviation together with their thresholds [11]. The following phenomena are most relevant for central Europe and can result depending on characteristic and magnitude in operational disruptions and additionally in destruction of infrastructure facilities. Possible protective action for the North American continent are collected in a report of the Transport Research Boards (TRB) [1].

Strong precipitation at an airport results in diversion and delay as rain can reduce the friction of the runway and consequently leads to changes in the operational procedures. In extreme situations with more than 30mm precipitation within an hour, visual restrictions can reduce the situational awareness, which may provoke incidents or even accidents. The high safety standard can be retained by adapting the operational regulations for these kinds of weather phenomena. But this may lead to additional delay. In case of long lasting rain, flooding and washouts can destruct infrastructure facilities. With proper layout of additional facilities like drain systems these risks can be mitigated.

Snow has quite similar consequences like strong precipitation. But additional snow clearing of the traffic area is necessary to maintain the flight operations. This process may disrupt the operational procedures, depending on the airport layout and cleaning capacity as runways have to be closed during that period. Therefore, only by provision of sufficient cleaning capacity the effects of strong snowfall can be reduced.

Hail reduces similar to strong precipitation the outside view and therefore, results in the same problems. In addition large hailstones have a high potential for damage, which affects aircraft and airports. Especially airborne aircraft must not fly into hail to avoid accidents. In future exacter weather prognosis can help to lower the risk [12]. For aircraft at the ground and buildings additional measures like an apron roof can reduce the damage.

Wind is still one of the most important factors in aviation. Knowledge about its characteristic and strength is essential for an exact flight planning to calculate fuel saving (with a high tail wind component) and on time trajectories. But wind has also impact on the configuration (landing direction and runway utilisation) of an airport, because operations should have a minimal tail wind component. Crosswind is also limited. For these reasons, quite low wind speeds can have a negative influence on airport operations.

Fog is a local weather phenomenon, which has a great impact on aviation due to the limited outside view, which can be accompanied by loss of situational awareness. Airports are equipped with an instrument landing system to minimise this impact for aircraft, which are equipped with an equal system to perform an exact approach under bad viewing conditions.

High temperatures have only a small impact on air traffic operations. On the one hand, the payload is decreased, but on the other hand an increase of average temperatures will reduce the need for de-icing procedures in winter. But high temperatures may result in higher cost for air conditioning and can also result in destruction of infrastructure. These impacts can be reduced by the use of appropriate materials.

Thunder storms are one of the most significant weather phenomena in aviation. They have impact on airport approach and departure operations (see Figure 3) as well as on en-route operations. Airports cancel operations during an acute thunder storm situation for safety reasons. Depending on airport size and number of movements unavoidable delay and cancellation may occur. In addition en-route traffic is affected by cumulonimbus, which has to be flown by. Apart from increasing flight distance and –time and the corresponding higher fuel burn, alternative routeing areas can be overloaded, resulting in additional delay or cancellations.

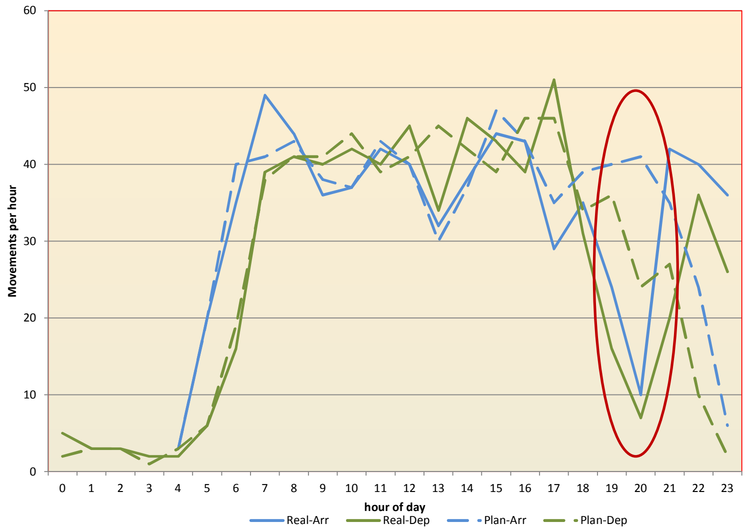

Figure 3 –Disruption due to thunderstorm and recovery phase, comparison of planned and operated flow (FRA, May 2008)

PERSPECTIVES

Assessing the impact of severe weather events on the European ATM system parameters of importance are besides the duration, type and intensity of the events the components of the ATM system. Bottlenecks of the recent ATM system are especially congested airports operating on or beyond their airside capacity. This can be seen at the international and European hub airports rather than at secondary ones. Even minor weather events can lead to disruptions in the flight plan. Severe weather events at these congested airports will result in limitations in the airside capacity, delays or re-routings due to increased separation minima and decreased runway conditions.

Special attention is given to extreme weather events such as long-lasting snow fall, freezing rain or thunderstorms. All airports independent of any size can be hit by these events that may both disrupt connections to other modes of transport and lead to partially or completely shutdown of an airport.

Another important aspect of the vulnerability deals with the size of the area that is affected by these extreme weather events. Central European airspace seems to be vulnerable against large-scale weather events in particular.

Concerning the assessment of an airports performance in times of extreme weather events, a first step for international and European hub airports should include an analysis of scheduled and actual take-offs and landings in terms of their punctuality. These analyses should offer information about the severity of disruptions beyond their impact on just one single airport.

Following Table 3 gives an example about the statistics of analyzed punctualities for arrivals at a virtual airport [14]. In the winter season of the year 2013 a total of 18 days is defined with a daily punctuality rate of less than 10 %. Overall punctuality rate is at 56 %.

***Table 3 -** Punctualities for arrivals on daily basis*

	Punctualities for arrivals on daily basis [%]							
	<10	10 - 15	15 - 20	…	80 - 85	85 - 90	>=90	Punctual. %
01	6	2	6	…	23	9	3	70
…	….	…	…	…	…	10	4	68
10	9	3	7	…	19	26	3	73
11	**21**	3	3	…	34	20	2	80
12	6	0	3	…	12	19	1	85
13	**18**	3	7	…	45	10	4	56

These analyses are complemented using statistics about the amount of daily movements at defined airports, re-routings as well as flight cancellations and METAR statistics according to the ATMAP algorithm. In addition, ATM stakeholder should be encouraged to document measurements that are taken and the status the system is inhered (system failures, runway conditions, long-lasting effects).

Jointly thinking about if and how an airport can return to a defined minimum state after extreme weather events is one of the great research needs in future work. In terms of resilience, a question of importance could be as follows: “Is there a chance to return to the reference state after a defined recovery time?”

CONCLUSION

Concluding, this paper offers an overview of the impact of extreme weather events on the performance of the aviation industry. Furthermore, it gives a definition of the conditions robustness and resilience within the air traffic management framework making up a solid basis for basis for performance measurements. Taking into account recent practices (ATMAP weather algorithm) this paper offers an enhanced objective approach in terms of evaluating activities in order to enhance the preparedness and to reduce the vulnerability and increase the resilience of the air traffic system against disruptive weather events.

Results show that large scale weather events may result in a strong disturbance of the air transport system. But each airport has its own scale of vulnerability:

- The ratio between demand and airside capacity is characteristic for each airport.
- Airports have their own metrological profile, as shown in Figure 2.
- Individual runway configurations with their own dedicated operations, but also the integration of airports with different obstacle structures and further special conditions define also the mode of operation of an airport.

As a consequence it seems to be useful, to define in a first step potentials of vulnerability of European airports, e.g. by using the proposed weather classification of the ATMAP group. By using it, several options can be identified, which helps to maintain at least resilient conditions.

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DEVELOPMENT OF THE GLOBAL AIR NAVIGATION SYSTEM

THE IMPLEMENTATION PROCESSES OF STRATEGIC PLANS

Ing. Filip Škultéty
Air transport department, University of Žilina, Slovakia
skultety@fpedas.uniza.sk

Abstract – *Global interoperability and harmonization are essential to making the seamless Air Navigation Services (ANS) system. In fact, most improvements can only be made through recognition of the need to cooperate at a global level. This requires a broader more inclusive vision, a wider planning perspective and planning for implementation of facilities and services over individual regions. This paper deals with the main regional initiatives, both NextGen and SESAR and its development. It is aimed to illuminate their roadmaps, processes and relationships. In addition it provides outcomes for further analysis.*

Key words – interoperability, harmonization, NextGen, SESAR

INTRODUCTION

„Aviation is the ultimate global enterprise"(Michael Standar, SJU). Air transport is a truly international business so global interoperability and harmonisation are essential prerequisites for this sector.

Interoperability is the capability of two or more networks, systems, components or applications to exchange information and to use the information exchanged for technical or operational purposes, so enabling them to operate effectively together. It relies on the application of uniform principles and common reference standards. It is important to note that global interoperability does not mean that the same system must be implemented everywhere – it should allow adaptable, scalable and regional solutions to be deployed in the framework of a globally interoperable aviation ANS system. [1] Therefore are created a variety approaches that will lead to seamless operations. As the most important initiatives for establishing the global air navigation system we can consider approaches of the European Union and the USA. Further paragraph are dedicated to FAA's NextGen and European SESAR.

NEXTGEN

Federal Aviation Administration's (FAA) initiative for ANS modernisation is The Next Generation Air Transportation System (NextGen). NextGen proposes to transform America's air traffic control system from an aging ground-based system to a satellite-based system in stages between 2012 and 2025. GPS technology will be used to shorten routes, save time and fuel, reduce traffic delays, increase capacity, and permit controllers to monitor and manage aircraft with greater safety margins. [2] Planes will be able to fly closer together, take more direct routes and avoid delays caused by airport "stacking" as planes wait for an open runway. To implement this the FAA will undertake a wide-ranging transformation of the entire United States air transportation system. This transformation has the aim of reducing gridlock, both in the sky and at the airports.

In 2003, the U.S. Congress established the Joint Planning and Development Office (JPDO) to plan and coordinate the development of the Next Generation Air Transportation System. FAA's Enterprise Architecture is the view of NextGen over 15 years. The first ten years of that is brought into sharper focus through the NextGen implementation plan. Tremendous consideration is given to linking the collaboration with SESAR to other countries. This is evident in the work with ICAO and other bilateral agreements with international partners. [4]

The FAA estimates that increasing congestion in the air transportation system of the United States, if unaddressed, would cost the American economy $22 billion annually in lost economic activity by 2022. [5] It also estimates that by 2018, NextGen will reduce aviation fuel consumption by 1.4 billion gallons, reduce emissions by 14 million tons and save $23 billion in costs. Each mile in the air costs an airline about $0.10-$0.15 per seat in operating expenses like flight crew and fuel. [5] Flying directly from one airport to the next and reducing congestion around airports can reduce the time and miles spent in the air for the same trip.

KEY ELEMENTS

NextGen consists of five elements:

- **Automatic dependent surveillance-broadcast (ADS-B)**. ADS-B will use GPS satellite signals to provide air traffic controllers and pilots with much more accurate information that will help to keep aircraft safely separated in the sky and on runways. Aircraft transponders receive GPS signals and use them to determine the aircraft's precise position in the sky. These and other data are then broadcast to other aircraft and air traffic control. Once fully established, both pilots and air traffic controllers will, for the first time, see the same real-time display of air traffic, substantially improving safety. The FAA will mandate the avionics necessary for implementing ADS-B.
- **Next Generation Data Communications**. Current communications between aircrew and air traffic control,

and between air traffic controllers, are largely realized through voice communications. Initially, the introduction of data communications will provide an additional means of two-way communication for air traffic control clearances, instructions, advisories, flight crew requests and reports. With the majority of aircraft data link equipped, the exchange of routine controller-pilot messages and clearances via data link will enable controllers to handle more traffic. This will improve air traffic controller productivity, enhancing capacity and safety.

- **Next Generation Network Enabled Weather (NNEW)**. Seventy percent of NAS delays are attributed to weather every year. The goal of NNEW is to cut weather-related delays at least in half. Tens of thousands of global weather observations and sensor reports from ground-, airborne- and space-based sources will fuse into a single national weather information system, updated in real time. NNEW will provide a common weather picture across the national airspace system, and enable better air transportation decision making.
- **System Wide Information Management (SWIM)**. SWIM will provide a single infrastructure and information management system to deliver data to many users and applications. By reducing the number and types of interfaces and systems, SWIM will reduce data redundancy and better facilitate multi-user information sharing. SWIM will also enable new modes of decision making as information is more easily accessed.
- **National Airspace System's voice switch (NVS)**. There are currently seventeen different voice switching systems in the NAS, some in use for more than twenty years. NVS will replace these systems with a single air/ground and ground/ground voice communications system.

Implementation Timing

In 2009, The FAA is pursuing a NextGen implementation plan and has established a NextGen Advisory Committee to aid in that implementation. In June 2010, European and American authorities reached a preliminary agreement on interoperability between their future air traffic management systems, SESAR and NextGen. In March 2013, the FAA released the latest version of its implementation plan.

SESAR

EU initiative for ANS modernisation is the Single European Sky ATM Research (SESAR). The SESAR project formerly known as SESAME aims at developing the new generation air traffic management system capable of ensuring the safety and fluidity of air transport worldwide over the next 30 years.

The European Council identified the project in 2005 as one of the "projects of common interest" for infrastructure to be implemented. SESAR is the technological element of the Single European Sky, adopted in March 2004, which lays down a clear organisation and establishes cross-border blocks of airspace. With these blocks, routes and airspace structures are no longer defined in accordance with borders but in accordance with the operational traffic needs.

Key elements

- **The network operation plan**, a dynamic rolling plan for continuous operations that ensures a common view of the network situation;
- **Full integration of airport operations** as part of ATM and the planning process;
- **Trajectory management**, reducing the constraints of airspace organisation to a minimum;
- **New aircraft separation modes**, allowing increased safety, capacity and efficiency;
- **SWIM**, securely connecting all the ATM stakeholders which will share the same data;
- **Humans as the central decision-makers**: controllers and pilots will be assisted by new automated functions to ease their workload and handle complex decision-making processes. [6]

Implementation Timing

The implementation of SESAR will have required several stages. Given the differences between the various air traffic control systems in Europe and the diverse nature of the fleet currently in service, a transitional period was necessary. The implementation of SESAR therefore is being carried out in three phases:

- **Definition phase** (2005-2008), in which the air traffic modernisation plan - the SESAR ATM Master Plan has been developed, establishing the different technological stages, priorities and timetables;
- **Development phase** (2008-2013) will make it possible to develop the basic technologies which will underpin the new generation of systems;
- **Deployment phase** (2014-2020 and beyond), which will see the large-scale installation of the new systems and the widespread implementation of the related functions. [6]

The transport ministers of the EU countries adopted, on 9 October 2008 in Luxembourg, a resolution officially approving the launch of the SESAR development phase. In the view of the European Commission, the new SESAR system should triple capacity in comparison to the current situation, with safety increased tenfold and unitary operating costs far lower than current levels.

Interesting is that EUROCONTROL, which is a major partner in SESAR, has a different time focus. EUROCONTROL is focused on the next five years, while SESAR is focused on the mid - and long term.

Comparison of the operational environments

Compared system are similar in geographic coverage, but other characteristics are different. However, the FAA controls approximately 67% more flights and handles significantly more Visual Flight Rules (VFR) traffic with some 13% fewer controllers and fewer en route facilities. The fragmentation of European ANS with 38 en route ANSPs is certainly a driver behind such difference. All characteristics are expressed in the following table.

Table 1 – Comparison of the operational environments [8]

	Europe	USA	USA/EU
Area (mil. km²)	11,5	10,4	≈ -10%
ANSPs	39	1	fragmentation
ATCO	16 700	14 600	≈ -13%
Total Staff	58 000	35 000	≈ -38%
IFR flights (mil.)	9,5	15,9	≈ +67%
Controlled hours (mil.)	13,8	23,4	≈ +70%
Av. length of flight	557 NM	493 NM	≈ -11%
ACCs	63	20	≈ -68%
Controlled A/d	450	509	≈ +13%

Transatlantic interoperability

Both SESAR and NextGen have invested to a large extent in the preparatory work of the technical content of the ICAO vision through technical teams, thus ensuring regional input for the maximum reuse of completed and ongoing developments in the global context. SESAR and NextGen are at the forefront of this modernization and change to a more holistic and system-of-systems approach for the aviation infrastructure. The traditional focus on airspace and infrastructure will move towards a focus on the business/mission needs of all civil and military flights and for the provision of the most efficient services to meet those needs.

To support this approach, the EU agreed an *EU/US Memorandum of Cooperation* with the US to cater for identifying and finding solutions for the interoperability issues between the two programmes. Common standards will be identified and proposed to support the next stage of developments in a coherent and harmonised way. [7]

The SESAR and FAA have agreed a set of coordination plans in areas like trajectory management and information management where the long term goal is to create a more integrated ATM network. There are also coordination plans for CNS and airborne interoperability, including activities such as future communications systems, satellite-based navigation and ADS-B avionics. other coordination plans are more transversal in nature and cover areas such as aligning road maps, overall concepts and architecture, safety, business case principles, and environment, etc. The current working arrangements follow the timescales of SESAR and NextGen independently. The overall timescales are being synchronised and match one another and should not constrain the ambition of achieving global and overall interoperability.

