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APPLICATION OF CONVENTIONAL METHOD IN DYNAMIC BUSINESS ENVIRONMENT: EXAMPLE FROM AIR TRAFFIC MANAGEMENT DOMAIN

ABSTRACT

Due to more frequent and significant changes occurring nowadays within Air Traffic Management (ATM) system in Europe, business reports have become an essential tool of decision-making. Usually such reports provide insight into the effects of planned or implemented changes, i.e. provide relevant information thus easing decision-making process. Thereby, within such business reports, with a purpose to synthesize data and extract useful information, various analytical methods are usually applied. It follows that analytical methods represent a basis for creation of business reports, while business reports represent a basis for the decision-making process. Accordingly, the application of proper analytical methods represents a crucial component of decision making. Simplified, if within business reports are applied analytical methods which result with partial findings, the decisions made will be of equal quality. In that context, this paper indicates the methodological shortcomings of data distribution method which is frequently applied within business reports in ATM domain. Also, it provides a brief overview of proposition of a novel methodological approach of data distribution analysis which goes beyond the conventional approach. Lastly, this paper provides a research background required to justify the need for introduction of novel approach of strategic planning of ATM system development in Europe.

KEY WORDS

Air Traffic Management; Strategic planning; Sturges' rule; Spatial statistics

1. INTRODUCTION

For the purpose of improving of their business position, many business organisations will firstly turn to implementation of performance measurement system. This is so because it's difficult to improve the state of something if it's not known the initial condition or what to strive for. Thereby, Air Navigation Service Providers (ANSPs), as well as other aviation related stakeholders, through performance measurement aim to improve their business positions, optimize resources, business effects etc. However, beside the motivation that streams from the need for improvement of the business situation due pressures coming from the business environment, the need for performance improvements for ANSPs also arises from regulatory requirements. More precisely, after

establishment of the Single European Sky initiative, the importance of performance measurement has considerably increased.

Despite above-mentioned, the practice shows that the implementation of performance measurement in ATM domain hasn't always resulted with actual measurable improvements. For example, it happens that although performance measurements indicate a need for improvement, they haven't been achieved. Usually, in such situations, there are several reasons why this is so. The reasons for failure mostly own from the fact that ATM system in Europe is complex system. However, failures also occur because frequently inputs or outputs of performance measurements were misinterpreted. There can be several reasons for that (e.g. due to ineffectively conceptualized methodological framework, due to application of erroneous methodological premises etc.). Thereby, the recognition of such failures, their correction and reduction of their occurrence in future can be seen as one of the aspects of performance improvements of ATM system in Europe. Therefore, before delivering business reports (information) it's always necessary to perform the validation of analytical methods used to create those business reports (information).

Performance measurement in ATM domain is mainly based on application of various analytical methods. Accordingly, it follows that within ATM domain analytical methods offer direct assistance and support to the decision-making process. That assistance and support usually manifests in two aspects. Firstly, different analytical methods are utilised during estimation of Key Performance Indicators (KPIs) values - according their methodological frameworks. Secondly, different analytical methods are applied again when obtained KPIs' values are further processed with a goal of their presentation within business reports. Thereby, it should be emphasized that the accuracy of both aspects directly depends on the accuracy of the applied analytical methods. In other words, within ATM domain, analytical methods applied can be considered as relevant as much as they accurately reflect real-world events.

Nowadays, data describing performances of ATM system in Europe is highly available - like never before. However, working with big data sets isn't always easy to represent. Therefore, in order to depict data distribution within business reports, various data visualization methods are applied. Thereby, data visualization represents a part science and a part art, where the challenge is to get the art right without getting the science wrong, and vice versa. Whenever visualizing data, data values are converted in a systematic and logical way into the visual elements that make up the final graphic. In doing so, it often happens that the same graphical representation someone perceives as important and informative, while it may be irrelevant to someone else. Since such situations are undoubtedly occurring within the ATM domain in Europe, the question arise why is that so? The answer on this basically simple, but actually quite complex question can be obtained by asking few, more precise, sub-questions such as: how data visualisations are actually made?; what are methodological limitations of data visualisation methods?; and lastly, by application of which visualisation methods the quality of the outputs can be improved?

