# Possibilities of Introducing new Standard Arrival and Departures Routes at Malacky Airport


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***Abstract*— The topic of the article is devoted to air traffic services routes for the effective use of the selected Slovak airspace and the elimination of negative impacts of aviation activity on the environment and public health. The main goal of the article is to analyze the current state of standard departure and arrival routes at Malacky Airport, to describe the factors affecting standard arrival and departure routes and individual types of approaches with regard to wake turbulence, weather, noise and the human factor, to analyze software tools for creating standard arrival and departure routes departure routes at a selected airport in the Slovak Republic with an emphasis on safety and risk assessment in air traffic control.**



***Keywords*— Air traffic control, SID, STAR, analysis, software**


## I. INTRODUCTION

In the context of society-wide trends of increasing the development of aviation and the provision of air traffic control services [1], modern and effective methods of air traffic control are sought. The priority is to create conditions for meeting the requirements of air traffic control service providers, standards and recommendations of the International Civil Aviation Organization [2], the European Aviation Safety Agency, NATO standards, the Transport Authority of the Slovak Republic, the Military Aviation Authority of the Ministry of Defense of the Slovak Republic, and the Air Force Command of the Slovak Armed Forces [3]. Standard arrival and departure routes are critical to any aircraft movement and airport operations. Airlines are also looking for the most efficient routes and trying to reduce fuel costs as much as possible [4]. However, the primary purpose of standard arrival and departure runways is to ensure safety while multiple aircraft plan to take off or land [5]. Planning standard arrival and departure routes is not an easy process at all. Also, planning must meet the requirements of several regulations, such as ICAO Doc 8168 Vol. 3, EU regulation ADQ 552/2004 and no. 73/2010 of the European Parliament [6]. Currently, standard arrival and departure routes are created using different planning methods or different software are used to facilitate the entire planning process. Current standard spacings are safe, but as the number of aircraft in the air increases [7], they become inefficient and economically burdensome regarding the cost of fuel. The development of new equally safe procedures for departures and arrivals at the airport is a must [8]. Standard departure and arrival routes (SID and STAR) are now a part of every larger airport [9], to which are added RNP/RNAV routes, previously only used for flight routes [10]. SID and STAR are created to increase the safety and efficient flow of air traffic, operated from the same or different runways to the same or neighboring airports. SIDs and STARs comply with ICAO PANS-OPS IFR (or equivalent) proposed departure and arrival criteria procedures that provide a transition from the end of the runway to the route of flight. There are many operational advantages to using SID and STAR, both for the pilot and the air traffic controller. For the pilot, a relatively complicated route section can be read from the database and flown using the flight management system (FMS), while ensuring the correct distance from obstacles, ground, or other air traffic. Air traffic control can enable the aircraft for SID and STAR, reducing the need for additional instructions during the initial climb phase of the aircraft, greatly reducing ATC workload and frequency congestion. SIDs and STARs are laterally defined by conventional navigational aids (such as VOR, DME, NDB or prescribed headings) or as a spatial navigation track (RNAV) consisting of several LAT/LON waypoints. RNAV SIDs and STARs can overlap conventional SIDs and STARs. In addition, SIDs and STARs may include vertical profile by defining minimum or maximum flight altitudes at en-route points or fixes along the en-route.

## II. FACTORS AFFECTING STANDARD ARRIVAL AND DEPARTURE ROUTES

In aviation, there are many factors that directly or indirectly affect individual phases of flight. These factors increase the workload of pilots, air traffic controllers, passengers and, finally, the population living near the airport.