Common approach

NextGen has a cooperative agreement in place with SESAR that provides a legal and institutional framework for harmonization issues. Both sides have been working together on new technologies such as System Wide information Management (SWIM) as well as on satellite-based aircraft procedures such as Area navigation (RNAV) and Required navigation procedures (RNP), which enable aircraft to fly more directly from origin to destination, saving time and fuel. Harmonizing international standards will also make it easier for countries to share information.

Benefits of transatlantic interoperability

The FAA's Assistant Administrator for NextGen, Victoria Cox, said „We're already seeing the benefits of interoperability over the Atlantic and the pacific. With our European partners in the Atlantic interoperability initiative to Reduce Emissions we've already successfully tested NextGen technology and procedures on commercial revenue flights. We've done the same with our partners in the pacific via the Asia and pacific initiative to Reduce Emissions. These flights have shown a 1-4% reduction in fuel per flight – a tremendous savings over many flights." [4]

Conclusion

NextGen and SESAR have different operating environments. There are many States encompassed by SESAR, while USA borders only with two other states. There is an intense commitment on both sides to work together, and the biggest hurdle has already been cleared.

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SAFETY AND SECURITY POLICY IN AVIATION ORGANIZATION

Vladimír Smrž
Department of Air transport, Faculty of Engineering, VŠB – Technical University of Ostrava,
vladimir.smrz@vsb.cz

František Martinec
Department of Air transport, Faculty of Engineering, VŠB – Technical University of Ostrava,
frantisek.martinec@vsb.cz

***Abstract** - The paper deals with aviation safety parts management Safety and Security Management. Requirements for Aviation Organization. Management System Aviation Organization Safety Management System.*

Keywords - air safety, Safety Management, Security Management, Aviation Organization.

I. INTRODUCTION

Safety in aviation is an essential part of which is built functioning and operation of existing organizations approved for commercial air (AOC) activities and also for providing flight training organization (ATO).

II. UNDERSTANDING OF SAFETY IN AVIATION

Objective of the safety

Safety of airport operations is understood as a set of measures (legislativs, organizational) and ways of integrating human resources (personnel selection and processes) and material resources (technology) designed to minimize loss of property and health of people working in the airport because of its own operation.

The basic objective of civil aviation is safety of the crew, airline ground personnel and the general public.

Basic documents and provisions governing the safety of the aviation security legislation:

- National documents
- National security programs
- Documents issued by international organizations.

Aviation Safety

Safety in aviation also seen as the integration of safety and security protection:

Aviation Safety = Safety + Security = 2S

Understanding 2S:
Safety understood as a set:

- Prevention of accidents and incidents (technical and human factor)
- Improving the working environment
- Reduction of the impact on health.

Security is understood as a set:

- Prevention of abuse
- Prevention of terrorism
- Protection of the population.

III. AVIATION ORGANIZATION

All organizations requesting approval for the operation has achieved compliance with EU regulations and requirements, it is necessary to develop operational documentation, which performs Regulation (EU) 965/2012 (EU) 1178/2011 and in the case of organizations providing management and preservation of Airworthiness (EC) 2042/2003.

Operating documentation of the organization applying for approval must consist of the Operations Manual, which is prepared in accordance with the requirements of Commission Regulation (EU) No 1178/2012 and is organized in accordance with the requirements of AMC ORA.ATO.230 1 (b). For organizations AOC Operating Manual must be prepared in accordance with the requirements of Commission Regulation (EU) No 965/2012 and The applicable licenses (AMC - Acceptable Means of Compliance).

The operating manuals, the new version of the abovementioned provisions, must be a monitoring program compliance and safety management program. This schema can be broken down into separate manuals (which in the case of complex organizations of course).

This consultative document is folded to provide general advice and principles for the implementation of a safety management system (SMS), which is coupled with the requirement to implement compliance monitoring system (CMS) is part of the requirement ORO.GEN.200 management system (MS) Annex III (Part- ORO) to Commission Regulation (EU) No 965/2012.

IV. AVIATION ORGANIZATION MANAGEMENT SYSTEM

Management System Aviation Organization

An operator shall establish, implement and maintain a management system that includes:

1. Clearly defined sequence of duties and responsibilities across the organization operator, including a direct executive responsible for security.
2. Description of the overall philosophies and principles operators in regard to safety, the safety policy.
3. Detection / identification of hazards which have an adverse impact on aviation safety, and which carry the operation, evaluation and management of the associated risks, including the implementation of measures to mitigate those risks, and verify their effectiveness.
4. Maintenance of trained and qualified personnel to perform their duties.
5. Documentation of all key management system processes, including processes to ensure that staff is aware of its responsibilities and procedures for making changes to the documentation.
6. The compliance monitoring to ensure compliance with the relevant requirements of the operator. Compliance monitoring shall include a feedback system to the accountable manager for ensuring that, where necessary, the findings of effective implementation of corrective measures.
7. Any additional requirements set out in the minds of this part or other applicable parts.

The basic idea of driving safety airlines

The ingredients in aviation organizations involved in the operation and therefore safety Picture 1:

- Air Traffic Control – ATC
- Pilots
- Cabin crew
- Passengers
- Operator
- Civil Aviation Authority – CAA
- Aerospace manufacturer
- Maintenance
- Airport

All components are bound by their missions. All problem we can also be divided by location:

- security solutions on the ground Ground Safety – GM
- security solutions for flight 3CRM

Optimization activities

- Flight crew (Cockpit Resource Management)
- Air Crew (Crew Resource Management)
- Companies (Company Resource Management)

"The effective use of all available resources crew - hardware, software and LiveWare - to achieve safe and efficient service"

John Lauber, 1984

Subject CRM

- Creation and adoption
- Delegation of duties
- Communication
- Cooperation

Management Systems Aviation Organization:

1. Sets of activities, processes and procedures to ensure the organization's ability to fulfill Goals:
   - Quality management
   - Security Management
   - Management of environmental impact
2. Ingrated Management System

Management System – Requirements

Changing legislation - ORO.GEN.200 requirement replaces the requirement EU-OPS/JAR-OPS 1/3.035, which covers the quality system and the requirement EU-OPS/JAR-OPS 1/3.037, which relates to the accident prevention and flight safety The current program of accident prevention and flight safety of the operator, which focuses on the re-active safety management, and only in the area of air traffic is replaced by a requirement to implement a safety management system (SMS), which is in contrast to the prevention of accidents and safety flights aimed, in addition to re-active safety management, particularly pro-active safety management. In accordance with ICAO SMS should be implemented across the entire organization service in the fields of flight operations, ground operations, crew training and continuing airworthiness of aircraft, including maintenance.

As mentioned above, SMS should be logically implemented (realized) and maintained throughout the organization of a commercial air transport, including the Organization for the continuing airworthiness management.

For an organization to achieve maximum production (yield) requires each of the operator's commercial air traffic control many processes within their business / business aviation. One of the main management processes is the function of security management and compliance monitoring.

The responsible manager (director, president, gen. Director, etc.) and senior management of the operator should bear in mind that security management and compliance monitoring takes an equally important function in the operation of a business, such as financial management, business and other matters that relating to maximize the production and profit organization. Organizational structure of the department of safety management and monitoring of compliance at the corresponding operators, including the allocation of sufficient, especially human resources, depending on the size of the operator, the nature, scale and complexity of its operations.

V. SAFETY MANAGEMENT SYSTEM

Safety management system in the aircraft devide by the activities.

The safety management system are:

- System
- Pro-active
- Explicit.

System (methodical and planned) - the activities of the safety management system is carried out according to a predetermined plan and are applied in a consistent and principled manner across the organization.

Pro-active - active approach to safety management that emphasizes continuous and constant hazard identification, assessment and mitigation of security risk because of the danger before it became an event that could adversely affect safety. Active approach includes strategic planning, maintaining security risk under constant control operator.

Explicit - all activities within the safety management are properly documented, visible and therefore defensible.

VI. SAFETY MANAGEMENT SYSTEM – SMS

SMS is a system that ensures the safe operation of aircraft using the effective management of security risks. This system is aimed at continuous improvement of safety survey / hazard identification, collection and analysis of security data (data) and continuous (constant) evaluation of security risks. Safety management system pro-actively control or mitigate risks before they result, or until the cause of the accident or incident. It is a system that is commensurate with the duties of the operator to comply with regulations and commensurate with its objectives to achieve and maintain an acceptable level of safety levels.

SMS is an essential part of every organization in aviation to detect / identify hazards and manage safety risks that are part of any business in providing products or services. SMS must include such key elements that are necessary for the identification / hazard identification and safety risk management and to ensure that:

- Are the necessary and required security information
- Are appropriate tools are available that can make use of the operator
- Tools are appropriate to the tasks and activities of the operator
- Tools are commensurate with the needs and constraints of the organization
- Make decisions are based on careful consideration of safety issues.

Devide of Safety managemet system by the identification of the risks

The safety management system can be divided into four groups:

- Identification of the risk analysis process (process control - Process Management-PM)
- Risk assessment of each risk (development risk matrix - matrix risk - MR)
- Determining an acceptable level of safety (ALOS)
- Mitigation measures appropriate to the minimum achievable level (ALARP).

CONCLUSION

If we look at the concept of security, in terms of historical development, we find that the individual factors alternated depending on the trend in technology, human factors, and currently we are in a time of organizational processes and quality improvement (quality) of body function - in our case - air traffic.

It is therefore necessary to continue increasing the level of safety which is inherently accompanied, even directly dependent, increasing quality levels.

How do we know in practice, few staff who would like to hear the "accusation" to your address. Just as it is difficult to overcome the fear of self-criticism and report event that I made myself. Probably every fact remains silent question "does not evaluate to leading such a breach of discipline"? It's a matter of trust between workers, as well as between the employer (management company) and individual employees. Only time will tell if this new model and work environment of mutual trust in the organizations are able to grow.

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PERFORMANCE BASED AIR NAVIGATION SERVICES

Key Area Safety

prof. Sanja Steiner, PhD
Air Transport Department, Faculty of Transport and Traffic Sciences, University of Zagreb, Croatia
ssteiner@fpz.hr

assist. prof. Tomislav Mihetec, PhD
Croatian Civil Aviation Agency, Croatia
tomislav.mihetec@ccaa.hr

Arijana Modić, mag. traff. eng.
arijana.modic@gmail.com

Abstract *– Performance scheme is the basis of Single European Sky for achieving the main efficiency related objectives. It also contributes to the sustainable development of air transport by improving the overall efficiency of air navigation services within four key performance areas: safety, environment, capacity and cost-efficiency.*
The Performance scheme should provide indicators and binding targets of key areas with condition of achievement and keeping the necessary safety level, allowing thereby setting targets in other key areas. Implementation of the performance plan itself is carried out during the reference period in which the objectives are set at EU level, as well at national and functional airspace block level. The first reference period includes the time between 2012 and 2014, while the second period will include time between 2015 and 2019.
Purpose of this paper is to investigate the level of efficiency of providing air navigation services in key area Safety, in terms of the European transport development during the reference period between 2012 and 2014, through the analysis of key performance indicators.

Key words – *air transport, air navigation services, performance scheme, key performance areas, key performance indicators, safety*.

INTRODUCTION

The service offer level of air navigation service providers doesn`t accompany the increase of traffic demand in European airspace. Air navigation services can be observed from several points of view. Primary objective of air navigation service providers is to serve as many aircraft in their own airspace, meeting the required level of safety, while aircraft operators look at the provision of services through the financial aspect (reduced costs) and the quality aspect which is reflected in the delay of the carrier itself. Due to requirement equalization of all stakeholders in air transport, the Performance scheme of air navigation service providers has been implemented.

European air traffic growth has a variable nature. According to statistics, during the 2011, IFR traffic grew by an average of 3.1 percent (which is below the traffic increase numbers before economic crisis during the 2007 and 2008). One of the main reasons for the slow traffic growth is adverse events in 2010 - strikes, the impact of volcanic ashes and weather, which led to stagnation.

Decrease in air traffic by -1.3 percent with an average annual increase of +1.0 percent based on medium term forecasts of traffic during the 2012 has been anticipated for period between 2011 and 2014. Descending path of air traffic caused by the continuity of economic crisis in Europe can be seen comparing forecast from 2012 with the previous one. It should be noted that development of air transport is uneven that depends on the size of the air transport market, demand, the economic development of a States, etc...

European air traffic management system serves more than 26.000 flights on a daily basis and despite the crisis it is predicted that air traffic will increase twofold by 2020. Costs of European air traffic management services annually amount between 2 and 3 billion €. [1]

The above mentioned facts have led to need for harmonization of air traffic growth with the possibility of reducing costs and increasing the overall performance.

In order to make the harmonization of air traffic possible, the idea of functional airspace blocks establishment has been developed. Functional airspace blocks are based on operational requirements and regardless the State boundaries, to improve cooperation between different air navigation service providers. There are currently nine FAB`s established.

Formulation of rules and procedures at European level was needed for their organization, leading to development of initiative Single European Sky (SES). The main objective of initiative is to meet future capacity and the necessary level of safety through legislation or regulatory packages.

Regulatory package related to improving the efficiency of air navigation services is second regulatory package – SES II. The ultimate objective of SES II is to increase the economic, financial and environmental efficiency of services provided in Europe. It represents the amendment of the first regulatory package, which set the foundations for the following areas: Performance scheme, Functional airspace blocks, Network management and Common charging scheme.

PERFORMANCE SCHEME

Performance scheme is the basis of Single European Sky for achieving the main objectives related to efficiency and also contributes to the sustainable development of air transport by improving the overall efficiency of air navigation services within four key performance areas:

- safety,
- environment,
- capacity, and
- cost efficiency.

The Plan should provide indicators and binding targets of key areas with condition of achievement and keeping the necessary safety level, allowing thereby setting targets in other key areas. Implementation of the Plan itself is carried out during the reference period in which the objectives are set at EU level, as well at national and functional airspace block level. The first reference period includes the time between 2012 and 2014, while the second period will include time between 2015 and 2019. [2]

The first reference period is considered to be a transitional period.

Key environment-related objective is to maintain a constant amount of emissions caused by service providing in the period from 2009 to 2014.

Cost efficiency-related objectives, along with the charging regime of service provision, will seek to ensure a constant unit rates, in spite of predicted traffic increase of 16,7% by the end of 2014.

Finally, regarding capacity, aircraft delays will be reduced to the lowest level so as to ensure flexibility of airspace capacity to unexpected large increase in air traffic.

Contribution of individual air traffic management indicators until the 2014 as the end of the first reference period is shown on the Figure 1.

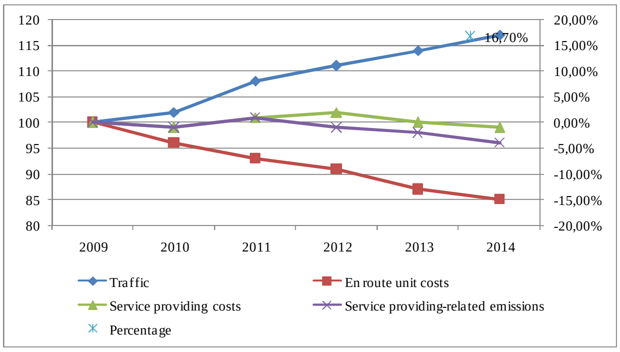

Figure 1 *- Objectives for achieving efficiency at EU level*

Source: Performance Review Commission: Performance Review Report 2011, EUROCONTROL, Brussels, 2012.

Example of specific targets is shown in Table 1.

Table 1 *- Targets for the first reference period*

SAFETY	States must monitor and notify a series of key safety indicators
ENVIRONMENT	Reduce extension of en-route flights by 0.75% compared to 2009
CAPACITY	Determine the unit rate at 53.92 € till 2014
COST EFFICIENCY	Reduce annual average en-route delays to 0.5 min per flight till 2014

National supervisory authorities have an important role in the Performance scheme implementation as well as in efficiency and certain objectives monitoring.

KEY PERFORMANCE AREA SAFETY AND INDICATORS ANALYSIS

Performance indicators are used for setting targets in particular key performance areas.

In key area safety the following key performance indicators are identified:

- safety management effectiveness,
- application of RAT method,
- the level of voluntary reporting – Just culture.

Although the targets for increasing safety aren't set up during the first reference period, three afore-mentioned key safety indicators will be considered. Same will be used for identification and analysis of main safety violation causes, as well as finding solutions for risk reduction.

SAFETY MANAGEMENT EFFECTIVENESS

Efficiency in this area can be measured in two ways:

- through the number and severity of accidents and incidents (passive indicators),
- through the efficiency of all barriers set to prevent occurrences of accidents and incidents (active indicators).

Therefore, detailed reviews and analysis of previous incidents as well as the total performance of air navigation service provision are needed for accident and incident prevention in future.

Safety management represents an essential efficiency element in this key area. Each State, as a part of its State safety programme must implement a safety management system. Safety management system is a systematic approach to managing safety, including the necessary organizational structure, responsibilities, policies and procedures. It will:

- identify potential hazards,
- ensure the implementation of corrective measures, necessary to maintain satisfactory level of safety,
- ensure continuous monitoring and regular safety performance assessment,
- aim at continuous improving of safety management systems' feasibility. [3]

Safety management effectiveness measures through the SMS implementation level and the main enabler of this system – safety culture. Air navigation service provider's safety management system, expect the foregoing, includes posterior:

- responsibilities,
- SMS organizational structure,
- safety planning (in the context of establishing targets to increase efficiency),
- measuring and monitoring safety performance,
- questionnaires on the safety level,
- reporting and investigation of incidents,
- documentation,
- continuous safety improvement. [4]

Questionnaires at State and ANSP level are being used for the purpose of measuring the total safety management effectiveness. Answer to each question should indicate a certain implementation degree of safety management system, describing the efficiency of every individual provider. Degrees are specified by the letters A to E, whereat:

- A refers to „start“ – processes are usually „ad hoc“ and chaotic,
- B refers to „planning/appliance start“ – where activities, processes and services are defined,
- C refers to the „implementation“ – where standard management processes are defined,
- D refers to „management and measuring“ – targets are used as a means of process control and overall efficiency is measured,
- E refers to „continuous improvement“ – continuous process and efficiency improvement.

