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POTENTIAL OF GEOSPATIAL BUSINESS INTELLIGENCE SOLUTIONS FOR AIR TRAFFIC MANAGEMENT

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ABSTRACT

By establishing the Single European Sky (SES) initiative, data describing European Air Traffic Management (ATM) network' performance has become highly available - like never before. Since data sharing problem is minimized, the strategic planning and development boards of ATM related stakeholders face with a new challenging situation; how to deal with large amounts of data and how to interpret it correctly. Consequently, that led to development of different Information Technology (IT) solutions with an ability to obtain, storage and process large amounts of data. But more importantly, that has also led to the development of IT solutions that can help e.g. Air Navigation Service Providers (ANSPs) by gaining them insight about their business environment, how it might change or about performance interdependencies. However, despite the technological developments, one correlating indication is still remained left out. Considering that the spatial component of data set is often underutilized, this research paper aims to highlight importance of the development of Geospatial Business Intelligence (Geo-BI) solutions for ATM related stakeholders. Hence, the opportunities and benefits of applying Geo-BI solutions in the context of ATM and its strategic planning and development have been studied and presented throughout this research paper.

Keywords: Air traffic management; strategic planning and development; performance interdependencies

1 INTRODUCTION

Nowadays, many successful aviation businesses manage to grow simply because they understand their business environment [1]. However, still in most business reports usually only two data' components are indicated. Besides its value and temporal component, data is also described by a spatial component. From the above arise the question of quality of the information provided and problem of the lack of understanding of components interrelation. Especially since it's recognized that high share of data has geography disseminated across them. So, for businesses it is of high interest to receive business reports which are supported by mathematical models (solutions) that quantifies all three data components. Particularly, because nowadays it's easier than ever before execute

data processing (through application of data mining, machine learning etc. technologies) [2].

However, despite technological and methodological advances, spatial component of data is still often left behind and is not considered within development of IT solutions designed either for business-to-business (B2B) or business-to-consumer (B2C) applications. In order to reduce such an improper practice, Business Intelligence (BI) and Geographic Information Systems (GIS) solutions have started to become more closely integrated [3]. Ultimately, that has led to the development of Geo-BI solutions.

Humans think visually, therefore spatially. Accordingly, as more advanced research methods and technologies are seen those solutions that are based on spatial analytics. Since spatial analytics operate Geo-BI solutions, an increasing number of transportation