### A. Wake turbulence

Each path of an aircraft creating lift creates air vortices. The blowing vortices coalesce into a pair of coherent, counter-rotating vortices that may persist for several minutes after the generating aircraft has passed, potentially creating a hazard for any subsequent aircraft that may encounter the vortices. The speed of return vortices and their dissipation time depend on the weight, size, wing configuration and speed of the aircraft, as well as atmospheric conditions. ICAO Doc 9426 Air Traffic Services Planning Manual provides considerations for the effect of wake turbulence and wake turbulence encounters on aircraft: “The three primary effects of wake turbulence on a following aircraft are induced pitch, loss of altitude or rate of climb, and possible structural stress. The greatest danger is the roll induced on the penetrating aircraft to such an extent that it exceeds the maneuverability of the aircraft in question. If wake turbulence occurs in the approach area, its effect is greater because the following aircraft is in a critical condition in terms of speed, thrust, altitude and reaction time. Air vortices are most dangerous to the following aircraft during takeoff, initial climb, final approach, and landing because the time to recover from a temporary loss of control is close to the ground.

### B. *Weather*

An atmospheric model is essential when considering the automation of standard arrival and departure runways, as it defines the air conditions in which the aircraft is flying and, as a result, its performance may vary depending on those conditions. The European Center for Medium-Range Weather Forecasts (ECMWF) is an independent intergovernmental organization supported by 34 countries. ECMWF is a research institute and a 24/7 operational service, producing and disseminating numerical weather forecasts to its member states. These data are fully available to the national meteorological services in the Member States. The center also offers a catalog of forecast data that can be purchased by companies worldwide and other commercial customers. The supercomputing facility (and associated data archive) at ECMWF is one of the largest of its kind in Europe, and member states can use 25% of its capacity for their own purposes.

### C. *Noise*

Airplanes generate noise during arrival and departure at the airport. The noise generated by the aircraft during arrival/departure at the airport is a constant concern of people living near the airport. The high level of noise during the flyover can cause annoyance and even wake people up during the night. To reduce the negative impact of aircraft noise on communities near major airports, several noise reductions measures have been adopted over the years. One of the frequently used measures is to enforce the maximum annual number of flight operations, as well as the maximum permitted day-evening-night noise level around the airport. Moreover, for a single flight, the International Civil Aviation Organization (ICAO) has defined two departure noise abatement procedures so that the total area affected by noise is limited (ICAO 1993). There have been several improvements to terminal noise abatement procedures proposed in recent years.

### D. *Human Factors*

There are many reasons why an aircraft may deviate significantly from its assigned SID and STAR. A significant deviation from the assigned SID and STAR may result in reduced flight safety. Significant deviations of SID and STAR are caused by a wide range of factors. However, by far the most important causal factor identified is the fact that incorrect SIDs and STARs are used by the flight crew. Flight crews are more likely to use the wrong SID and STAR if similar sounding SID and STAR names are used at the airport.

## III. Safety and Risk Assessment

The requirement to assess system safety results from the need to establish a uniform methodological procedure for assessing system safety in each phase of its life cycle. This safety assessment procedure consists of the following three main processes:

- Functional Hazard Assessment (FHA),
- Preliminary system security assessment (PSSA),
- System Security Assessment (SSA).

If the assessed change does not affect the provision of ATS, the safety assessment process can be carried out in a less extensive process, the so-called Safety Considerations. The Safety Assessment Methodology (SAM) describes the basic principles of safety assessment and leaves the possibility of determining the details when introducing these principles (or their necessary addition) individually for each specific project. The safety assessment methodology described in this article considers the three basic components of the system (human resources, equipment, procedures) and their interaction (within the system and its environment) in a specific operating environment. The system may include ground, airborne and space components.

### A. *Functional hazard assessment*

The main functions of the FHA process are:

- identification of possible dangers and their effects based on the function of the assessed system,
- determining the severity class of hazard impacts,
- risk analysis and assessment,
- establishing safety objectives and, if possible, how to monitor them.

The functional hazard assessment process is performed during the system definition phase. Defining the system consists in specifying the services, functions, and activities that the system will provide/perform. System functional hazard assessment consists of three main processes, namely hazard identification, hazard analysis, and risk assessment. In the process of hazard identification, possible hazards resulting from a change in the concept of operation (change in system function) are determined. Dangers arise because of malfunctions within the system, a combination of errors and interactions of other systems, including external ones, which are involved in the provision of services in the operational environment. In the process of risk analysis and assessment, possible impacts of individual hazards are identified, for each impact its severity and probability of occurrence are determined. For each hazard, the worst-case scenario is established, and safety objectives (SOs) are specified using the Risk Classification Scheme. The result of the process of assessing the functional risk of the upcoming system change is the FHA report, which the processor submits to the approver.