Another method to determine the efficiency in this area is based on the following equation:

$$S_j = \frac{100 \sum_{k=1}^{n_j} r_{k_j} \cdot w_{k_j}}{4 \sum_{k=1}^{n_j} w_{k_j}} \qquad (1),$$

wherein:

- S_j is the final result of safety management effectiveness of a State,
- r_{k_j} is numerical value of the State`s response to question k within the analysed area j (value from 0 to 4),
- w_{k_j} is the weight of an answer k within the analysed area j,
- n_j refers to number of questions within the analysed area j for which there is no answer with value 0. [5]

Final questionnaire result (final estimate) can be expressed in two forms:

- with numbers 0 – 4 as a result of pre-defined equation,
- with percentage that indicates the position of a subject in the interval from 0 (0%) to 4 (100%). [5]

Safety management effectiveness by particular States (for 2012) is shown in Figure 2. It is evident that some certain extent in the same field has been made in Ireland with 84.7 percent, the UK with 83.7 percent, Italy with 79.8 percent, Malta with 74.2 percent and France with 71.5 percent efficiency achieved.

On the other hand Luxembourg with 28.7 percent, Czech Republic with 38.3 percent, Greece with 40.2 percent, the Netherlands with 4.8 percent and Austria with the actual 41.9 percent efficiency achieved should work on improvement of the overall safety management effectiveness (Figure 2).

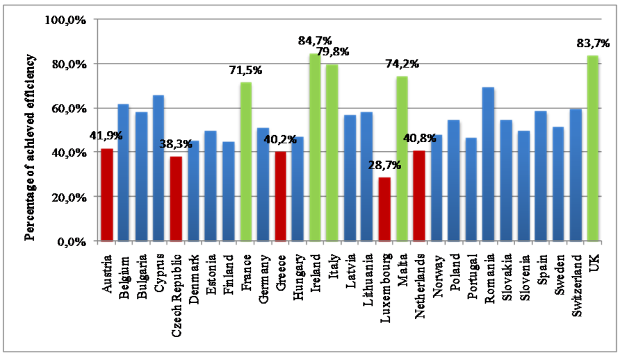

Figure 2. *Safety management effectiveness by States*

Source:[*http://prudata.webfactional.com/Dashboard/eur_view_2012.html*](http://prudata.webfactional.com/Dashboard/eur_view_2012.html)

Safety management effectiveness by individual air navigation service providers (for 2012) is shown in Figure 3. Apparently, NAVIAIR (Denmark) with 89.0 percent, DFS (Germany) with 85.5 percent, NATS NERLS (UK) with 84.1 percent, HungaroControl (Hungary) with 83.6 percent and ORONAVIGACIA (Lithuania) with 82.9 percent have achieved the best efficiency.

Air navigation service providers, which need to enhance and improve their safety management system, are HANSP (Greece) with 42.1 percent, ANA (Luxembourg) with 43.1 percent, LGS (Latvia) with 57.3 percent, NAV (Portugal) with 60.0 percent and CYATS (Cyprus) with 60.1 percent efficiency achieved.

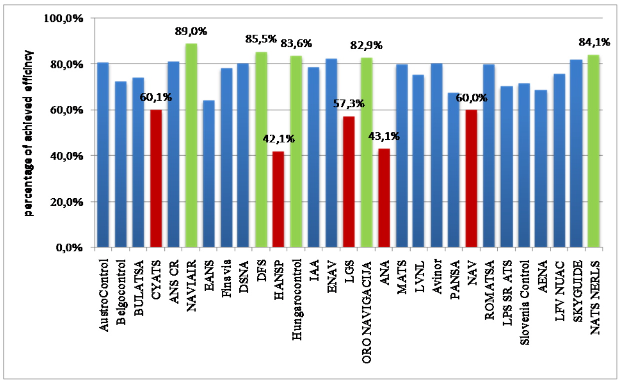

Figure 3 *– Safety management effectiveness by ANSP*

Source:[*http://prudata.webfactional.com/Dashboard/eur_view_2012.html*](http://prudata.webfactional.com/Dashboard/eur_view_2012.html)

EUROCONTROL and EASA conduct initiatives to assist providers in managing safety risks. During the first reference period until the end of 2014, EUROCONTROL has set objective for itself to help and support 22 service providers in order to improve and enhance safety management system within the organization.

This objective will be accomplished through:

- development of guidelines for the best air traffic management practice,
- structured approach to identification of key safety risk areas,
- gathering information on operational safety,
- coherent approach to safety management within the functional airspace blocks. [6]

RISK ANALYSIS TOOL

Risk is a factor that exists in every human activity, including operations related to aircraft (no matter if operations are carried out in the air or on the ground). Large numbers of ANSP's and national supervisory authorities have begun with the RAT method application. It allows coordinated reporting about severity assessments of events that lead to violation of safety:

- separation minima infringements,
- runway incursions,
- ATM specific technical events. [7]

Risk analysis method enables further development of these indicators during the second reference period up to 2019.

Air navigation service providers use the following categories of severity when registering and reporting of risk occurrences:

- serious incidents,
- major incidents,
- significant incidents,
- no impact on safety,
- has not been defined due to insufficient available information or dubious evidences.

Risk analysis tool method is applicable to each given event.

Level of reported high-risk separation minima infringements in Europe (severity A and B) is shown in Figure 4. In comparison to previous year, in 2009 a significant decline of SMI occurred of even 42 percent, while in 2010 the same has increased by 26 percent.

Despite the mentioned increase, level of reported separation minima infringements was still below the level from 2008. Total number of reported occurrences has increased by only 3 percent - from 1.418 to 1.458. As far as the 2011, compared to the previous year, the number of reported occurrences has increased by 12 percent as well as the number of serious and major incidents.

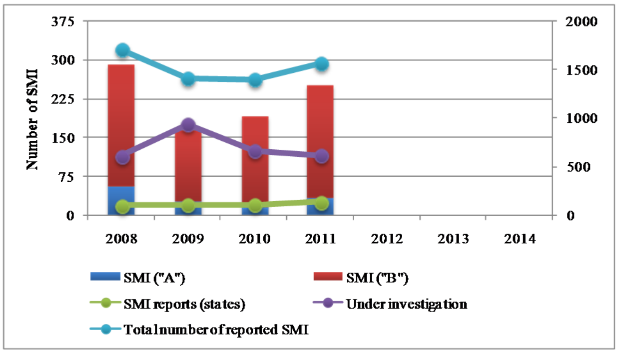

Figure 4 *- Separation minima infringements*

Source:http://prudata.webfactional.com/Dashboard/eur_view_2012.html

Serious incidents (severity level A) increased in the total number from 16 to 35. Major incidents (severity level B) increased in the total number from 178 to 217 (Figure 5). [8]

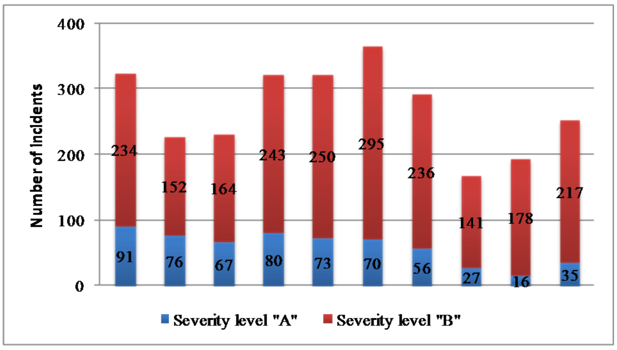

Figure 5 *– Number of reported high-risk RI*

Source: Performance Review Commission: Performance Review Report 2012, EUROCONTROL, Brussels, 2013.

Runway incursion refers to unauthorized entry and movement of aircraft, vehicles or people on the runway. Values for RI are described in the text below and in Figure 6.

Significant growth in total number of reported runway incursions from 1.093 to 1.377 (+12 percent) has been occurred in 2010. Such increase corresponds with reporting system improving, particularly in the Member States. It may also indicate on the existence of a real RI increase, but also at some unapproved entrances onto the runway, severity level A or B.

Number of reported events in 2011 grew by 1 percent, from 1.377 to 1.384 (Figure 6). Unauthorized entry on the runway severity level A has risen from 22 to 26, while severity level B decreased from 77 to 61. For 2012, more than 10 percent of unauthorized movements are still under investigation. [8]

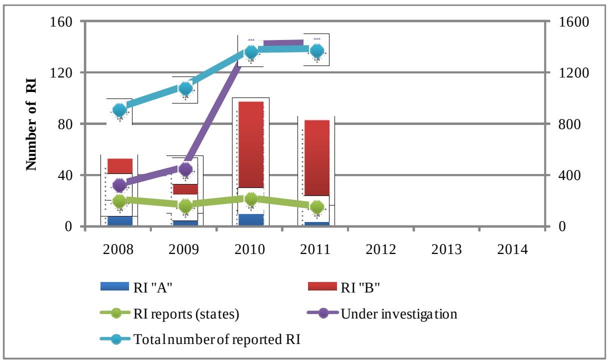

Figure 6 *– Runway incursion*

Source:http://prudata.webfactional.com/Dashboard/eur_view_2012.html

In 2009, 2010 and 2011 there were altogether 12.200, 15.668 and 14.576 specific technical events reported, respective. During the 2012 figures of the highest risk categories have remained the same as those in 2010 or have had slightly decreased:

- AA – complete inability to provide ATM services – 18 events reported as in 2010,
- A – a serious inability to provide services – recorded 50 events in 2010, 49 in 2011,
- B – partial inability to provide services – decreased from 809 in 2010 to 799 in 2011 (Figure 7). [8]

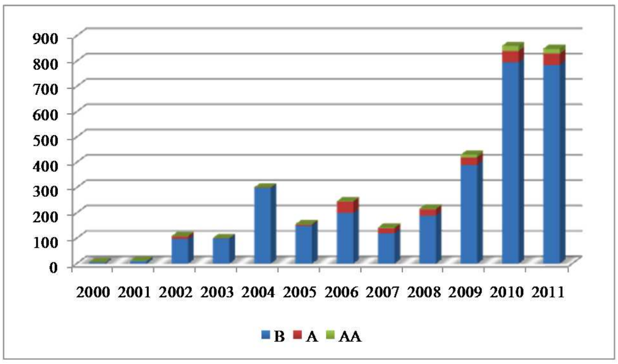

Figure 7*. Number of reported ATM specific technical events*

Source: Performance Review Commission: Performance Review Report 2012, EUROCONTROL, Brussels, 2013.

JUST CULTURE

The last key performance indicator in safety area is just culture. Just culture applies to voluntary reporting of events (mistakes) that led to risk, but without punishing the responsible person.

Work environment where every mistake is punished leads to distrust and reluctance for reporting errors or other flaws and risks. This kind of environment disables proper decision making and informing about the real risks. For this reason, just culture has been developed as an atmosphere of trust in which people are encouraged and even rewarded for providing needful information, with a clear line of acceptable and unacceptable behaviour. Hence, this way, the level of safety awareness and safety risks enhances and information exchange about the same is induced. [9]

The third key safety indicator concerns to reporting of incidents by Member States and their providers through questionnaires determined in accordance with the EUROCONTROL regulations, which measure the level of existence or lack of just culture. Just culture concept has originally been intended for development of organizational safety culture based on trust and information exchange. Over the past decade, just culture has been developed with purpose of overcoming relation investigation – legal consequences. Actualization of this concept still remains a problem for most States. Attitude alteration to implement just culture is a slow process, especially if this change involves the expansion of safety culture stands. States with difficulties can slow down the implementation process for a while, distinctively if the organizational culture considerably differs from national norms.

Just culture is only being observed during the first reference period. EUROCONTROL in cooperation with European Commission and EASA works on defining indicators and alert mechanisms to be considered for evaluation of just culture implementation level. In defining these indicators, questionnaires that examine following specific areas are being used:

- policy and its implementation,
- jurisdiction and incident reporting,
- investigation.

Questions are answered positive or negative to detect obstacles in each of these three areas. Measurements are carried out based on questionnaires at national and ANSP level. Distributed over three examination areas, 21 questions are composed for States and 24 questions are composed for air navigation service providers (Table 2). [10]

Table 2 *– Questions segmentation for just culture measuring*

	Policy/its implementation	Jurisdiction/reporting	Investigation
National level	10	8	3
ANSP level	13	3	8

Based on questionnaire results, following figures show just culture implementation at State and ANSP level. On the best way of full implementation of this concept are Cyprus, Ireland and UK, while Luxembourg is far away and needs more hard work to catch up with other European countries.

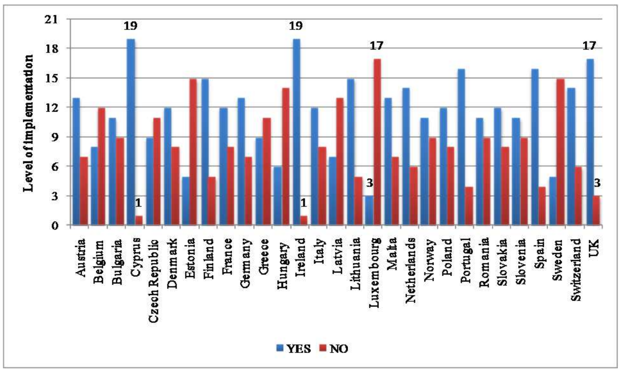

***Figure 8** – Level of just culture implementation by States*

Source:http://prudata.webfactional.com/Dashboard/eur_view_2012.html

For a more detailed analysis, precisely at ANSP level, AustroControl (Austria), ORONAVIGACIA (Lithuania) and SKYGUIDE (Switzerland) have achieved the best implementation of just culture. HungaroControl (Hungary) and AENA (Spain) are at a crossroads, which indicates the need for restructuring in some fields in order to accomplish the appropriate application of just culture concept (Figure 9).

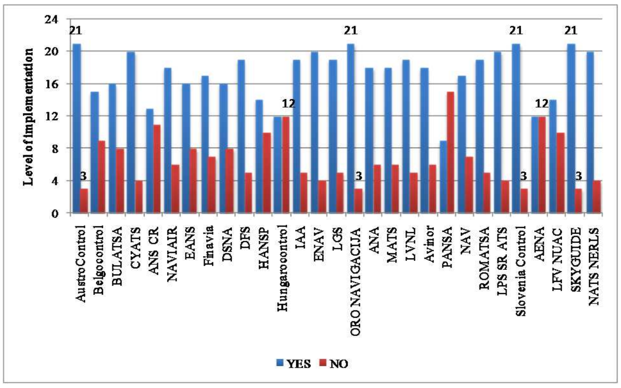

***Figure 9** – Level of just culture implementation by ANSP*

Source:http://prudata.webfactional.com/Dashboard/eur_view_2012.html

Conclusion

European airspace is one of the most congested airspaces in the world with over 26.000 flights in the peak day. For this reason and for the purpose of European network coherence, as well as air traffic and network management based on safety and efficiency, concept of the Single European Sky has been developed. Main objectives of the SES initiative are restructuring of European airspace, creating additional capacity and increasing the overall efficiency.

Air traffic is increasing every day and with ascending traffic unavoidable costs, severe delays and environmental pollution appear. Performance scheme of air navigation service providers is developed to obligate Member States of the Single European Sky to achieve the ultimate targets of initiative during the reference period. It will also try to accomplish balance between all users and providers needs within a given airspace. In order to assure implementation of the performance targets, EUROCONTROL has been designated as a Performance Review Body, responsible for collecting, analyzing, evaluating and providing information, which will enable the achievement of adequate performance levels. The same role at the national level have national supervisory authorities, which forward information collected within a State to Performance Review Body in order to increasing the efficiency of a whole network.

Binding targets are set by the end of the reference period to maximize efficiency within European airspace, but in order to achieve those targets certain measures must be taken.

One part of the solution lies in the full establishment of functional airspace blocks that will lead to capacity enlargement and bettering of air traffic flows, safety, cost reduction and increasing the overall efficiency through enhanced organization of airspace and cooperation between different service providers.

Another part of the solution refers to the flexible use of airspace requiring civil-military coordination within the airspace and through air traffic management.