Within ATM domain, business reports (i.e. analytics applied) mostly don't consider the spatial dimension of aeronautical data distribution [1]. However, as the result of omitting that data's component, such reports may deliver partial findings or may have biased estimation results. Hence, that raises the question of their quality and the quality of decision made based on such report. Moreover, this issue is of high relevancy for ATM in Europe as it represents a system with a high number of participating stakeholders [2] where each of them may have greater or smaller impact on the overall performance level of ATM system in Europe [3]. Hence, by correlating location of a certain event or phenomenon (e.g. capacity constraint) with its attribute value (e.g. minutes of delay), it's possible to determine the spatial reflection of such event or phenomenon. Therefore, business reports in ATM domain should be based on application of analytical methods that have possibility to analyse aeronautical data based on both, their attributive and spatial dimension. However, considering that nowadays there're no many such reports, the main goal of this research paper is to point the methodological shortcomings of frequently applied data distribution and

visualisation method. In that context, the further content of this paper gives an overview of currently applicable framework of data distribution analysis (which represents conventional approach). Thereby, an example from practice was introduced with a purpose to demonstrate methodological shortcomings of conventional approach. As an example it was used document published by the European Organisation for the Safety of Air Navigation (EUROCONTROL). Further, the paper provides a brief overview of proposition of a novel methodological approach of data distribution analysis that goes beyond the conventional approach. As result, this paper enriches existing literature since it, on the example from practice, identifies methodological shortcomings of frequently applied methodological framework of data distribution analysis. Lastly, this paper provides a research background required to support introduction of novel approach of strategic planning of ATM system development in Europe.

2. CONVENTIONAL APPROACH OF DATA MANIPULATION

In principle, a sense of data distribution among the variable of interest is most often obtained by data grouping method - so it can therefore be considered as conventional approach. Data grouping represents the breakdown of a data set *N* into a certain number of classes *k* according to the previously established modality x_i. Thereby, data grouping is quite useful method in cases when *N* is large enough, but may perform poorly in cases when data isn't normally distributed. After breakdown of a data set, the following phase is identification of comparable attributes. Statistical data $x_1, x_2 \cdots x_N$ is grouped so that similar values $x_i, i = 1,2 \dots N$ are placed in one class. That means that in one class are placed values belonging to the corresponding interval (a_i, b_i) so that $a_i \leq x_i \leq b_i$. Furthermore, in order to determine a_i and b_i values it's mandatory to determine the number of classes *k* and their width, i.e. size *h* which equals to:

$$h = \frac{x_{max} - x_{min}}{k} \tag{1}$$

Thereby, both, *k* and *h* depend on the size of the statistical set and the difference between its largest and lowest value. Additionally, it can be emphasised that the classes must be adjacent and are often (but not required to be) of equal size. Further, it can be highlighted that the number of classes *k* usually ranges between 5 and 15, but also a fact that there's no exact way how to determine *k*. Nowadays the most frequently applied method is so called the Sturges' rule - which was named after Herbert Sturges. According to Sturges' rule, the number of classes *k* for grouping a statistical set of x_N elements is approximated by the following expression:

$$n = \sum_{i=0}^{k-1} \binom{k-1}{i} \tag{2}$$

where the right-hand side of the equation by the binomial theorem equals to:

$$\sum_{i=0}^{k-1} \binom{k-1}{i} = \sum_{i=0}^{k-1} \binom{k-1}{i} (1)^i (1)^{k-1-i} = (1+1)^{k-1} = 2^{k-1} \tag{3}$$

Furthermore, by taking logarithms in base of 10 on both sides, Sturges' formula [4] equals to:

$$(k-1)\, log(2) = log(n) \Rightarrow k = 1 + \frac{1}{log(2)} \log(n) \approx 1 + 3.3 log(n) \tag{4}$$

After determining all the elements of equation, the next phase of conventional approach of data manipulation includes counting of the number of attributes in each class. The outcome of that is identification of frequency distribution. If some class *i* contains a certain number of f_i elements of statistical data set, that number represents a relative frequency f_r and it equals:

$$f_{r_i} = \frac{f_i}{N} \qquad\qquad i = 1, 2 \dots k \tag{5}$$

The last phase of conventional approach of data manipulation is visualization of obtained findings (data visualisation). Since they provide an accurate representation of the distribution of numerical

data, nowadays histograms are frequently used method of data visualization. Moreover, histograms represent a popular visualization method since the 19th century, i.e. after they were introduced by Karl Pearson [5]. In general, histogram is a convenient graphical object representing the shape of an unknown density function [6]. Hence, they can be applied to reveal the distribution of data values, especially the shape of the distribution and to reveal outlier values [7]. It is being constructed so that the bases of the columns must be proportional to the sizes of the classes, and if they aren't equal, the height of the columns must be proportional to the corrected frequencies. Lastly, it should be noted that for the construction of histograms, both, absolute frequencies or relative frequencies can be equally used.