### B. *Preliminary System Security Assessment (PSSA)*

The FHA and PSSA processes are functionally and logically linked and can be combined in one study.
The main functions of the PSSA process are:

- determination of safety requirements (SRs) for individual components of the system (human resources, procedures, and equipment) to achieve the set safety objectives (SOs),
- designing ways and means for monitoring the established security requirements (SRs).

The goal of the PSSA is to demonstrate that the system architecture (concept) under consideration can meet the safety objectives (SOs) that were specified during the FHA process. The safety requirements established during the PSSA process are derived from the Safety Objectives (SOs) and represent the means of hazard mitigation. Security requirements (SRs) can take the form of organizational, operational, process, functional, performance requirements and operational capability requirements.

### *C. System Security Assessment (SSA)*

This part of the system security assessment process is focused on the need to demonstrate that the implemented system does not exceed an acceptable level of risk, maintains the target level of security, and meets the security requirements that have been established for the given system. This part results in the following outputs: safety study, SSA study, collected data and evidence for safety assurance.

Main roles

- determine the interdependence of development, implementation, commissioning, operation, maintenance, and decommissioning phase,
- scheduling, SSA steps, SSA resources, SSA responsibilities and outputs.

The SSA process must be carried out regarding:

- relevant phases of the life cycle – implementation, operation, decommissioning,
- transitional criteria for the next phase of the life cycle, which include criteria and steps to obtaining approval for operation regarding the acceptability or tolerability of the risk,
- impact on system security: strictness of target danger levels, security requirements and level of assurance,
- the complexity of the system and its commissioning,
- newness of the system: use of conventional/usual or new technologies/technology that has not been used in similar systems before,
- other specific elements of the system that could have an impact on security.

## IV. SID AND STAR CREATION SOFWARE

The development of new technologies and software for the design and creation of new procedures for aviation is constantly progressing due to the creation, modernization, and expansion of airports with an ever-increasing number of passengers. New innovative procedures are becoming a matter of course, as it is necessary to divert a greater number of flights without reducing safety and the impact on the population and the environment.

One of these software is PHX SOFTWARE from ASAP PHX is a leading procedure design software that was originally designed as an internal company software to enable ASAP to efficiently and cost-effectively address the AIS (procedure design, airspace design and special aeronautical studies) submissions requested by the company. The software was released to the open market in 2001 after being used for more than two years in ASAP branches. and has been used to design hundreds of IFR procedures. The software is constantly updated to meet the latest requirements. There is one new release per year. The content of new versions is always discussed with our customer group at our annual user group meetings.

All procedure segments and associated protection zones generated by PHX software comply with ICAO PANS-OPS Volume II rules and recommendations. During segment generation, obstacle analysis and calculation of important parameters such as safe height above obstacles, OCA/H, initial heights, and descent rates are dynamically performed. Primary and secondary protective surfaces can be built in 2D or 3D. Default settings for specific segments can be customized where standard profiling according to Doc 8168 cannot be met.

PHX considers horizontal obstacle position tolerance as well as any vertical tolerance and an additional buffer may be specified for trees or unknown obstacles. Areas of mountainous terrain can be determined in a similar way. This software includes the option to not apply any vertical tolerances.

PHX can import data about airspaces, tracks, obstacles, runway positions, aerodrome reference points, waypoints, reporting points and navigation devices from any external source (Excel Aerodrome and obstacle Survey report, text or CSV file) or AIXM database file. Data can be inserted into a graphic file in the correct geodetic position (ie latitude and longitude) retaining all data from the original text database (ie name, type, notes, etc.). All entered data is immediately displayed by a graphic entity (Fig.1).