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DEVELOPMENT OF DEMAND FORECASTING MODEL FOR TRANSATLANTIC AIR TRANSPORTATION

Ing. Katerina Strelcova, MSc.
Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
strelkate@gmail.com

doc. Ing. Ladislav Bina, Csc.
Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
bina@fd.cvut.cz

Ruey Long Cheu, Ph.D., P.E.
Department of Civil Engineering, The University of Texas at El Paso, The United States
rcheu@utep.edu

Abstract *– The paper describes the airline planning process, analyzes the demand of transatlantic routes and establishes a methodology on how to plan new transatlantic routes from Europe to United States with Prague Airport as a hub. A few of the most used airports in Europe are chosen and flight data in 2011 from these airports to the United States was analyzed. In addition, demographic, traffic and socioeconomic data of selected airports are collected. A demand-forecasting model is developed in steps using correlation analysis, multiple linear regression analysis and doubly constraint gravity model that calculates the number of passengers between two airports in relation to the productivity and attractiveness of these airport-pairs. The results are compared with available data. The purpose of the gravity model is to predict the demand of transatlantic flights between defined airports in Europe and United States by a simple method. The suggested methodology and findings of this study can be helpful for different airlines to forecast demand and plan new transatlantic routes.*

Key words – air transportation, airline schedule planning, demand forecasting, gravity model, long-haul routes, Vaclav Havel Airport Prague, route development, transatlantic flights.

INTRODUCTION

Today, commercial air transportation plays an important role in connecting people and businesses in the world. The aviation industry needs to be improved, not just in safety and security, but in the planning and services too, so that operations can be more efficient and profitable. Passengers are demanding airlines to operate on the most direct routes, with more comfortable aircrafts and inexpensive tickets. The airlines should follow these trends and try to enhance passenger's experience and accomplish high level of passenger satisfaction."

Since 1970, the commercial air transport has grown at a remarkably steady annual rate of 5%, in terms of Revenue Passenger Kilometer (Boeing 2012)." But, the airline industry is very dynamic. "There are many events that create positive and negative impacts, which always affect profitability and commercial development of airlines and airports throughout the world." For example, the merging of airlines, technological development, development of infrastructure and Air Traffic Management (ATM) changes can be viewed as positive external factors. In contrast, capacity limits, airport congestion, oil crisis, global airline deregulation, the terrorist attacks and political instability can negatively influence air transportation.

Transatlantic long-haul routes have been an important part of air transportation since the beginning of commercial aviation in 1939, when the flights were regularly flown from Europe to North America, South America, Africa, the Far East and Australia, and vice versa.

Route forecasting is one of the numerous decisions made by airlines and it represents a critical part of a profitable network planning. Especially, the identification and forecast of new market and revenue can potentially lead to an increase in profit for the airline. This could lead to increased passenger demand from the new market. Airline route decision can be made by an individual's judgment based on experience, but it becomes more challenging when the number of routes and size of the airline increase. Then, the right model should be chosen to forecast demand and plan new routes.

OBJECTIVE

The aim of this research is to develop a transatlantic air passengers forecasting model for airlines to plan direct flights from Prague to selected U.S. cities.

The paper will describe the possibilities of collecting historical and existing data, analysis methodology, which can help to identify the main factors that influence the passenger demand of the transatlantic route network. This model should help airlines operating at Prague Airport to plan direct transatlantic long-haul routes to U.S. cities. Although this model describes the solution for Prague Airport and U.S. route network, it should be general enough for planning routes in similar environment with similar conditions (e.g., from airports in central and eastern Europe to U.S.) and bring new ideas for the modelling of long-haul routes.

PROBLEM STATEMENT

This paper focuses on the transatlantic flights from Prague to the United States (U.S.). Prague Airport is a modern airport with a strategic position in the middle of Europe. It has the potential to be one of Europe's international air hubs for its location and the contemporary equipment. It has been a part of the joint stock company, Czech Aeroholding, since 2011. Prague Airport is already an important hub for Central and Eastern Europe, and serves almost 12 million passengers annually. It is also the biggest airport among the new EU member states, with the current capacity of 15.5 million passengers per year. The airport has a catchment area with 2.5 million people living within 60 minutes and 8 million people living within 120 minutes. This adds to the possibility of attracting more passengers (Prague Airport 2013b: Prague Airport 2013c).

For the purposes of this paper the term transatlantic flights are defined as flights connecting countries on both sides of the Atlantic, typically between EU countries and U.S.

Airline scheduling is a difficult problem that cannot be represented simultaneously and solved as a single problem but has to be divided into sub-problems and be solved in steps, because many decisions in airline schedule planning process have traditionally been classified and optimized in a sequential manner (Grosche 2009; Lohatepanont & Barnhart 2004). The scheduling methodology also depends on airline size and network structure. Big airlines companies usually use special software systems for schedule planning.

DEMAND FORECASTING

In general, demand forecasting is the main tool for airlines to predict the future behavior of potential passengers so that it can be ready to offer service in the market where it will be needed and profitable. It is usually quantified in terms of currency (revenue) or in revenue passenger miles (RMPs) in a defined period of time (Wensveen 2007).

Based on the demand forecast, airlines can make decisions about opening new routes or optimization of the existing routes. There exist several demand forecasting techniques, but in practice these different techniques are combined or compared with each other because no single one can guarantee high accuracy (Grosche et al. 2007).

Forecasting techniques can be divided into two main groups: qualitative and quantitative. The choice of forecasting techniques should be based on several factors, i.e.: what the forecast is going to be used to for, availability of data and its quality and accuracy, possible data processing techniques (Wensveen 2007).

The biggest airport and airlines do not always use the most sophisticated methods.

Moreover, complex methods do not always result in better forecasts (TRB 2007). For forecasting, one may use causal models that are based on a statistical relationship between the dependent (forecasted) variable and independent (explanatory) variables, or judgmental methods that are based on assessment of experts (Wensveen 2007).

The most common casual model in air transportation forecasting is the gravity model (Chang 2011).

METHODOLOGY OF THE DEVELOPMENT OF DEMAND FORECASTING MODEL

Route development is a difficult problem that cannot be solved as a single problem, but it has to be divided into sub-problems and be solved in following steps showed in Figure 1: Problem Identification, Current Methods Analysis, Parameters definition, Data Collection, Data Reduction, Demand Estimation, Modeling, Verification of the Results, Implementation and Final Suggestions.

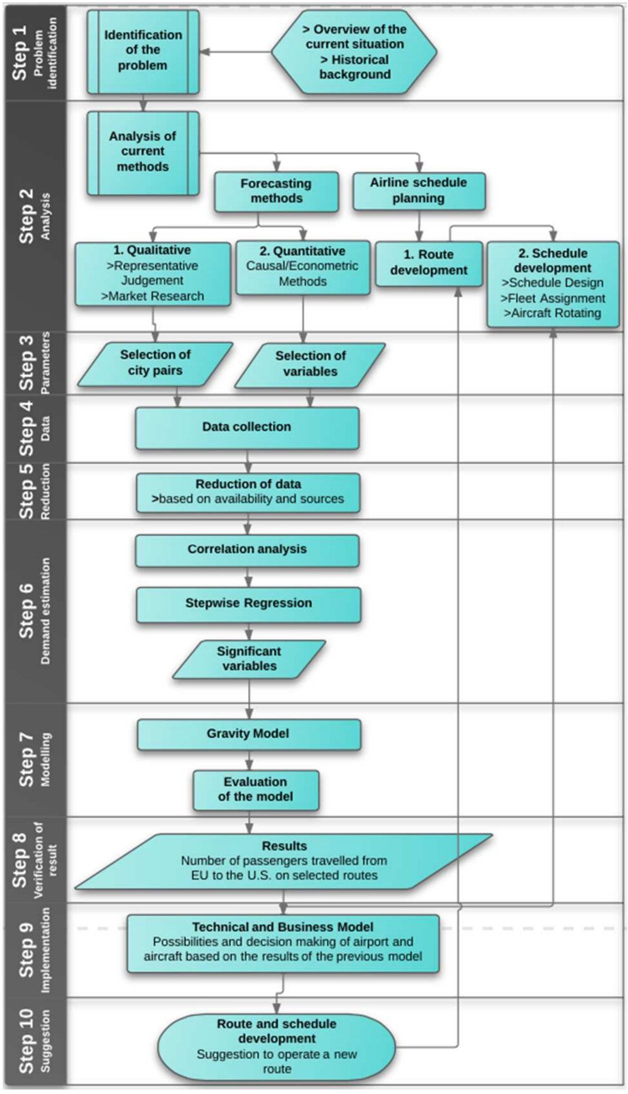

Figure 1 – Sequence of steps to develop model for long-haul routes

Airport Selection

The process of selecting airports for future development of demand forecasting methodology was conducted by qualitative method. First, the judgmental method was used to investigate the six airports in the U.S: New York (JFK), Boston (BOS), Chicago (ORD), Miami (MIA), Los Angeles (LAX), and San Francisco (SFO) followed by a few airports in Europe that have competing flights with Prague and passengers from Prague usually take connecting flights from Prague via these cities to the U.S.: Vienna, Frankfurt, Paris, London, Amsterdam, Copenhagen, and Zurich, supported by market analysis from Prague Airport, worldwide statistics and current situation of PRG.

Table 1 – Final selection of U.S. airports

U.S. Airports	IATA code
Logan International Airport	BOS
John F. Kennedy International Airport	JFK
Los Angeles International Airport	LAX
Miami International Airport	MIA
Chicago O'Hare International Airport	ORD
San Francisco International Airport	SFO

Table 2 – Final selection of European airports

European Airports	IATA code
Amsterdam Airport Schiphol	AMS
Budapest Liszt Ferenc Inter. Airport	BUS
Charles De Gaulle Airport	CDG
Frankfurt am Main Airport	FRA
Heathrow Airport	LHR
Vaclav Havel Airport Prague	PRG
Vienna International Airport	VIE
Zurich Airport	ZRH

Variables Selection

Identification of variables is an important step for causal modeling. In general, there are two types of variables: dependent and independent. Dependent variables are typically the number of passengers (passenger trips) on an airport-pair route during a set period. Independent variables are related mainly to two factors (Srinidhi 2009):

- Geo-economical factors describing economic activity,
- Geographical factors describing location impacts.

Based on availability of historical data and previous research (Chang, 2011) ten variables are statistically significant in determining passenger flows between airport pairs. The final selection of variables is shown in Table 3.

Table 3 – Defined variables

Dependent variables	Code	Description
Number of passengers	PAX	Number, one-way from European to U.S. airports
Independent variables	**Code**	**Description**
Population	POP	Number, in 2011
Unemployment rate	UER	%, in 2011
Distance	DIS	Distance between two selected cities, in air miles
Total passengers of the airport	TPAX	Total passengers handled in 2011
National income	NIPC	US$ (per capita) of the destination city in 2011
Business	BUS	Total number of companies in the destination city in 2007

Data Collection

Thee types of data have been collected:

- Demand data
- Supply data (airline schedules)
- Geo-economical data (available statistics and databases)

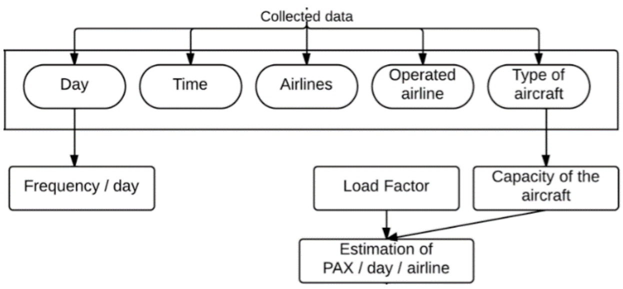

Figure 2 – Part of the process of estimation of passenger demand from the supply data

Data was mainly collected from available sources on the Internet, such as US DOT, U.S. Department of Commerce, Airports Council International or ACI, Boeing, ICAO, IATA and so on. The rest had to be estimated based on the statistics, predictions and by indexing.

Demand data were obtained, in terms of total number of passengers travelling from Prague Airport to the various U.S. airports in 2011, geo-economical data as well. Supply data were collected to fill up the missing demand data that were not possible to get, especially for trips originating from European airports other than Prague Airport. For the purpose of this research, the supply data of the direct flights was recorded from Expedia (2013) and collected in two distinct periods: airlines' summer timetable (August 2012) and winter timetable (March 2013). For each flight between a defined airport pair, the following data were collected on daily basis (for one week in the defined period): operated airlines, co-shared airlines, operated aircraft and investigated their capacity based on configuration of the seats.

The biggest challenge of this research was the collection and estimation of the annual passenger demand from the detected European airports to the selected U.S. airports. All existing scheduled flights between defined airport-pairs had to be collected from available flight databases, for each airports-pair the extra sheet in Excel was created and based on the load factors, used operated aircraft and frequencies passenger demand was estimated. After completing database of data needed, index methods was used to core database of input data for further simulation. Additionally, the needed statistics data such as population, unemployment rate, total annual passengers of the origin and destination airports, national income, number of companies was collected for future modeling and demand estimation.

Data Limitation

Data was mainly collected from available sources on the Internet, such as US DOT, U.S. Department of Commerce, Airports Council International or ACI, Boeing, ICAO, IATA and so on. The rest had to be estimated based on the statistics, predictions and by indexing.

The sample of the passengers demand data from Prague Airport to U.S. through the biggest hubs in Europe and U.S. was obtained from Prague Airport. This is not the actual demand for direct flights from Prague Airport to U.S.

Development of Demand Forecasting Model

First, correlation analysis was modelled to identify the degree of relationship between variables. Values of eight independent variables (population of origin, population of destination, unemployment of origin, unemployment of destination, total passengers of the origin airport, total passengers of the destination airport, national income of destination and business of destination) were analyzed by the CORREL function in Excel. Additionally, distance between airport pairs was evaluated.

Table 4 – Correlation analysis no need to show last 2 lines (DISTD)

Variables	POPi	UERi	TPAXi	POPj	UERj	TPAXj	NIPCj	BUSj
POPi	1	-0,64343	0,72013	-0,05898	0,01715	-0,05044	-0,02486	-0,05235
UERi	-0,64343	1	-0,57971	-0,09146	-0,00346	-0,04017	-0,02307	-0,08633
TPAXi	0,72013	-0,57971	1	-0,10822	0,04641	-0,07919	0,02221	-0,09992
POPj	-0,05898	-0,09146	-0,10822	1	0,03021	0,36366	-0,129	0,99586
UERj	0,01715	-0,00346	0,04641	0,03021	1	-0,87789	0,3639	0,05942
TPAXj	-0,05044	-0,04017	-0,07919	0,36366	-0,87789	1	-0,2938	0,32617
NIPCj	-0,02486	-0,02307	0,02221	-0,129	0,3639	-0,2938	1	-0,12749
BUSj	-0,05235	-0,08633	-0,09992	0,99586	0,05942	0,32617	-0,12749	1
	POPI	ERI	TPAXI	POPJ	ERJ	TPAXJ	NIPCJ	BUSJ
DISTij	0,15255	-0,20062	0,12987	0,25441	0,44866	-0,32615	-0,2054	0,21201
	DISTD							
DISTij	1							

From Table X it is obvious that strongly related pairs of variables are business of destination BUS_j and population of destination POP_j.

The other strong related variables are total passengers of the airport of origin $TPAX_i$ and population of origin POP_i. The last strongly related is unemployment of origin UER_i and population of origin.

Second, stepwise regression modeling (linear model, forward selection) was conducted to relate the dependent variable PAX_{ij} with other independent variables. The stepwise regression was modeled in NLogit 4.0. to selects the best combination of independent variables that best predicts the dependent variable.

Table 5 – Final selection of European airports

```
+----------------------------------------------------------------------+
| Analysis of Variance for the Current Regression                       |
| Source          Deg.Fr.     Sum of squares      Mean Square        F  |
| Regression         2    1663770007599.12300 ***************    16.80 |
| Residual          28    1386719161151.40800 ****************          |
| Total             30    3050489168750.53100 ****************          |
| Variable entered this step =              Deleted =                   |
| **********> This is the final equation <**********                    |
+----------------------------------------------------------------------+
+--------+--------------+----------------+--------+--------+----------+
|Variable| Coefficient  | Standard Error |t-ratio |P[|T|>t]| Mean of X|
+--------+--------------+----------------+--------+--------+----------+
 POPI    |    .02965633       .00641352     4.624   .0001   .559798D+07
 BUSJ    |    .46127316       .12360316     3.732   .0009   340722.419
 Constant|  -63985.3444     55224.3587     -1.159   .2564
```

Stepwise regression model contains, as a result, the independent variables POP_i, BUS_j with p values of 0.001 and 0.009 respectively. These two variables are significant variables and will be used as input for gravity model in the other section.

Gravity Model

For modeling of demand the gravity model was chosen. Gravity model calculates the number of passengers between two airports in relation to the productivity and attractiveness of these airport-pairs.

Based on the output of stepwise regression, for gravity modeling POP_i and BUS_j are used as the variables that describe the trip generation rates of the origin i and the attractiveness of destination j respectively. Then, the distance (DIS_{ij}) is used as the impedance of travel between i and j. The data set was adjusted due to results from previous steps.

The number of passenger-trips between two airports T_{ij} is calculated by following gravity model equation according to Cheu (2012):

$$T_{ij} = a_i b_j \frac{POP_i BUS_j}{DIS_{ij}^x} \qquad (1)$$

where:

a_i	is an airport specific trip production constant (to be calibrated)
b_j	is an airport specific trip attraction constant (to be calibrated)
POP_i	is population of origin airport
BUS_j	is business of destination airport
DIS_{ij}	is destination between the airport of origin and destination x is calibration parameter (exponential coefficient)

Production constant a_i and attraction constant b_j is calibrated as:

Assume all a_i=1,

Calculate all b_j using $b_j = \left[\sum_{i=1}^{n} \frac{a_i POP_i}{DIS_{ij}^{x}} \right]^{-1}$ (2)

Calculate all a_i using $a_i = \left[\sum_{j=1}^{n} \frac{b_j BUS_j}{DIS_{ij}^{x}} \right]^{-1}$ (3)

Calculate $T_{ij} = a_i b_j \frac{POP_i BUS_j}{DIS_{ij}^{x}}$ for all *i* and *j*

Repeat steps (2)-(4) until all a_i, b_j and T_{ij} converges

The result of the application of a gravity model is a demand matrix *Tij*.