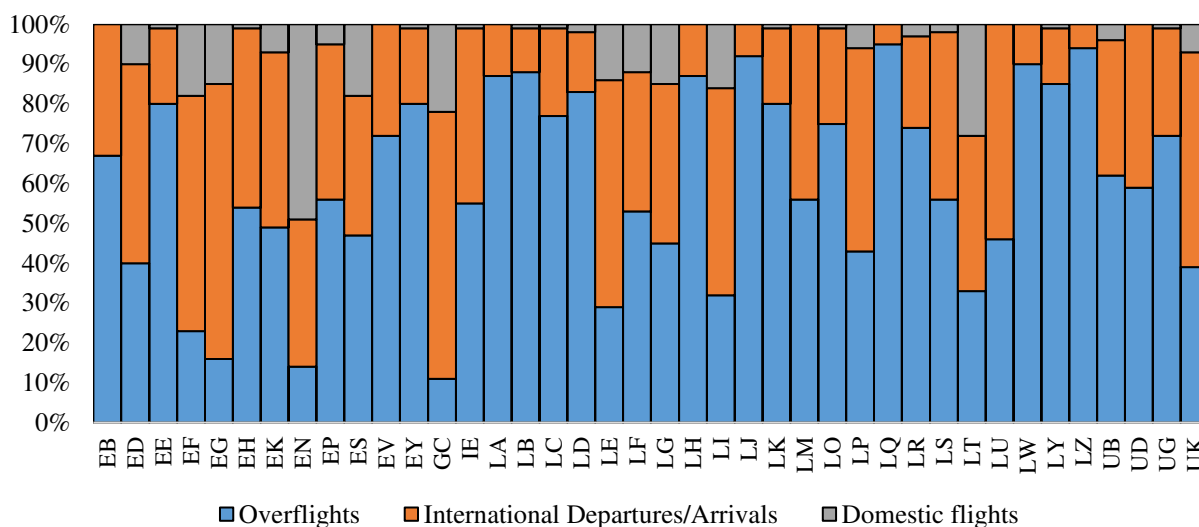


related businesses have already started to adopt Geo-BI solutions to support development of their businesses. Usually the main purpose of such innovative solutions is to provide new or strengthen existing understanding of their business environment or performance interdependencies, to valorise the effects of applied strategies or concepts etc.

Considering that functionality of future ATM system is based on collaborative and coordinated airspace and air traffic flow management [4] and on respecting the adopted development guidelines in sense of ATM regionalization, Geo-BI solutions have great potential within framework of Air Traffic Management system. Therefore, the further content of this paper gives an overview of performance interdependencies in context of Air Traffic Management, provides information about Geo-BI solutions and lastly identifies their applicability areas and gives recommendations how they can support further development of ATM system in domain of its strategic planning and development.

2 PERFORMANCE INTERDEPENDENCIES IN AIR TRAFFIC MANAGEMENT

European ATM system represents a complex system with a high number of participating stakeholders which may in different areas have a greater or smaller impact on the performance of total European ATM Network [5]. Moreover, by its nature, international air transport does not end at one States' borders. If an international flight is subject to Air Traffic Control (ATC) services in one State, service provision must be also continued in adjacent State (into which the aircraft intends to enter) and so on until aircraft reaches its destination. Accordingly, it can be inferred that the prerequisites that enable functionality of ATM system are interoperability and cross-border cooperation between Air Traffic Services (ATS) units concerned. In that context Figure 1 shows the distribution of provided Air Navigation Services (ANS) per State (according International Civil Aviation Organization nomenclature) in 2017. Since "a picture is worth a thousand words" it in the best possible way depicts scale of inter-connectivity between ANSPs. Moreover, it shows areas where understanding of performance interdependencies between ANSPs is of high importance.



Source: EUROCONTROL. Local Single Sky implementation monitoring (LSSIP), 8 November 2019, available at: <https://www.eurocontrol.int/service/local-single-sky-implementation-monitoring>

Figure 1: Distribution of provided Air Navigation Services (2017)

Figure 1 provides additional relevant information which depicts international nature of ATM business environment. If we categorize ANS provided during 2017 in terms of whether service was provided to international or domestic flight, it can be concluded that averagely 93.43% of total number of ANS provided in 2017 were conducted in cooperation of two or more ANSP. Furthermore, it can be defined that a bit more than ¼ of observed ANSPs have provided their services only to international flights overflying ANSP's Area of Responsibility (AoR) or to the international flights departing or arriving within ANSP's AoR. Spatially observed, that means that in area of 663,000 km² (3.58% of total controlled area in Europe) which is

differently scattered within the European airspace, there is no delivery of services to commercial flights operating within one State's boundaries. That primary refers to ANSPs managing airspace above Albania, Armenia, Belgium, Bosnia and Herzegovina, Hungary, Latvia, Malta, Moldova, North Republic of Macedonia and Slovakia. Hence those areas can be singled out as the most exposed ones. On the other hand, in 2017 averagely 6.58 % of total ANS were provided to commercial flights which have only operated within one State's boundaries and so were managed by only one ANSP.

Beside stats review, performance interferences can be also spotted throughout empirical approach. In theory,



performance interdependencies between ANSPs should not be detrimental to neighbouring ANSP, but in practice (day-to-day operations) this is not the case.