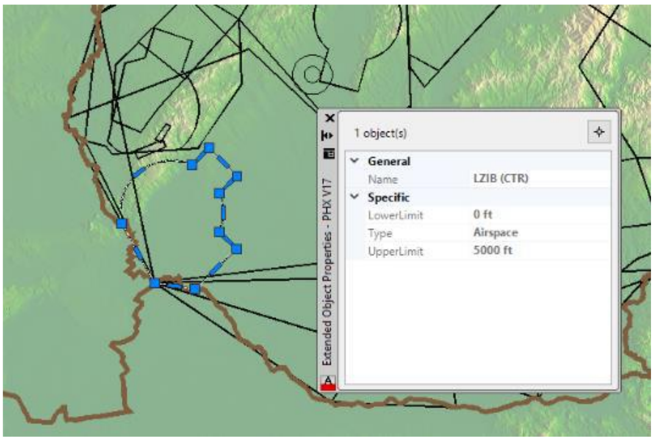


Fig. 1. PHX graphic enthity

There is also an option to insert a digital elevation model. Subsequently, the PHX software tools create an image of the specified area. This allows the user to check that PHX has correctly evaluated the intended area to be clear of obstructions. When the obstacle evaluation is complete, PHX creates a text table of the results. The creation and analysis of aerodrome obstacle area limitations is defined in ICAO Annex 14 or UK CAP 168 criteria. Default area dimensions have been updated according to Annex 14 Aerodromes Volume and Aerodrome Design and Operations Eight Edition. Calculating obstacle limits is a complex process, PHX can facilitate this solution, saving a significant amount of research time (Fig.2).

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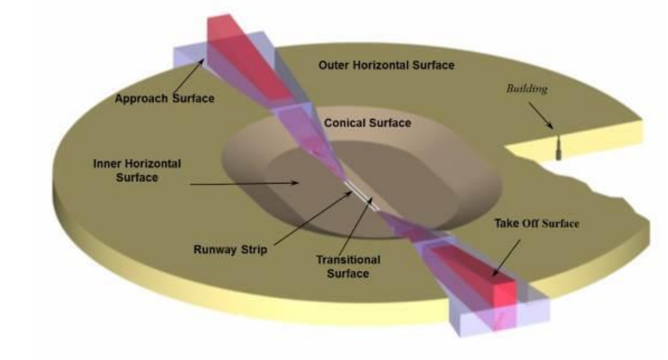


Fig. 2. Creation and analysis of airport obstacle area constraints

The export program contained in the general module of the PHX program allows you to export created 2D or 3D surfaces of obstacles to Google Earth to create a better idea of obstacles (Fig.3).

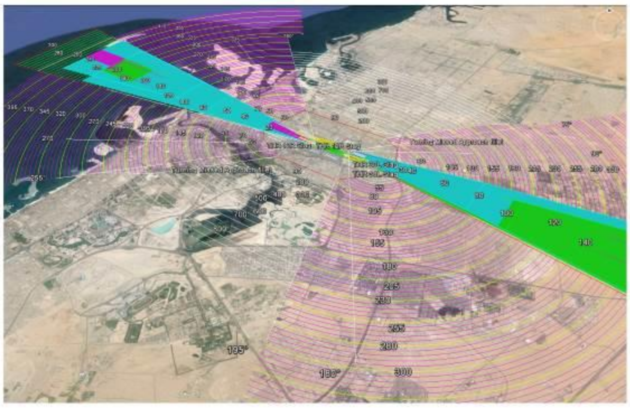

Fig. 3. Obstacle surfaces in Google Earth

After obtaining the above data, there is a next phase where aircraft speeds, climb or descent gradients, and altitudes are evaluated to determine the best possible SID or STAR operating configuration. These parameters are usually discussed with air traffic controllers at the airport, along with aviation experts and other interested parties. Once completed, this can be a very time-consuming and repetitive process that is manually adjusted at the end if necessary.

Following the determination of optimal and operationally feasible routes, they are evaluated based on the given airspace. This step may lead to route changes or other airspace restrictions.