The gravity model with variables POP_i and BUS_j was tested in Matlab first. Model was tested with *x*=1 and for different number of iterations *k*=5, *k*=50, *and k*=2000. The results showed that after the second iteration T_{ij} do not change significantly. The matrix of average absolute relative errors does not change significantly either.

The gravity model is also tested in Excel running for the first 10 iterations to see how the gravity models behave.

Modification of the Gravity model

The model requests modification of data to balance the trips from all origins and all destinations. The sum of the number of passenger-trips in a row should equal to the number of passenger-trips emanating from that airport; the sum of the number of passenger-trips in a column corresponds to the total trips attracted to that airport (Bruno & Improta 2008).

These conditions can be written as:

$$\sum_i PAX_{ij} = \sum_{i=1}^{6} POP_{i\_pax} \quad (4)$$

$$\sum_j PAX_{ij} = \sum_{j=1}^{6} BUS_{j\_pax} \quad (5)$$

Passenger trips are summed and this sum (7099979 passenger trips/year) is used to try to keep model into balance by utilization of coefficient 3.7574.

Modeling

Two variables of destination were tested, POP_j and BUS_j, which represent the attractions at U.S. airports. For each variable, *x* was varied and all the coefficients a_i and b_j were calibrated. The accuracy of the gravity model was judged based on the absolute average percentage error between the prediction (T_{ij}) and observed data (PAX_{ij}).

Different values of calibration parameter *x* were tested. After testing various values of *x*, the range of *x*=0.8 to 1.2 has been found with the smallest values of the error. Out of this range the results were not acceptable.

Based on this observation and modelling later on the gravity model was finally tested with *x*=0.8 for iteration k=2 and k=3.

Table 6 – Part of Gravity model

2nd iteration (k=2)								
T_{ij}	BOS	JFK	LAX	MIA	ORD	SFO	a_i	POP_i
AMS	7395	97766	46108	67	25922	9740	1.8012	186998
CDG	109621	1449139	673220	74209	381155	141775	1.7622	2829118
CPH	733	10091	6694	624	232834	1394	10.7065	252369
FRA	6346	84090	40159	4334	22369	8491	1.8292	165788
LHR	139500	1835568	843834	93012	482220	178049	1.6970	3572183
ZRH	3586	47457	22635	2466	12602	4777	1.8605	93524
b_j	0.000013	0.000014	0.000020	0.000017	0.000012	0.000020		7099979
POP_j	267180	3524111	1632650	174711	1157101	344225	7099979	

3rd iteration (k=3)								
T_{ij}	BOS	JFK	LAX	MIA	ORD	SFO	a_i	POP_i
AMS	7397	97795	46112	67	25165	9741	3.2136	186278
CDG	109569	1448433	672765	74166	369745	141680	3.1415	2816358
CPH	845	11631	7714	719	260456	1606	22.0104	282971
FRA	6343	84053	40134	4331	21700	8485	3.2612	165047
LHR	139441	1834765	843305	92963	467809	177939	3.0255	3556222
ZRH	3584	47434	22620	2465	12225	4774	3.3168	93102
b_j	0.000008	0.000008	0.000011	0.000010	0.000007	0.000011		7099979
POP_j	267180	3524111	1632650	174711	1157101	344225	7099979	

Error Matrix of the gravity model

The error matrix expresses the average absolute percentage error between each airport pair. In this case the errors are quite big. The most accurate results are in the cases of airport pairs involving Paris (CDG) and London (LHR) as the origins. As a destination, San Francisco (SFO) has two pairs with errors smaller than 0.20.

CASE STUDY – PRAGUE AIRPORT

Based on the evaluation of the average absolute percentage error matrixes in the previous chapter, the most suitable gravity model was selected to forecast air passenger demand between selected European airports and U.S. airports.

From the previous results, the gravity with *x*=0.8, attraction variable BUS_j and three value of a_i (minimum a_i, average of a_i, and maximum a_i.) was identified as the most suitable for application for passenger demand forecasting between Prague Airport and U.S. airports. Conclusively, the result based on minimum a_i and the smallest error in error matrix were generated in Table 7.

Table 7 – Results of estimated demand from Prague Airport

PAX/year	BOS	JFK	LAX	MIA	ORD	SFO
PRG	7124	136059	68505	12858	27875	16067

The results are compared with available data from Prague Airport.

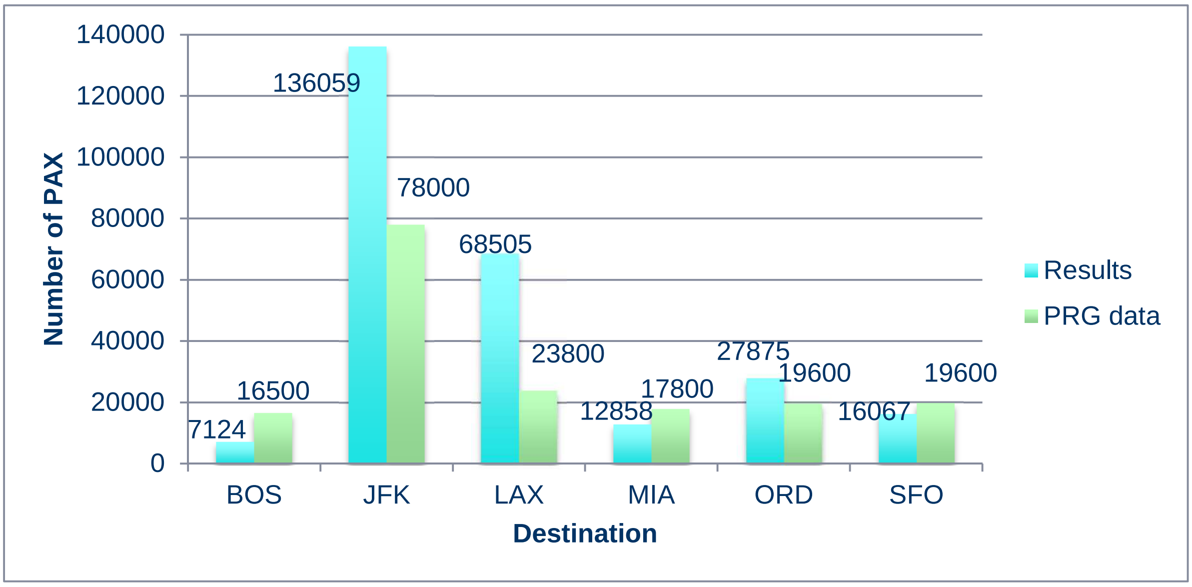

Figure 2 – Comparison of the result of the gravity model and available MIDT data

CONCLUSION

This study introduces a correlation-regression-gravity model sequential methodology to estimate the passenger demand based on qualitative and quantitative methods of demand forecasting. This research demonstrates a methodology of performing demand forecast for transatlantic flights with the lack of historical commercially sensitive data. The methodology demonstrates the possibilities of gathering publicly available data from various sources, the methods to process them and a simple technique to forecast the passenger demand in the defined market. The actual results of the gravity model in this study may not be accurate enough for eventual decisions on route development. The errors of the gravity model can be due to:

- The estimated data are not precise enough, although the value was close to the historical demands of indirect flights from Prague Airport to the selected airports in U.S.
- The variables were not the best that represent the generation of the origins and attractiveness of the destinations. More variables should be explored if more data is available. The impedance function may not be the best as well.
- The gravity model may not be not suitable for demand forecasting with the defined variables used in this research, because of large magnitude of errors

FUTURE RESEARCH

Based on the list of limitations, there are many possibilities on how to improve the gravity model, or to use other models. One of the options is to validate model by collecting more data or try to use more accurate data. Another option is to use different variables.

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HUMAN FACTORS RISKS IN AIR TRAFFIC OCCURRENCES

Ing. Richard ŠTECHA
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
richard.stecha@atlas.cz

Doc. MUDr. Jiří ŠULC, CSc.
Institute of Aviation Medicine, Prague, Czech Republic
sulc.jiri@atlas.cz

Prof. Ing. Věra VOŠTOVÁ, CSc.
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
vostover@fd.cvut.cz

Doc. Ing. Ivan NAGY, CSc.
Department of Applied Mathematics, Faculty of Transportation Sciences, Czech Technical University in Prague, Czech Republic
nagy@fd.cvut.cz

Abstract *– Air Traffic Controllers play a crucial role in Air Traffic Control, which is considered the most visible and flexible part of the Air Traffic Management (ATM) system. All decisions made by controllers are influenced by a huge number of factors, both objective and subjective. Some studies have established a model of the risks in ATM, but none have combined statistics and modeling principles in a Bayesian approach. The study is based on a wide retrospective analysis of the air traffic occurrences where controllers were involved. The data presented in this article comprise 981 air traffic control-involved occurrences records covering the years 2000 – 2012 in the Czech Republic, Great Britain, Canada and the United States of America. We analyzed the individual roles of all known factors contributing to the occurrences. Occurrences were classified as air accidents and incidents of serious, major, significant or no safety effects. The most significant and correlating variables were used for the discrete risk model. Our results did not confirm the impact of adverse meteorological conditions or high air traffic intensity on the number of ATC involved occurrences. On the contrary, the majority of reported accidents occurred in ideal weather and in low-density traffic. Most occurrences were recorded in the vicinity of the airports, during aircraft approach maneuvers and landing. The most critical time for the occurrences is between 04:00 and 07:59 a.m. Our discrete risk model suggests the combination of time of day, meteorological conditions, type of flight and aircraft (vortex) category as the most relevant.*

Key words – Season, day, time of day, workload, traffic, aircraft category, type of flight, flight rules, area of the occurrence, phase of flight.

INTRODUCTION

Human Factors have been defined briefly as "fitting the task to the man" (Grandjean 1981), and as "designing for human use" (Sanders and McCormick, 1992), and more lengthily as "aiming to design appliances, technical systems, and tasks in such a way as to improve human safety, health, comfort and performance" (Dul and Weerdmaster, 1993). An implicit fourth and operationally interesting definition (with which controllers might concur) is "give us the tools and we will finish the job" (Oborne, 1992). Clearly, Human Factors is about giving the human operator an efficient working environment and tools that account for human strengths and limitations, but it is also about selecting the most suitable operators and giving them the required skills. In this way, Human Factors seeks to optimize Human Performance and thus system performance, though not to the detriment of the health (physical and psychological) of the humans in the system. Human Factors can therefore be said to be "work-focused", though it also demands "healthy" work.

Human Factors has its roots in applied psychology but has had substantial inputs over the years from fields as diverse as medicine (e.g., to understand the psychological effects of work systems on humans), physics (e.g., to understand perception), engineering and design. In fact, people working in Human Factors themselves come from a range of backgrounds such as psychology and engineering, and it is considered a hybrid discipline.

In contrast to the way automation has been embraced by a range of other industries, Air Traffic Management (ATM) in practice at the time remained very human-focused, with relatively little automation support. Nevertheless, with the evolution of computer-based systems, the Human Machine Interface (HMI) became an item of central interest to the ATM community, as it was seen as desirable to replace older radar screens with systems that could superimpose more information for the controller, to enable more efficient performance. Legibility and contrast, as well as font size and design, were subsequently the subject of research for quite a long time. In parallel, the controllers' workload evolved as a central issue for successful system design, arguing that appropriate design of the human-machine interface could help to reduce operators' workload, thus contributing to overall safety and efficiency. The aim was to increase "capacity" (volume of traffic) in response to more public demand and to increase the accessibility of flight-based travel. It became obvious to many that Human Factors could be a key enabler in increasing capacity and hence the growth of the industry as a whole. The human element in the ATM systems, still the key element, should therefore receive support to improve performance.

The Air Traffic Controllers play a crucial role in Air Traffic Control, which is the most visible and flexible part of Air Traffic Management (ATM) system. ATM comprises airborne and ground-based functions (air traffic services, airspace management and air traffic flow management) to ensure the safe and efficient movement of aircraft during all phases of flight operations. Despite all the automated processes and tools for controllers' decision-making support of the airspace and air traffic control, problem-solving will remain in the hands of controllers. No automated system is 100% reliable and accurate, and no one can replace all human-provided actions. All decisions made by controllers are influenced by a considerable number of factors. Their impact on each person varies individually, and it is usually impossible to determine which factor had the most significant impact on flight safety and which were less important. On the other hand, research in Human Factors and Human Performance is very complex, and it will extend far into the future because the issue is not yet closed. Despite advances in technology, ATM is still critically dependent on the day-to-day performance of highly skilled front-line personnel, such as controllers, engineers, supervisors and other operational staff. Operational personnel safely and efficiently handle millions of flights, and effective human performance at the front line makes this possible. [1]

METHODS

This study is based on a wide retrospective analysis of the air traffic occurrences in which controllers were involved (ATC Involved Occurrences). For the unity of data interpretation and classification, the authors of this paper asked for assistance in this matter from the majority of European and overseas investigation institutions and Air Navigation Services Providers (ANSPs). Several organizations were not interested in the study, and some refused to provide the data because of its sensitivity. Thanks to the positive responses of five of the queried bodies, it was possible to summarize and analyze 981 accidents and incidents between 2000 and 2012 in the Czech Republic (Air Navigation Services of the Czech Republic, Armed Forces of the Czech Republic), Great Britain (Civil Aviation Authority), Canada (Royal Canadian Air Force) and the United States of America (National Transportation Safety Board). The data were extracted from the national databases in their respective format and content styles. The Czech ANSP (civil) data were collected directly from their internal database. These records are mostly complex and contain all time-location information, occurrence description, controller's workload, weather information and occurrence category. Other data (especially from the USA and Canada) were received as written reports containing almost the same details but without incident category. This classification was assessed based on the description (distances between the aircraft, their heading, consequences), according to EAM2/GUI3 Mapping Between the EUROCONTROL Severity Classification Scheme & the ICAO Airprox Severity Scheme. Some databases contain information concerning time on duty, time after break and controllers' age.

The initial normality test of the data test was successful (data show a normal distribution). IBM SPSS Statistics Base, ver. 21 software was used for statistics constructions. Tested data were linearly correlated, summarized and analyzed. The risk model philosophy is based on measuring of non-symmetric difference between two probability distributions x_i and y; in other words, the similarity of data is measured by the Kullback-Leibler divergence. Matlab 2007b software was used for the construction of the model.

RESULTS

SCOPE OF THE RESEARCH

The research was focused on the occurrences involving Air Traffic Control (ATC) that led to accidents or incidents in air traffic. The level of ATC involvement was divided into two subtypes: occurrences in which controller activity was the main contribution (cause) and those in which it played a secondary role (factor). The occurrences were divided into nine categories; each category was qualitatively described as a certain severity risk according to ESSAR2 – Reporting and Assessment of Safety Occurrences in ATM. The study covers Accidents, Serious, Major and Significant Incidents (Category A, B, C) and No Safety Effect Incidents (E). Not Determined Incidents (Category D) were omitted. [2]. These occurrences covered the entire spectrum of flights, i.e., commercial (scheduled and non-*scheduled*), general aviation, military, instructional and special flights (e.g., aero-medical, sightseeing, positioning etc.). Occurrences by types and numbers are presented in Table 1.

Table 1 – Occurrence Types and Categories

Occurrence Type	**Frequency**	**Percentage**
Separation Minima Infringement	629	64.1
Controlled Flight Into Terrain	43	4.4
Mid-Air Collision	27	2.8
Ground Collision	30	3.1
Airspace Infringement	101	10.3
Another Aircraft Interference	21	2.1
Runway Incursion	100	10.2
Aircraft Mis-Identification	23	2.3
Mis-Communication	1	0.7
Total	**981**	**100.0**

The accident ratio (Controlled Flight Into Terrain (CFIT), Mid-Air Collision (MAC) and Ground Collision (GCOL) is 10.3 %. All of the accidents occurred in the USA; there were 75 fatalities, 6 people suffered serious injuries and 3 people suffered minor injuries. Additional factors were analyzed, including time of day and season, air traffic type, aircraft movement phase, meteorological conditions, moon phases, flight-rules conditions and air traffic intensity in particular airspace.

THE ROLE OF INDIVIDUAL FACTORS

SEASON, DAY AND TIME OF DAY

The density of air traffic does not remain constant during the year but varies with the seasons. The typical yearly distribution of air traffic can be characterized as a continuous increase over the first seven months (January – July) followed by a continuous decrease in the latter period of the year. The peak in air traffic occurs in summer and is connected with holidays and travel by a significant proportion of the population. The highest number of accidents and incidents does not fall in the summer months, when the density of air traffic is at its highest, but coincides with the spring months. In other words, a higher number of aircraft in the airspace does not automatically imply higher numbers of accidents or incidents. The number of aircraft is not a single, isolated factor. Instead, the number of incidents is related to the clustering of aircraft, i.e., with the density of air traffic in individual parts of the airspace – the sectors. This factor better represents the workload of air traffic controllers.