The best examples of aforementioned are reflected when extreme events occur - such as Eyjafjallajökull volcano eruptions, airspace closure due to military activities and safety hazards in Ukraine or ATC industrial actions which are nowadays occurring more frequent and lasting longer than ever before [7]. Their occurrence in the best possible way depicts performance interdependencies between ANSPs since then it's easy to notice so-called *spill-over effect*. According to its definition, if an activity or situation spills over, it begins to affect another situation or group of people, especially in an unpleasant or unwanted way [8]. So empirically, in case of extreme events it's not that hard to spot an area(s) and scales of performance interdependencies in-between ANSPs.

When it comes to understanding of performance interdependencies in-between ANSPs it's crucial to emphasize that, unlike e.g. ATC industrial actions, performance interdependencies do not have expiration date or precisely defined period of their occurrence. Within ATM system, they are occurring continuously and so influence execution of day-to-day operations.

Moreover, performance interdependencies should be seen as the result of tactical and pre-tactical, but especially of strategic management and decision-making activities of each individual ANSP.

Lastly, it can be concluded that it's not reliable to base strategic planning and development of national ATM potentials just on data review or on empirical approach. Especially since within complex European ATM Network, unfortunately, it's difficult to improve one performance segment without compromising other segment(s) [12]. So, the need for application of more advanced IT solutions that can e.g. determine performance interdependencies in-between ANSPs has become the *Conditio sine qua non*.

3 GEOSPATIAL BUSINESS INTELLIGENCE

The process of merging different technologies has resulted with creation of powerful visualization and intelligence systems among which are Geo-BI solutions. Usually they can provide comprehensive analyses (reports) by executing more advanced data manipulation processes and have possibility of efficient data browsing and storing in very large spatial-temporal data bases [13]. In this regard, Geo-BI solutions can be defined as innovative and powerful solutions that outstrip traditional methods enabled through merging of GIS and BI technologies.

Although Geo-BI solutions may vary in terms of applied technologies, the main purpose of their application does not change - to improve the efficiency of business activities [14]. For example, Geo-BI solutions can be applied to evaluate achieved results, to

support execution of planning and decision-making functions or to optimize service delivery [15]. Moreover, they can support businesses development by identifying business advantages, shortcomings or opportunities and so help to, where it's needed, adjust service delivery in regard to business environment.

Usually, Geo-BI solutions are supported with good data visualization capabilities. However, this is not what sets them apart from other data processing and visualization tools. Although data visualization capabilities built in Geo-BI solutions are of high importance, that is not the reason of Geo-BI solutions' advantage over other technological solutions. The greatest advantage of Geo-BI solutions is in their analytical systems that can perform complex analytics in very short time and with a high level of accuracy. The analytics behind Geo-BI solutions blends business data with geographic data to (a) reveal the relationship of location to (b) data describing e.g. people, events, transportation, transactions, investments, facilities, assets etc. by (c) placing new information in the context of interest of business enterprise. Thereby, it's important to highlight that Geo-BI solutions do not add more data to the existing plethora of data, but utilizing the geographic information disseminated across existing databases and hence enrich information provided.

Lastly, it's important to highlight that Geo-BI solutions can lead to reduction of business risks by providing new insights. But, as a tool, Geo-BI solutions have the ability only to describe business environment as that much precisely as the applied indicators and data are reflecting the real-world situations. So, in order to maximise utilization of information provided by Geo-BI solutions, they should be operated by trained staff members having sufficient level of education and experience. Only the combination of those elements can lead to creation of more competent information and hence effectively support decision making process.

4 APPLICABILITY AREAS IN ATM

Considering that aviation industry continuously tries to achieve process and resources optimization and that Geo-BI solutions can be of great help to achieve that, there is no barrier as to why not to use them in the ATM context. For example, information provided by Geo-BI solutions can be used by ANSPs to optimize their resources, to evaluate the effects of their business decisions, to monitor and keep in line their performances in relation to local, FAB or performances of entire European ATM Network, to capture local performance interdependencies, etc. Moreover, since ANSPs are financed by Airspace Users such solution can help ANSPs to understand their customers behaviour (Figure 2) by providing answers on questions: how much of performance improvement is enough, when "much" turns into "too much", is it worth it to do, how some changes may reflect in near future and why some measures were not sufficient or have failed etc.