During the finalization of the proposed procedures, there is a review according to ICAO Pans-Ops by a qualified procedure designer. Changes may occur in this step as well. In the final phase, the new tracks are checked one last time by the development team, who will make a final assessment.

For the analysis of the SID and STAR noise traces, it is possible to use a tool that generates a noise contour model. By analyzing this model, we will get an overview of the generated noise that will arise when using our proposal. The tool meets the conditions specified in ICAO Doc 29, 4th Edition, Volume 1-3. It is also possible to view the contour model in Google Earth.

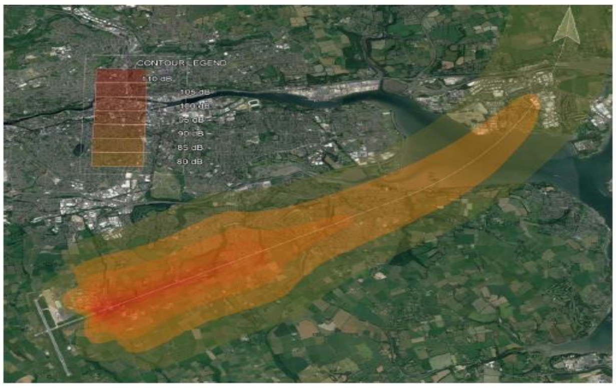


Fig. 4. Noise contour model displayed in Google Earth

## V. DISCUSSION

We will apply all the acquired knowledge about the current state of the solved issue of standard departure and arrival routes when defining the given research problem. The collected knowledge is used to formulate theses, main goals along with the solution methodology. The analysis of the studies helped us to identify possible solutions for the creation of new standard departure and arrival routes with maximum emphasis on safety and environmental impact.

From the available publications and documents, we can conclude that simulation and software technologies are widely used and are at a high level, as they enable effective designs, creation, simulation, and testing of new progressive procedures in air transport.

It is advisable to use simulation and testing to increase the safety and efficiency of the issue of departure and arrival routes. Most of the risk factors are thereby eliminated to a minimum and performance, quality and safety in real operation will be increased.

### *A. Defining research problems*

The issue of standard departure and arrival routes to the selected Malacky airport and its solution is of practical importance for foreign as well as domestic flights. The burden that pilots and air traffic controllers undergo is constantly increasing due to the growing air and ground traffic, which has an adverse effect on physical and mental health. The new procedures bring many benefits in the form of increased user performance, reduced fuel consumption in direct relation to the environment and public health.

The research problems of the issue are:

- Technical equipment of the airport (malfunctions and limitations of navigation systems).
- Usability of standard departure and arrival routes due to the location of the airport, close to the state border with Austria and the Czech Republic, together with neighboring airports in Bratislava and Piešťany.
- Spatial utilization of temporarily segregated areas in the controlled precinct and terminal controlled area of Malacky Airport
- Legislative approval of new procedures between the Ministry of Defense and the Air Traffic Services of Slovakia and Austria.

- Introduction of new standard departure and arrival routes to the workplace of the simulator of air traffic controllers

Based on the facts found, we can formulate the following research questions:

- Q1: Will the planes be able to fly the proposed routes without any horizontal and vertical restrictions?
- Q2: Is it possible to legally introduce the new standard arrival and departures routes into real operation?
- Q3: Will the procedures be efficient enough considering the proximity of the state border and the temporarily limited space?
- Q4: Will the proposed routes help reduce the workload of pilots and air traffic controllers?

## VI. Conclusion

The military control of air traffic in the airspace of the Slovak Republic, the priority level of security of the services provided, as well as its effectiveness through military professionals, are a complex matter. The dominant factor in it remains the quality of the provided education and training in all parts of the implementation of the educational process. In view of this finding, the consistency and interconnectedness of individual elements is evident, which significantly determine the security of the provision of services by military professionals and touch on a possible solution to the crisis that has arisen daily.

The presented work is a substantive summarization of the current view of the solved issue. It points to other open problems, descriptions of other proposed and planned activities, which directly result from the conclusions obtained during the processing of the topic so far and which we will address in further research.

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