Another important factor was the distribution of air traffic movements during the week. The amount of air traffic on Mondays, Tuesdays and Wednesdays is almost identical and approaches 14 % of the weekly total amount on each day. There is a typical sharp rise of air traffic on Thursdays (nearly 15 %) and this trend is followed by another increase above 15 % on Fridays. Saturdays are characterized by a decrease in air traffic, and Sundays (13.5 %) on the contrary by an increase to above the first three weekdays (Mon-Wed). [3]. The weekly occurrences distribution was in line with the distribution of air traffic. The peak of all incident categories was observed on Thursdays, when air traffic typically increases; the lowest numbers were documented during weekends. However, accidents on Thursdays are rare.

Furthermore, the hourly distribution of occurrences and the appearance of incidents and accidents were analyzed. Of course, the amount of air traffic during a day is variable, and its typical distribution is characterized by a peak between 08:00 and 12:00 local time [3]. This is followed by the highest number of incidents in all severity categories except for accidents. A significant proportion of the more severe occurrences, such as accidents, fall into the period of 04:00 - 07:59 hours. Although this time is not an air traffic peak, it encompasses a sharp increase in activity after the minimal traffic between midnight and 03:59, and it leads to a large number of accidents as well as the highest number of serious incidents (Category A) in comparison with the rest of the periods of a day.

WEATHER AND FLIGHT RULES

Weather plays a very important role in aviation. Not only can adverse meteorological conditions influence planned aircraft routes (vertical and horizontal), their unexpected changes can lead to dangerous situations in flight. The basic weather characteristics are visibility, cloud ceiling, sky coverage by clouds, wind direction and speed, temperature and significant weather phenomena (storm, rain, snow...). The accident/incident reports were frequently reluctant to specify all weather details. When the weather contributed to an occurrence, it should be mentioned in the report, but sometimes the information concerning weather conditions is absent. Therefore, the meteorologically significant information was interpreted in three main groups (1 – weather was ideal, i.e., visibility more than 7 km, ceiling above 5 km, cloud coverage to 2/8, no significant wind); 2 – weather had no impact on the occurrence but was not ideal, i.e., visibility 4 – 7 km, ceiling 3 – 5 km, cloud coverage 3/8 – 5/8, no significant wind; 3 – weather had significant impact on the occurrence and was observed at least as a dangerous meteorological condition (strong wind, low visibility or ceiling etc.). Correlation between the weather and occurrence categories was significant at the 99 % confidence level.

The highest number of occurrences was documented in meteorological conditions described as “normal weather”. The lowest number of all occurrences was reported during adverse weather. On the contrary, the highest number of accidents was observed when the weather was ideal, i.e., without dangerous meteorological phenomena. These data are interesting because it is probable that controllers are reluctant to admit the possibility of safety problems in ideal weather. On the other hand, during adverse meteorological conditions, they (and air-crews as well) are more able to take into account the severity of the situation, and the number of incidents significantly decreases. Flight rules (visual or instrument) had no significant impact on the probability or category of and occurrence. Types of flight were also analyzed, but none showed evidence of special significance for the rising number of occurrences.

CONTROLLER WORKLOAD

Workload is an important focus because errors can be induced if mental task demands exceed the capabilities of the human operators. In this way, the consequences of these errors might be critical and detrimental to safety. Workload might simply be defined as the demand required from the human operator. This definition, however, is overly limiting because it only includes the requirements generated by external sources (e.g., task difficulty). To address workload completely, it is also necessary to consider demands generated internally that compete for an operator’s resources. Therefore, an appropriate Human Factors definition of workload is as follows: Workload is the demand placed on an operator’s mental resources used for attention, perception, reasonable decision-making and action. [4].

The controller’s workload is a subjective sensation (impression) and has no accurate measures. Controllers’ workload level was assessed in the occurrence reports as the level of the air traffic they controlled (1 – low workload, 4 – highest workload). Task demands are not the only factor that can affect the effort required by a task. The time spent on a given task demand will also affect the performance as well as the workload of the operator. The workload increases as a function of time, even if the task load is stable. After a variable threshold of time, resources are exhausted, and an increase in workload and a breakdown in performance are likely to occur. The operator gives up or "sheds" the least significant parts of the task to make the workload more manageable. [4]. There are two extremes, very light traffic (low workload) and very intensive traffic (high workload). These extremes are connected with very low numbers of occurrences; the number of accidents is practically zero. Logically, serious incidents would occur most frequently during high controller workloads. Alarmingly, the highest frequency of accidents and incidents of all categories is in positive conditions, when workload/traffic felt either normal or closer to low. This is because of an unintended lowering of controllers' awareness and their feeling that "nothing could happen" in these good conditions.

PHASE OF FLIGHT AND AREA OF THE OCCURRENCE

More occurrences happen at airports than en route. This is reflected in the phases of flights involved in accidents or incidents. Most occurrences are connected with aircraft approach and descent prior to landing. Those phases of the flight are, from a controllers' perspective, the most challenging, due to the number of aircraft, their different headings, altitudes, vortex-categories and speeds. The right aircraft sequencing for this maneuver is crucial, and the probability of controllers' or pilots' error rises. The safest phase of aircraft movement is taxiing. Despite these assumptions, occurrences connected with that phase of flight (especially ground collisions and runway/taxiway incursions) are more frequent than en-route contingencies, though their consequences are not severe.

TYPE OF FLIGHT AND AIRCRAFT CATEGORY

The majority of occurrences involved scheduled flights of medium vortex category aircraft (i.e. 7 – 136 tons). This connection seems obvious when considering the ratio of flights in a representative period of time and the manufactured aircraft around the world. The scheduled flight group has the highest representation of all categories of incidents but the lowest proportion of accidents. The highest number of accidents was recorded within general aviation flights, specifically in the light aircraft category (less than 7 tons). The second highest number of incidents occurred in military aviation, followed by training flights (both civil and military).

THE RISKS MODEL

The risks model is based on computing the Kullback-Leibler divergence between data measured in different occurrence situations. Occurrences in air traffic control are modeled in dependence on other measured variables observed in the particular occurrence. The aim is to identify variables with significant impact on the occurrences and to identify which values imply the presence of critical situations in the air traffic control. According to descriptive statistical results, there were four most significant variables entering the modeling: time ($x_{1;t}$), type of flight ($x_{2;t}$), weather ($x_{3;t}$) and aircraft category ($x_{4;t}$), and controllers' workload. These variables were divided as follows: time (6 blocks of 4 hours), type of flight (6 categories) weather (3 categories) and aircraft category (3 categories). Modeled output y_t is the classification of the occurrence. For modeling purposes, the occurrences are categorized into 3 output groups: group 1 represents accidents and serious incidents, group 2 represents major and significant incidents and group 3 represents incidents with no safety effect. The initial data set included 981 records. A training group of secondary inputs was divided into x_i clusters (1, 2 or 3, in line with output). We observed differences among the inputs in each particular cluster.

For discrete probability distributions y and x, the Kullback-Leibler divergence is defined to be

$$KL = \sum f_i \ln \frac{f_i}{g_i}$$

where *f* and *g* are distributions of data for different occurrences.

All inputs are discrete therefore their distributions will be characterized by normed histograms (see Figure 1).

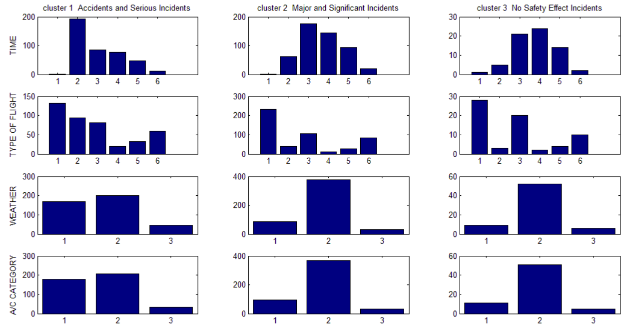

Figure 1 – Figure description figure description figure description

<u>Legend:</u>

Time	1:	00:00 – 03:59
	2:	04:00 – 07:59
	3:	08:00 – 11:59
	4:	12:00 – 15:59
	5:	16:00 – 19:59
	6:	20:00 – 23:59

All times are local times.

Type of flight	1:	scheduled
	2:	general aviation
	3:	military
	4:	special
	5:	non-scheduled
	6:	training
Weather	1:	clouds and visibility OK (CAVOK), no dangerous meteorological phenomena
	2:	visibility 4 – 7 km, ceiling 3 – 5 km, clouds coverage 3/8 – 5/8, no dangerous meteorological phenomena
	3:	visibility less than 4 km, ceiling below 3 km, clouds coverage more than 6/8, dangerous meteorological phenomena

Aircraft Category 1: light (up to 7 tons)
2: medium (7 – 136 tons)
3: heavy (more than 136 tons)

DISCUSSION

The purpose of this study was to examine the particular role of each individual factor listed and described in the occurrence reports. Time of day was evaluated as a critical factor. Time is an essential characteristic of air traffic control (ATC) as well as the principal constraint in the air traffic controller's job, which routinely involves dividing attention among multiple sources of information and performing multiple tasks nearly simultaneously under, at times, severe time pressure. Attention and switching attention require time (Hopkin, 1995), as does performing control actions [5]. The majority of occurrences were observed between 04:00 and 15:59, with the largest fraction between 08:00 and 11:59. This fact corresponds with the air traffic peak in the mid- to late morning. However, the majority of accidents occurred in a period characterized by lighter air traffic activity, 04:00 – 07:59. The reason for this decrease may be found in a change in the sleep need curve at approximately 6 a.m. [6]. The other most correlated factors were meteorological conditions, type of flight and aircraft category.

According to our results, adverse weather had no negative impact on the number of occurrences. The majority of occurrences (in all classifications) were reported during "normal" meteorological conditions. Moreover, the highest number of accidents was observed in "ideal" weather. The occurrence of Accidents and Incidents under conditions of easier decision-making ability is therefore strongly connected with the downgrading of situational awareness in these conditions.

Interpretation of the histograms leads to these results: The largest values of divergence within time of day (x_1) and type of flight (x_2) were observed between clusters 1 – 2 and 2 – 3; within weather (x_3) and aircraft category (x_4), there were significant divergences between clusters 1 – 2 and 1 – 3. For accidents and serious incidents (the most danger and unacceptable occurrences), the highest typical risk for light and medium aircraft on general aviation and military flights is in the combination of time of day (04:00 – 07:59 a.m.) with normal or ideal meteorological conditions. Major and significant incidents for medium aircraft on scheduled flights are, according to our model, characterized by the critical combination of time of day (08:00 – 11:59 a.m.) and normal meteorological conditions. No safety effect incidents for medium aircraft on scheduled flights and for military aircraft were most common between 12:00 noon and 15:59, with normal meteorological conditions.

CONCLUSION

The air traffic density on particular days of the week and in particular time periods (peaks and saddles) affects the frequency of occurrences. The majority of occurrences were observed at airports and in their vicinity during final approach and landing. This phase of flight is the most critical for controllers as well as for pilots. The time of year had no impact on the incident rate. Higher workload did not induce a higher rate of incidents. Most incidents occurred during normal operational workloads. Proper arousal (i.e., no under- or overload) is vital to fulfill all controllers' tasks at requested quality. Flight rules had no significant impact on the occurrence of accidents or incidents; the distribution was identical for visual and instrumental flight rules. The mathematical risks model considers the most critical factors for Major and Significant incidents to be time of day, meteorological conditions, type of flight and aircraft category. No significant impact of the other analyzed variables was discovered.

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LOW COST AIRPORTS IN THE EUROPEAN REGION

Ing. Marek Turiak
Air Transport Department, University of Žilina in Žilina, Slovak Republic
turiak@fpedas.uniza.sk

Abstract *– The evolution of low-cost carriers has in recent decade uncovered the trend in which mainly low-cost carriers operate from secondary airports rather than from crowded primary airports. This has caused the rapid development of many secondary airports that were previously not fully or at all utilized. Aim of this paper is to identify these airports as well as to give an insight into their main characteristics as well as problems and challenges they face and pose to other carriers in the region.*

Key words – Low-cost Airports, Low-Cost Carriers, Secondary Airports, Terminal.

INTRODUCTION

The new commercial formula for low-cost air companies relies on short-haul flights, fast stops, and simplified air traffic, which result in transit network configurations that operate through multi-nodal, point-to-point trajectories rather than centralized, congested interchange hubs. The success of these new structures has been bolstered by substantially reduced fares. Once an elite experience, air transport has become a mass phenomenon. It is a constantly evolving flow: in 2012 the two main low-cost airlines — Ryanair and Easyjet — transported according to the data from corresponding annual reports almost 130 million passengers in Europe. In only a few years, this economic phenomenon created the emergence of a network of secondary airports that are less congested and have lower landing fees in comparison to traditional hubs.

These two terms — ‘airports’ and ‘low-cost’ — are not susceptible to any existing interpretation independently. These airfields, which can be regional or ultra-peripheral airports but also secondary hubs, are difficult to classify by type and size. Similarly, a variety of economic and spatial models correspond to the definition of low-cost carrier' itself.

EMERGENCE OF LOW COST AIRPORTS

Although the definition of ‘low-cost airports’ is in itself ambiguous, it clearly identifies a phenomenon that has become part of our common vocabulary and imagery today. Ryanair's commercial strategy relies on a system of capillary networks throughout Europe that consists almost exclusively of over 150 secondary or regional airports (figure 2).

Figure 10Map of European low cost airports (1997)

The majority of these secondary airports were already present in non-primary European territories before the advent of airline deregulation. These structures were mostly inherited from previous military bases and from city airports built to promote regional development. Previously they offered private flights, rescue flights, and charter flights to tourist destinations, and from time to time international services for regional air companies that had small aircraft, high fares and smaller capacity. More often, these airports provided connections to national hubs in cooperation with flagship companies. Although they offered these specific services, small and mid-sized airports were often operated at an economic loss, subsidized by the state to promote regional development in proximity to some urban centres.

If today secondary airport terminals have become successful and sometimes seem overcrowded, only a decade ago these places would have felt vacant, abandoned, deserted. Before the advent of airline deregulation in Europe air traffic would converge at the principal airports of the 'hub and spoke' network: the hubs being centres where the majority of traffic would converge to be directed to other destinations, the 'spokes.' The role of the spokes was only to support the hubs. This was purely a role of connection or liaison, with some additional services such as small planes with high rates and lower capacity. As Castells states, the hub was the true core in a system where national airlines operated within an uncompetitive market environment. 'Some places are exchangers, communication hubs playing the role of coordination for the smooth interaction of all the elements integrated into the network [1].'

Figure 11 – Map of European low cost airports (2013)

Before deregulation, the system left the majority of the secondary airports empty and underutilized from the moment that the national airlines distributed passengers to principal hubs. If initially there was no interest in developing these airports, the situation rapidly changed with market deregulation and the development of a transport network focused on smaller towns. Passengers began to use the new structures, at first encouraged by low rates, and thereafter by a number of features that improved the travel experience: fast check-in, flight punctuality, and the simplicity of organization and construction of the terminals [2].

In addition to underutilized secondary airports, whether military or civil terminals, low-cost airlines also employ a number of medium-to-large international airports, where airport taxes and the number of available time slots are not a barrier. Airports located in Eastern Europe, such as Bratislava, Slovakia, but also underutilized facilities such as London Stansted, have become models of another strategy that is being consolidated over the years.

The case of Stansted is exemplary in many ways. Oversized according to the traffic forecasts of the 90s, it was initially listed as one of the most striking commercial failures in airport development. The airport was designed by Norman Foster as the third London airport after Heathrow and Gatwick. Despite the extravagance of its construction technology, and the substantial investment by the managing British Airport Authority (BAA), the airport was deserted since its opening because of its distance from London. It would be low-cost airlines, attracted by low prices and high traffic capacity that would transform Stansted into an efficient operational base. The 'calm, clarity, and convenience' [3] formula, the inspirational guiding principle of the building design, became by chance and necessity the constructive prototype of a new generation of low-cost airports. As Sir Norman Foster says, 'We drew inspiration from the early days of flying when airfields were very simple affairs. There was always a clear airside and landside so you were never in any doubt where you were.'

According to data, secondary airports are less expensive when compared to hub airports. Secondary airports are strengthened by a point-to-point traffic system and by an effective cost containment program, while hubs are primarily managed by traditional airlines, whose luggage services, complex flight connections, security lines, surface transport, and terminal magnificence lead to a considerable increase in cost. If originally the binomial secondary airports/low-cost airlines are the product of a contingency, due to the inadequacy of available slots for new air carriers at hub airports, they soon developed a low-cost culture with an all-inclusive character. Simple interior volumes and clarity of distribution contrast to the complexity of large international hubs, where the long labyrinthine walkways, delays in flight connections, and long lines at check-in and security desks are part of a consolidated routine.

The golden age of airport buildings from the non-competitive era is being replaced by low-cost buildings with essential features and simple volumes, such as Frankfurt Hahn or the low-cost airport in Marseille, where important changes in spatial organization were deployed.

Figure 12 – Low Cost terminal at Bordeaux Airport

The number of check-in desks has been reduced, since seat assignments are no longer necessary. There are no more business lounges or air bridges. No more internal surface transport. No more shuttles or buses. Alone, in complete autonomy, travellers weigh their luggage, and head on foot towards the airplane.

Airports and airlines have reduced air inactivity from 75 to 25 minutes, making quick turnarounds to have more daily flights with a single aircraft that spends more time in the air than on the ground. Outside, the aircraft are parked perpendicular to the terminal, not parallel. This simple spatial strategy saves about 20 minutes in boarding time. That is to say it allows the plane to make one additional return trip per day.