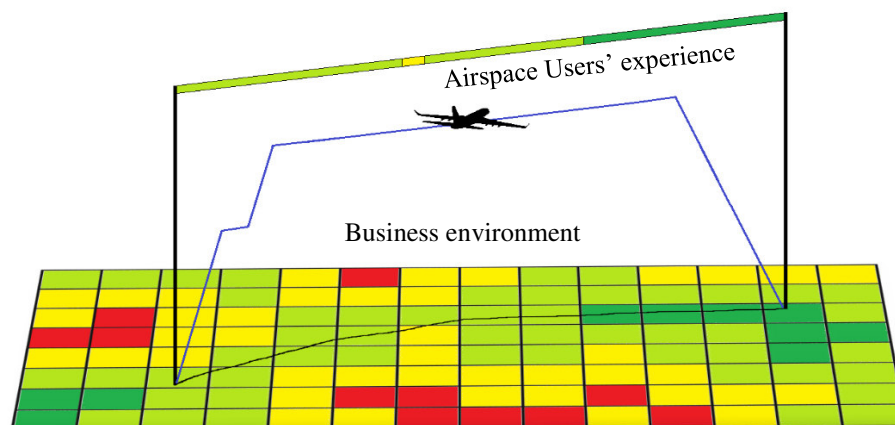


Figure 2: Understanding Airspace Users behaviour through application of Geo-BI solution

So, as it's shown by Figure 3, Geo-BI solutions in context of ATM can be also utilized to obtain better understanding of the historical, current and future aspects of business operations, to improve the efficiency of business activities and services delivery and to make most effective decisions by capturing the extent to which some decision will have a spatial reflection. So, they can be also used to derive useful insights about ANSP's future position within ATM Network or to support determination of performance targets for future Reference Periods of the European Union performance scheme. Therefore, the potential of Geo-BI solutions can undoubtedly improve entire European ATM systems design by providing answers on the key questions of further development.

Furthermore, it's expected that Geo-BI solutions will have a great potential primarily in Europe – where the current application of strategic air traffic planning has caused an unbalanced air traffic development [9]. That is not surprising because from methodological and technological view, on-going situation (where strategic planning and development boards find it hard to valorise the impacts of their decisions) also rises because many currently applicable traditional methods of data manipulation do not take into consideration a spatial component. As the result, spatial component of data set is often underutilized. This is also problematic because 80% of information requirements of policy makers are related to spatial location [10-11]. Therefore, since Geo-Bi solutions take into consideration spatial component and analyse the spatial distribution of observed variable, they go far beyond traditional methods of data processing and visualization.

Nowadays in ATM data is being continuously collected by different business entities. Accordingly, the preconditions for application of Geo-BI solutions in ATM context already exist. However, enterprises are frequently not aware of the fact that some solutions (tools) can provide them more competent information. So, beside already mentioned benefits, the synthesised potentials of Geo-BI solutions for Air Traffic Management and its stakeholders are in the following major components of business:

- Performance targets based on local potentials
The application of Geo-BI solutions can offer an overview of how local operations are performing on different scales (individual, regional, FAB, etc.). Moreover, Geo-BI solutions are very helpful when it comes to interpretation of e.g. different ANSPs' or Key Performance Indicators' interdependencies. Especially because they can help ANSPs to target the appropriate level of performance sufficient to succeed at the chosen scale. That can be also supported by setting up alerts which are sent to User with a goal to improve quality control of delivered services.
- Forecasting and its better understanding
In order to make efficient use of forecasts (and so optimize available capacities), Geo-BI solutions can provide forecasts that are easily understood by, and acceptable to, the decision maker or other End user.
- Information sharing
Information provided by Geo-BI solution can be helpful to desegregate global business plan at the lowest local level. That means that they can help ANSPs to communicate and share local objectives within an organization. Thus, application of Geo-BI solution can ensure that all employees view the same objective. That is of particular importance when it's needed to represent organizations' interests at meetings with other ANSPs, Airspace Users, National Supervisory Authorities (NSAs), etc. Lastly, organization with more competent information can decide whether to share information with the meeting participants (and so encourage collaborative work) or to keep information for themselves (and so improve their negotiations position) [16].
- Business process automation
Business process automation improves control and reduces exposure to costly delays, errors and omissions [17]. In this regard, Geo-BI solutions are enabling benefits such as: (1) man-hours savings (financial savings), (2) time savings, (3) workload reduction, (4)



continuous availability of information, (5) reduction of error appearance, (6) avoidance of incorrect results interpretation, (7) optimization of human and machine

interactions with a goal to achieve a high degree of safety, (8) process standardization and its quality increase, etc.

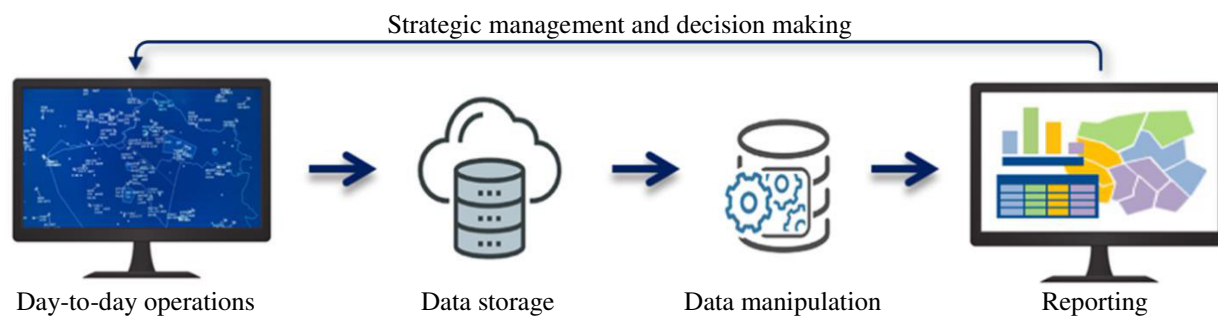


Figure 3: Air Traffic Management' strategic decision-making process supported by Geo-BI solution

5 CONCLUSION

As demand for Air Navigation Services is increasing, problem of not understanding business environment and performance interdependencies in-between ANSPs gets bigger over time. One of the reasons why is that so is that most of currently applicable traditional methods and technologies processing data do not reflect real-world situations in best manner. In addition, considering the advent of the big data era it can be concluded that the management and strategic development boards of ANSPs and NSAs will face with challenging issue of dealing with large amounts of data and its interpretation.

The combination of GIS and BI technologies has led to the development of Geo-BI solutions. Those solutions are frequently based on application of more complex methodologies (than traditional ones). Therefore, there is no surprise that they can better describe performances of European ATM Network and so help within its further development. However, it's important to highlight that Geo-BI solutions are not designed to make ATM system look more complex. Although their creation and applied technologies can be very complex, their output (information provided) must be as simple as possible.

As it's shown in the paper, European ANSPs are highly interconnected and interdependent. The result of such system arrangement is that performance interdependencies occur between ANSPs. Considering that performance interdependencies reflect on day-to-day operations and have an impact on ANSPs' primary activity - delivery of Air Navigation Services, their better understanding and monitoring are of high importance. Hence, aviation industry should aim for more competitive information which can be provided by applications of innovative Geo-BI solutions. Particularly because provided information can be of great help in enhancing cooperation between ANSPs itself, ANSPs and Airspace Users or ANSPs and NSAs/Civil Aviation Authorities. Lastly, it can be concluded that already in near future there will be ANSPs and NSAs which, based on the information

provided, will know how to achieve business advantages (often to the detriment of others).

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