Ticket purchasing is completed only online via internet or in some cases by phone reservations, and payment via the Internet. Without making use of travel agencies and, therefore, without increasing costs. E-mail identification, personal data and credit card information, as well as personal preferences, constitute a virtual community of passengers and a data bank that low-cost carriers use to better define and orient our choices and their services.

No-frill flights, increased personnel productivity, ticket purchase via the web, elimination of travel agency procedures, and negotiation of discounts with airline suppliers are only some of the cost reduction strategies. In addition, the airports themselves need to be involved in cost-benefit policies since new airlines foster competition among airports to provide further discounts in services. A famous example was the competition between Rimini and Ancona airports for the Stansted route, or between the Kerry and Shannon airports for the Hahn route. Airports seek advantageous long-term agreements with new airports since every new route produces a consistent volume of passengers, parking, car rentals, restaurant services and commercial areas, proportionally increasing revenues.

It is a winning strategy that is also fostered by state aid to those airports which are located in less developed areas. This goal is also pursued by the European Community providing funding for the development of small airport facilities. Airports, in fact, come to play a major role in the integration of peripheral regions, fostering not only economic activities but also social and territorial cohesion. Due to renewed utilization, the new airport goes from an entity in loss to a real economical resource for the region.

Accessibility to airport infrastructure has also changed. Although the ground transport system does not yet have coherent characteristics, it is more flexible and more suitable for the new consumer typology. The new passenger prefers the freedom offered by individual transport, thus bringing about increased business volume in the car rental sector. In secondary airports accessibility to the territory is easier while traffic, infrastructural crowding and parking costs are reduced. In addition to automobile use, which dominates, there is a limited public transport service that guarantees a bus connection in correspondence to individual flights.

New airports have, as defined in technical terms, specific 'catchment areas' for a new customer profile. In the traditional system of airports, the passenger's criterion of choice was the most convenient airport in spatial terms. With the low-cost system we instead talk about the 'concentration model' [4] where customer preference refers to the carrier with a more advantageous rate but not necessarily the nearest airport. Space and time are not the relevant variables in assessing accessibility. In the low-cost 'space of flows' [5] travel, cost is the determinant variable.

If Heathrow airport in the London system is advantageous for Oxford. Stansted is convenient for the city of Cambridge and London's financial centre. Cambridge, the renowned centre of culture and technology, finds in London an European network accessible to entrepreneurs, scientists, and scholars who can avoid 'wasting time' in the more complicated Heathrow system.

If at first the new airport seemed to be located far from urban centres — even hubs to be honest — we have to consider that major economic activities have also been transferred to the metropolitan hinterland. Studies done by some hub airports show that downtown is the origin and destination for a relatively small number of passengers.

One of the significant aspects connected with air transport deregulation deals with network change in the structural and spatial configurations. Low-cost carriers and charter companies tend to organize their own networks according to 'point to point' routes. This structure represents for the passenger the possibility to arrive immediately to the favoured destination, without being confined in the a-political, a-spatial, a-temporal hub limbo.

It is important to highlight that in the last few years, with the increase of routes and airports served, the larger low-cost carriers have progressively substituted point to point configurations with a hybrid polycentric network. A series of airports spread over the European territory are designated as 'bases' or 'centres' from where the diverse destinations radiate. Stansted. Dublin, Frankfurt Hahn, Stockholm Skavsta, Gerona. Bergamo Orio al Serio and Rome Ciampino are Ryanair bases that are joined complementary to other secondary airports. Easyjet has also taken on a similar strategy, offering centres of greater activity such as Luton, Prague, Berlin, Geneva, and Dortmund.

The creation of new bases is, in fact, a technical necessity for these companies to expand their own networks. The use of an aerial fleet which is essentially constituted by Boeing 737-800 or Airbus A319 and A320 family jets means performing short-distance flights, where the average flight is about 1,000 km. Therefore, route and airline expansion can only be polycentric so that aircraft can be maintained in the bases in the evening and the personnel can be assembled conveniently. The low-cost nomad is changeable, hybrid, and complex: from the tourist to the city-user, from the commuter to the business traveller, from the student to the legal immigrant. Young, less than 40 years old, and with a university level education, the new traveller is on the move mainly for tourism with medium-to-long stays of four to seven days, travelling by choice as opposed to obligation.

The low-cost space of flows is no longer reserved for a minority of people as it was ten years ago. It has assumed such a degree of familiarity as to become a place of everyday life, and travelling by airplane a daily practice, since an always greater portion of the population frequents these transport structures with a monthly or weekly cadence.

This is why the collective imagery of airports has changed: the paradigms of the city-airport, of the 'non-places' [6] of modernity — well detected by Marc Augé more than ten years ago and which promoted an intense debate among critics — seem to be obsolete. They have been replaced by low-cost airports'.

Development of low cost airports

Low-cow airlines have been major drivers of the development of low-cost airports. Ryanair has prominently been the impetus behind the development of Barcelona/Girona, Brussels/Charleroi, Frankfurt/Hahn, London/Stansted and others. Likewise, EasyJet has led the business development of Manchester/Liverpool and the growth of London/Luton. In the United States, the phenomenon has been known as the “Southwest effect”, as that airline has energized the doubling and tripling of traffic at airports such as Boston/Manchester, Boston/Providence and Miami/Fort Lauderdale. In Asia, Asia Air has been promoting Manila/Clark and Jetstar in Australia has created Melbourne/Avalon from virtually nothing. Table 1 provides details. Overall, the low-cost airlines have catalyzed the widespread development of multi-airport systems in metropolitan areas. These used to be confined to metropolitan areas with over 10 million departing passengers a year [7], but now these are a feature of many smaller areas – such as Oslo, Stockholm and other metropolitan regions.

Table 1 – Secondary airports of major European cities

Metropolitan Region	Secondary Airport	Low-cost Airline
Barcelona	Girona	Ryanair
Brussels	Charleroi	Ryanair
Copenhagen	Malmo, Sweden	Ryanair
Frankfurt	Hahn	Ryanair
Glasgow	Prestwick	Ryanair
Hamburg	Lübeck	Ryanair
London	Stansted	Ryanair
London	Luton	easyJet
Manchester	Liverpool	easyJet
Milan	Orio al Serio	Ryanair
Oslo	Torp	Ryanair
Paris	Beauvais	Ryanair
Rome	Ciampino	Ryanair, easyJet
Stockholm	Skavsta	Ryanair
Venice	Treviso	Ryanair

It is worth noting that the cost of developing low-cost airports has been minimal – in contrast to that of a new or expanded traditional major airport (such as Madrid/Barajas, Miami/International, Paris/de Gaulle, Tokyo/Narita, etc.) that cost several billions of euros. Low-cost airports have almost been free, due to the fact that obsolete or abandoned military and other airfields are plentiful. These have provided the runways and basic facilities for almost all the airports listed in Table 1. In any case, regional authorities have been glad to supply the modest supplemental facilities needed for passenger services, in exchange for the jobs created by the low-cost airlines and the passengers they bring to the locality. And the possibilities are far from exhausted.

Low-cost carriers like to use low-cost, secondary airports for two reasons. Most obviously, they appreciate the low charges. Perhaps more importantly however, they like the smaller airports because these are relatively uncongested and thus free from ground and air traffic control delays, as Warnock-Smith and Potter have documented [8]. This lack of congestion, together with work rules that permit fast turn-around times at the gate, enables low-cost airlines to increase the flying time and thus the productivity of their aircraft, and thus lower their operating costs significantly. Low-cost airlines promote secondary airports because they are generally integral to their efficiency.

Competition with Hub Airports

Most obviously, low-cost secondary airports in a metropolitan area compete with the traditional main ports. As the low-cost carriers expand along with these low-cost airports, they reduce the market share of these legacy airports. Table 2 illustrates this obvious point. The impact of this competition on the specific routes served by low-cost carriers can be much stronger (such as Dublin-Brussels served by Ryanair) [9]. More subtly, the low-cost airlines and innovative freight carriers are establishing parallel networks that by-pass the traditional main airports [10]. This is strikingly evident in Europe, where both Ryanair and EasyJet make a point of serving major metropolitan areas through secondary airports. Thus the Ryanair network comprises London/Stansted, Barcelona/Girona, Brussels/Charleroi, Frankfurt/Hahn, Rome/Ciampino, Stockholm/Skvasta, and so on. The situation in the United States is similar as Southwest serves Boston/Providence, Dallas/Love, Houston/Hobby, Miami/Fort Lauderdale, Washington/Baltimore.

Table 1 – Example of market share drops for primary airports associated with rise of low-cost carriers [source: data drawn from various reports]

Metropolitan Region	Primary Airport	Market share (%) in	
		1994	2004
Boston	Logan	90	72
Brussels	International	99	90
London	Heathrow	65	53
Miami	International	69	56
Rome	Fiumicino	99	91
San Francisco	International	68	58

Moreover, the low-cost carriers compete with the main airports when they fly directly from major metropolitan areas (such as London) to secondary airports, thus bypassing the hub airports that have traditionally provided connections to secondary areas. Thus when Ryanair serves Carcassonne direct from London, it not only competes with flights that might go direct from London/Heathrow, but also those that might provide service through Paris.

Overall, we are witnessing the development of parallel air transport networks. On the one hand there are the legacy carriers, largely attached to their hub or legacy airports. On the other hand, there are the low-cost carriers, which have been promoting the definition of low-cost airports. This low-cost network has been complemented in North America by a network of FedEx and UPS low-cost, secondary airports such as Chicago/Rockford, Los Angeles/Ontario, and San Francisco/Oakland.

Business Model for Low-cost Airports

The business model of the low-cost airlines generally aims to cut frills. Low-cost airlines simply do not intend to pay for architectural showcases and gateway projects, and the associated high airport charges, to the extent that they can avoid them.

According to an interview with the head of Ryanair, their top three airport requirements are:

- low airport charges,
- fast turn-around times, and
- single-story airport terminals [9].

Thus the Ryanair wing of the London/Stansted airport is a one-storey structure that passengers walk to in sharp contrast to the expensive multi-level buildings, designed by a signature architect (Sir Norman Foster), that travellers on other airlines have to access using a special-purpose train.

When the low-cost carriers have the opportunity to define the passenger facilities they are simple and sparse, with a minimum of commercial facilities. This is thus the pattern, for example, at the Ryanair terminal at Frankfurt/Hahn; the EasyJet facility at Manchester/Liverpool; the JetBlue terminal at Los Angeles/Long Beach, the Jetstar sheds at Melbourne/Avalon, and the Air Asia low-cost terminal at Kuala Lumpur. At Singapore, an airport known for its excellent shopping opportunities, it is remarkable that the design of the low-cost terminal has essentially no shops. Specifically, the low-cost airlines apply design standards that can be deeply different from those that have been and are generally applied to traditional passenger facilities, such as those of the International Air Transport Association[11][12]. They use space more intensively, by planning on higher densities of passengers per unit of area, and by using shared hold rooms instead individual gate lounges. Additionally, they process passengers more quickly, with turn-around times of around 30 minutes instead of the more standard hour, which means that they need fewer gate positions for a given number of daily flights. The net result is that low-cost airlines often require around half the space per passenger as the legacy airlines[13].

Figure 13 – JetBlue terminal 5 at LAX

This approach gives the low-cost carriers a tremendous financial advantage compared to the legacy carriers that must operate out of, and consequently pay for, grandiose monuments. The airlines operating out of Terminal 5 at London/Heathrow will be carrying a substantial handicap, compared to their low-cost competitors. In effect, the cost of this grandiose building (by the signature architect Lord Richard Rogers) is already over €6.5 billion. Its annual cost for amortization and operation will be on the order of €20 per passenger. This kind of burden is one that low-cost airlines will not tolerate, and such expenses are avoided wherever possible by going to the low-cost airports. As low-cost airlines continue to expand at the expense of the legacy carriers, so will the low-cost airports at the expense of the legacy airports.

CONCLUSION

It is apparent that low-cost airlines will have low-cost airport facilities. This seems inescapable. What is unclear is whether these low-cost airport facilities will continue to be distinct from the legacy airports. Indeed, it is possible that to the extent that low-cost carriers drive the legacy carriers out of business, they will supplant them at major airports, much as Southwest has taken over Chicago/Midway, replaced US Air at Baltimore/Washington.

In face of these facts, airport planners, investors, and managers need to develop strategies that will enable them both to avoid over commitments that are financially risky, and position them to take advantage of opportunities as they may develop. To achieve this, they need to adopt a new, flexible approach to airport analysis and design, possibly along the lines indicated.

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CERTAIN ASPECTS OF THE FLIGHT OPERATIONS BY A DOMINANT AIR CARRIER TO A SMALL REGIONAL AIRPORT AND THE CONSEQUENCES OF SUCH TRAFFIC ON AIRPORT´S SUSTAINABLE DEVELOPMENT

Radek Zábranský, MSc., MBA
Airport Karlovy Vary, Ltd., Czech Republic
radek.zabransky@airport-k-vary.cz

Abstract – *The aviation sector worldwide has undergone a fundamental transformation over the last 20 years. The liberalization of the European and US skies particularly lead into the emergence of competitive, innovative low-cost airlines, which created a new aviation market defined by efficiency, productivity and competitive practices. Regional airports are regarded as drivers for an economical boost in regions today. It is believed that a functioning regional airport is important for providing new jobs and attracting direct, indirect and induced industries to settle in the vicinity of the airport, which means that an airport is seen as a job motor. Airports, including the regional ones, were originally considered natural monopolies, but today they are very much an integral part of airline business, with all its vagaries and uncertainties. Unfortunately, only limited attention is being paid to certain aspects of how small regional airports are affected by the changes in this new institutional environment, especially how far they can adapt themselves to the new, competitive market conditions and how they can deal with purely commercial threats. Highly mobile airlines, especially low-cost, are very aggressive in their demands, namely as regards to airport costs and in many cases small regional airports do have just little bargaining power or limited options how to deal with such, usually dominant, airline flying there. Ultimately, they end up in the uncomfortable position of having to balance very divergent requirements from its stakeholders and at the same time, to compete with others, to cope with the market volatility, to fulfill all legal and administrative requirements and finally, simply to survive in the market.*

Key words – regional airport, low cost airlines, liberalization, competitive market, bargaining power

INTRODUCTION

As the popular and widely used old saying goes, change is the only constant in any industry. This indeed means that the aviation industry would hardly be an exception and we all know it is not. The on-going liberalization of airline, airport, ground handlers and other suppliers markets, technological progress or the establishment of new business models are just a few examples that illustrate the dynamic development of air transportation within the last years. Over last two decades, the air travel became accessible to more travelers than ever before and more millions of tons of goods were carried at the same time. Looking ahead, the industry professional bodies such as IATA or ACI predict that in 2050 aviation will fly around 16 billion passengers and 400 million tons of cargo, which means there will be an on-going demand to effectively and sustainably manage the entire industry value chain.

Airports have no other option but to mirror the shift of the industry and to reflect it in their activities. Therefore, it is not surprising that they are forced to operate on a different economic and operational mode then twenty or even just ten years ago. As a part of the industry value chain, airports had to implement a lot of new practices and procedures in order to reflect the increasing demand especially by their major customers – the airlines, asking on one hand for improved efficiency and quality of services provided and on the other hand decrease of charges or at least their status quo.

Small regional airports are an integral part of industry value chain. It is widely accepted that these airports are of vital social and economic importance for the nation's regional, rural and remote communities. Given that they do operate in a fully liberalized environment, it is evident that these airports shall be facing the same issues as the bigger or even biggest ones: competition, operations, regulatory or environmental issues. On top of it, they are more exposed to stronger competition by other means of transport, volatility of passenger demand, turbulences in economy, lack of available funds and limited availability of experienced workforce. Finally yet importantly, it is the relationship with airlines, which concerns them primarily because in most cases the airline serving small regional airport would be in monopoly or near monopoly situation.

In the following sections, this paper discusses some important consequences of this situation, namely how airlines tend to do business and "cooperate" with small regional airports and what are the risks of current flexibility of especially low cost airlines to switch their operations from one airport to another. Using practical examples, it will demonstrate how the airlines could abuse their monopolistic or dominant and why airport managements and stakeholders should be prepared for it.

SITUATION OF AIRPORTS IN EUROPE – BRIEF SUMMARY

Changes in the European aviation industry and market liberalization in particular brought a fierce competition not only between airlines but do have a natural reflection also in airport sector. Political and economic changes particularly in former Eastern Europe at the end of nineties and consequent positive development of international relations have had direct reflection in the increased demand for air travel. Demand for travel further boosted in connection with the expansion of European Union. All these changes were first reflected in the evolvement of new air carriers, especially low cost airlines, hence available seat capacity that had to be complemented by development of available airport capacity. Consequently, numbers of new civilian airports were put in operations within last 25 years of which partially were newly constructed and partially converted from former military airfields. Currently there are approximately 650 airports in Europe with scheduled traffic, ranging from megahubs such as Heathrow, Paris CDG, Frankfurt or Amsterdam to tiny regional or local airports, handling couple of thousands passengers a year.

Both airline competition for passengers and increased number of available airport capacity, in particular on regional airports has implications for those airports. Airports must now compete with each other for both passengers and airlines, which have significantly more choice than in the past.

Apart from the competition there are other factors affecting the performance of European regional airports. The initial months of 2013 saw passenger traffic significantly weakening as a large part of Europe experienced continued recession and growing unemployment. The situation has especially deteriorated in the EU, where passenger traffic receded by -2%. Regional airports are showing less resilience than hubs, as they are more dependent upon intra-European traffic and more exposed to airline capacity cutting. At present 48% of Europe's airports are losing passenger traffic and 42.5% of European airports remain loss making, down from 49% in 2009. Many of these are smaller regional airports which are structurally unviable and which require targeted public funding to maintain their contribution to local, regional and national economies. Airlines aggressive capacity cuts (lower frequencies & dropped routes) are heavily affecting regional airports in particular resulting in more pressure on aeronautical revenues as airports struggle to retain traffic.

There are many reports, analyses or studies dealing with current market situation of airports in Europe. In these there are widely discussed especially aspects such as airport competition, commercialization of operations, economic regulation, ownership issues and environmental impact of airport operations. Unfortunately, these papers normally deal with medium to large airports, including most important hub airports. Unfortunately, much less of attention is paid to the situation of small and very small regional airports. From the passenger volume perspective, these airports are considered to have just limited regional importance, i. e. they are seemed to be important just for the particular region, where they are located. However, the overall importance is a bit underrated, unless such airport is located in densely populated area. In this case and if the airport is located in relatively close distance from a major airport within the same area, its importance might grow in the future, depending on how fast will decrease the ability of the major airport to satisfy the demand due to lack of its capacity..

NATURE OF BUSINESS ON SMALL REGIONAL AIRPORT

The ownership and governance of airports in Europe in general has been transformed over the last few decades and this certainly applies to small regional airports too. Approximately 80% of Europe's airports have been corporatized. Most publicly owned regional airports now operate as commercial entities at arms-length from government (either central or local), they are now more commercially focused. This massive undertaking has resulted in situation, when small regional airports should be more competitive and efficient – operating with lower costs and fewer employees and working closely with their partners – communities, air carriers, and employees.

Running a regional airport that is commercially successful poses major challenges to local government operators. The most crucial in this context is to keep the right level of balance between the financial costs and the social and economic benefits airports bring at a regional level. The difficulty is that in many cases the local government authorities are not honest as far as the potential of their airport and/or do have difficulties in understanding the airport business in general. This could lead into ineffective investments to facilities and spending significant amount of money for direct or indirect subsidizing of airlines. If the market is not being substantially developed or the conditions of cooperation with airlines are not properly set up, there is a big risk of losing this traffic when the financial stream has to be reduced for whatever reason.

There should be no investment without first weighing up the risks as well as the potential benefits. Local governments have limited funds to support the development of their airports, however it is still quite often to see the approach "Build it and they will come". This approach could turn into real financial disaster and there are examples of nicely build airports across Europe having no traffic. Over expectations of generating profit within just few years are still quite common and there are projects across Europe, which are currently being developed and financed based on such unrealistic expectations.

On the other hand, there is also no guarantee of achieving the commercial success by doing things the other way around – invariably investing a lot of hard work into promotion and securing opportunities before making significant investments. Both activities need to be rightly balanced and amended, as situation requires. Airport owners and management firstly need to ask what is operationally critical investment (meaning both investments into infrastructure and to subsidise loss-making operation), in other words, what happens, if we do not invest in this. Will the airline cease to offer the connection? Is this connection essential for the community? This will indeed vary between airports: in the most remote places, even a few days without use of the airport causes major logistical, social and economic detriment; at other places, the socioeconomic impact might be less. If the investment isn't essential operationally, what will the increase in revenue be as a result of its implementation? This is a much tougher one to answer, as there are so many unknowns. Raising user charges to cover the cost is often prohibitive, so one has to be realistic about the increase in usage that can be achieved.

The reason is that unlike airlines, many of whose assets are movable, the airport industry is primarily a business of fixed assets - terminals, parking garages, runways, aprons. This means when an airline decides to cease or reduce its operations to a particular airport, the airport still has to cover the cost of operating these assets, pay its employees or any outstanding debt service.

Airports can generate revenue in two ways — through fees paid by airlines and aircraft operators and through income from parking, car rentals, concessions, advertising space sales, rentals of commercial space and royalties. If an airline threatens the airport with the possibility of elimination of flights, if it merges or even files for bankruptcy, i. e. if the airport faces a real likelihood of losing flights, both types of revenue may be reduced. To deal with a drop in revenue, airports are taking a number of steps, including personnel reductions and deferral of nonessential projects. They also may be forced to raise prices for services at the airport but for obvious reasons this is normally the last option in most cases. In order to retain the traffic, airports hand in hand with their owners and stakeholders had to implement incentive schemes, targeted investment and increased marketing spend in order to differentiate their products so as to cater for new or different airline types.

AIRPORT – AIRLINE BUSINESS

The liberalization of aviation industry is directly linked with two factors. The first one is the low-cost revolution; the second is the mushrooming of regional airports, both factors clearly related to the massive expansion of new routes. However, airlines of any business model are especially today seeking to improve their financial margins and failure to operate a route with sustainable profit normally results into decision to cut or shift the services. This on one-hand leads into improved load factors on airlines side, on the other hand, this newly found flexibility targets the airport-associated costs putting more airports in the difficult position.

It is obvious that due to the nature of the aviation business in Europe it would rather be the low cost airline, which will operate as dominant airline to a small regional airport. However, it is important to stress that there are less and less differences between low cost and traditional airlines when in comes to the means of cooperation with regional airport. Difficulties in airport-airline relations are not limited just to cooperation of small regional airports with low cost airlines. The same difficulties could be and are experienced when cooperating with so-called traditional or full service airlines. Once the airline, regardless of its business model, becomes a dominant airline operating to the airport, there is always a risk of abusing this dominant position and the situation for the airport becomes very vulnerable.

LOW COST AIRLINE AND REGIONAL AIRPORT

As mentioned earlier, during the last decade number of flights had amazingly increased, opening travel possibilities for people not having believed they could afford flying and visit so many countries. This development is mainly thanks to market liberalization and evolvement of so-called low cost airlines. The heart of their business is simple operations, distribution and fleet but above all, direct and measurable relationship between cost and revenues, i. e. they manage their costs and then set prices accordingly. Low cost airlines operate using different business models, ranging from pure or strict low cost operators, such as Ryanair or Wizzair to number of hybrid airlines trying more or less successfully to combine the advantages of low cost and traditional airlines.

The unquestionable market leader is Ryanair, who mostly serves secondary airports at relatively low frequencies and focuses on new leisure markets with no direct competition. The Ryanair model focuses on costs rather than on markets, which includes to persuade strongly suppliers and airports to reduce charges. Wizzair uses the same business tactic, while other low cost airlines, like EasyJet or Air Berlin, serve primary high costs airports at high frequencies and focus on existing business and leisure markets, accepting competition from incumbent carriers.

Low cost operators such as Ryanair or Wizzair are in general very good in stimulating demand and increasing the number of passengers, which means more business for airports. More passengers however do not increase the costs of airports that much because of the presence of economies of scale at airports. With a large share of fixed costs airports can only benefit from every additional passenger. Nevertheless, significant reductions and discounts in aviation revenue often provided to low cost airlines might not always be offset by increases in the non-aviation revenues and this must be considered when entering into agreement with a low cost operator. It is hard to prove that low fare passengers spend more at airports compared to other passengers using traditional carriers, despite the fact that some sources tend to stress this.

Unfortunately, quite often it is being overlooked that the decision by low cost airline to operate to secondary airport is motivated not only by customer demand. Low cost airlines demand many start-up deals such as reduced landing fees, handling charges or so-called marketing contributions from airports For example, Ryanair pays at airports to which operates in average just some € 3.50 per departing passenger. Easyjet who normally flies to main airports, pays approximately € 11.00 per departing passenger. Officially, discounts are not allowed as long as they constitute a disadvantage for other competitors and are discriminative. Indeed, if an airline becomes a monopoly or dominant operator at the airport, this would not be an issue. However, by entering into cooperation with powerful partner such as Ryanair or Wizzair and enabling them to become dominant operator, the airport risks ending up in a situation that they usually have very limited or even null bargaining power for future negotiations. New operational principles and habits of principal industry stakeholders – airlines and airports have in fact reversed their relations and it is now the airline, which plays the dominant role in business relations especially with small regional airport. The strong competitive pressure exercised by airlines results in continued restraint as regards the level of airport charges, reducing airport’s ability to pass through costs incurred in providing necessary infrastructure and services.

Monopoly or Near Monopoly Airline at Regional Airport

Ryanair or Wizzair are in a monopoly or near monopoly situation in a lot of the airports they serve. Historically, these airlines developed traffic at number of airports and became a backbone of the successes the airports achieved. Often they were the first airlines to use fading airports desperately needing the traffic to their full extent. A lot of those airports and surrounding areas have benefitted from the low cost airlines philosophy.

However, the industry development, mainly still increasing number of available regional airports and their competition (as well as competition of regions) has led to problems in some places. Low cost airlines more and more move into an airport due to their lower cost base and offered subsidies. Consequent ability of low cost airlines to offer lower fares resulted in other airlines moving out. At that moment, the low cost airline starts pushing for lower charges and if the airport could not afford to give lower charges, the airline responds by cutting frequencies and then reduction of routes, number of based fleet or even complete withdrawal from the market. This leads into situation that more and more small regional airports will find themselves in situation that they will not be able to sustain service over the long term.

Case study 1 – Ryanair

The central of Ryanair's philosophy is flexibility. They reserve the right to move aircraft around and between bases, the right to move people around between bases, and they intend to do so, should the conditions at airports and overall income are not favorable for them.

Most recently, this has been reflected in number of cases when the carrier announced new routes or cease of operations. As an example, the following cases could be highlighted:

New openings were announced in Poland, where the carrier moved back to new Modlin airport, following the finalized runway reconstruction. The carrier will benefit from its monopoly position here since Wizzair, the other airline originally targeted by the airport management, decided to stay at main Warsaw Okecie airport. Ryanair plans to operate both domestic and international routes from Modlin.

At the same time, the airline announced commencement of operation to Lisbon, Portugal from its basis Brussels, London, Frankfurt-Hahn and Paris-Beauvais. By this decision, Lisbon becomes the third Ryanair destination in Portugal and it is expected this new routes will boost the traffic at the airport by approximately 400 000 passengers.

At the same time, the airline recently announced closure of operation in Klagenfurt and significant downsizing of operations in Santiago di Compostela, where only domestic routes will remain in operations. In both cases, the decision to cease the flights is directly linked to the decision to stop providing marketing subsidies to the airlines. In both cases, the regional administration concluded agreements with an airline to provide financial support (to subsidize, in other words) to the airline. Now, because of the economic downturn, this became widely criticized by the public and both regional governments have decided either to stop providing of such subsidies Klagenfurt or not to prolong the contract (Santiago). While for Santiago, there are no exact financial data available, according to Austrian papers it is expected that the Carinthia government spend over € 1,000,000.00 supporting three weekly flights from Klagenfurt to London-Stansted. Since Klagenfurt airport also announced that they could not afford to provide subsidies to the airline, the reaction by Ryanair was immediate and all flights will be cease as of early November 2013.

Case study 2 – Bankruptcy of an Airline

Regional airport in former Easter Europe with quite reasonable mix of traffic: 60% low cost, 25% charter operations, 15% traditional airlines. At a certain moment, one from the volume perspective top low cost airlines at the airport filed for a bankruptcy and ceased the operations, causing loss of approximately 40% of the traffic. The remaining low cost operator immediately approached the airport management and demanded significant reduction of airport charges in exchange for the increase of capacity at this airport. The airline demanded reduction of airport charges from approximately € 15.00 per departing passenger to approximately € 5.50 per departing passenger. The airport counterproposal was to introduce the discounts gradually in order to reflect the increasing volume of flight. After long negotiations, the volume based discount scheme was agreed and if the airline would reach in average 20+ daily frequencies departing from this particular airport, the cost per departing passenger would be approximately €8.00.

Case study 3 – New Low Lost Airline Willing to Enter the Market

The same airport as in Case study 2. Following the bankruptcy of major airline operator at the airport, the airport was approach by low cost airline, willing to make use of this situation, enter the market and overtake some of the routes originally operated by the bankrupt airline. Since the negotiations with this particular airline started earlier then the bankruptcy happened, the change in attitude and desire to capitalize on this situation could be nicely demonstrated.

Originally, the negotiations discussed the average per passenger charge from approximately € 15.00 - € 18.00 for 2-3 frequencies per day to approximately € 7.40 – € 9.60 in case the number of daily frequencies reaches 21 and more. However, just next day after the bankruptcy case the airline submitted "revised" offer, stating:

Quote

"The situation has now changed with Airline XX no longer in business. We tried many times to agree with a charging structure prior to today with no luck. We do not want to end up uncompetitive against other airlines and for this reason we cannot accept your counter-proposal. Given the new environment, we could only agree to the following structure".

Unquote

The new by airline then proposed charging, which ranged from € 9.60 in case of 1 – 4 flights to € 5.90 in case the number of daily flights reached or exceeds 18. On top of it, a marketing support to promote the airline on the market was required, further reducing the proposed income.

Besides the financial requirements, the airline asked to include additional, in fact very unusual conditions of cooperation to the contract. The most special requirement was that the airport will be fully responsible and liable for any bird strike cases, that would happen not only within the airport territory, but anywhere, if the plane was up to 1000 (one thousand) feet on take-off and up to 500 (five hundred) feet on landing.

The agreement with the airline has not been reached.

Case study 4 – Revenue Sharing

The most recent initiative, at least in Europe, is related to the demand by airlines that airports should share their retail revenues, such as share of royalties from duty free shops. Airports are bending over backwards to find (legal) means to attract airlines with minimal charges, shared marketing costs, and PSO deals etc. However, it seems for airlines it is still not enough and they feel that airports are missing a real possibility enhanced cooperation – to share airport retail revenues. As discussed during the ACI Trading conference in Hamburg this year, airlines of completely opposite business models are in this case of same opinion. This could be potentially a very dangerous development and yet another was how airlines could terrify the airports and for airlines like Ryanair to get access to a new way of squeezing money out of them. This is in complete contrary to what have been demanded over long period by almost all airlines and low costs in particular, i. e. to reduce direct airport charges and to recover this missing revenue from other streams, such as retail or parking. Moreover, based on recent findings it seems that revenue sharing is being traded for the withdrawal of "one bag policy" at certain Ryanair airports. Ryanair's Garry Walsh, Director of Commercial Development: "We have 180 airports in the network and countless others knocking on the door to get a Ryanair route – yet in two years I have had only three vague approaches to consider retail cooperation". This statement very clearly defines the next approach by low cost airlines and Ryanair in particular. One should however not be surprised that the same approach is being reviewed also by traditional airlines.

Case Study 5 – Negotiations with Airlines

Regional airport, that is served by single airline or there is a dominant operator desperately tries to find additional customers, both airline and passengers, in order to reduce the risk of losing majority if not all traffic should something goes wrong in cooperation with existing operator. However, even this could be quite difficult. There are in fact two problems. First, it is quite often that if one airline closes a route, it is quite difficult to replace it by equivalent service. The fact that one airline decided to cease the particular route sends a negative signal to the market and all other airlines are quite cautious to overtake the route. And even there is a new provider, it can still negatively impact the airport economy due to number of reasons, such as use of smaller aircraft, less frequencies and others. Should there is not replacement of ceased services, the airport faces further decline in traffic and serious problems.

Second, even in case the airport management actively promotes the airport and communicates with number of airlines, the success in obtaining new airline is still questionable, especially should the airport is served by one of pure low cost operators. The airline route managers from other airlines and airlines in general are not willing to enter into direct competition with those low cost airlines, despite the airport offers the same business conditions. The reason is that in most case the cost base of such airline is much higher and therefore they cannot offer competitive prices.

Conclusion

Trends in the airline industry directly affect also the trend in the airport industry – focus on minimizing cost, developing new commercial activities, shifting their business and operations model from public service to business oriented entities. Such a basic change in company structure makes a lot of airports rethinking their marketing concept and their revenue strategy. Airports must place more emphasis on non-aeronautical revenues from retail concessions. With the emergence of low cost airlines in the European market, the relationship between airports and airlines changed even more, directly impacting airport business in general. Originally it was assumed that the profitability of airlines is low and airlines are often "condemned to make losses", while airports benefit from continued financial health. Unfortunately, nothing could be further from the truth, especially at regional airports. The relationship between airlines and airports changed significantly in the environment of low cost carriers and one should be prepared that nowadays there is no significant difference between traditional and low cost airline when it comes to negotiations with regional airports or requirements for risk sharing, new routes subsidies, discounts on charges etc. The classical economic relation between airports and airlines has been rewritten by airports paying airlines to operate instead of the conventional model. Low cost airlines operate to achieve a profit and regions that intend to attract new low cost operations need to keep this in mind and be prepared to invest a significant amount of money into such operations. Secondary airports and regional tourism will become dependent on the development of low cost operations, especially if they adapt their offer and infrastructure in order to meet the needs of an increasing number of passengers. However, nobody can assure how and if the low cost market will develop in the future. Airports, airport owners and regional administration should always balance the growth of passenger numbers and local employment with related costs, be it deficits because of reduced airport charges or possible financial commitments. If possible, airports and regional tourism providers should not rely solely on low cost air travel. Low cost airlines can act as a trigger, but cannot be a general cure for economic problems at airports or in regions or even an ultimate solution for regional development in general.

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