3. APPLICATION OF CONVENTIONAL APPROACH OF DATA MANIPULATION IN AIR TRAFFIC MANAGEMENT DOMAIN

An example of application of conventional approach of data manipulation in ATM context can be found within annexes of EUROCONTROL's documents prepared by Enlarged Committee for Route Charges (Figure 1). Briefly, Enlarged Committee for Route Charges represents a tool of EUROCONTROL Member States and participating non-Member States with purpose to supervise the operation of the en-route charge system and to prepare the decisions [8]. Committee meets in March and June to provide the estimated unit rates for the following year, and then again in November to present the final values. Those meetings also represent the main forum for consultations with the Airspace Users (AUs).

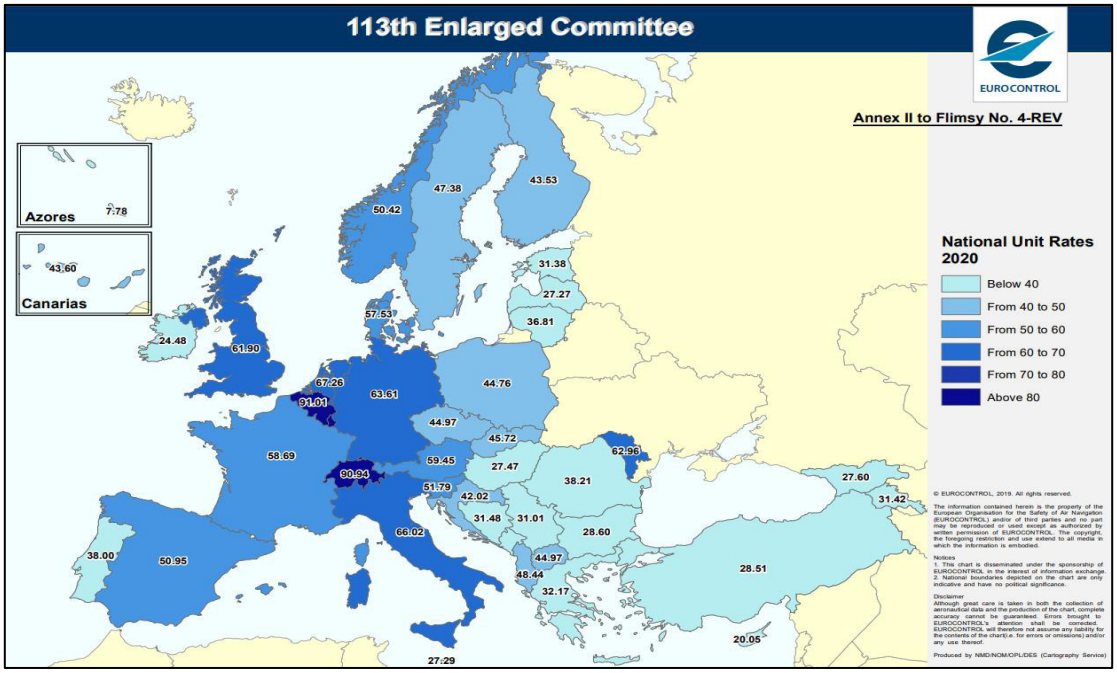
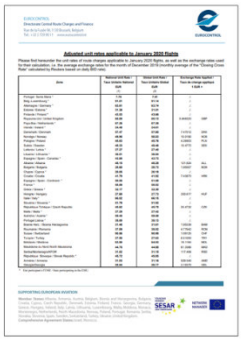
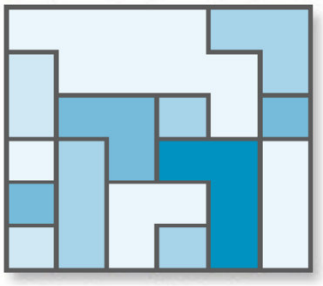


Figure 1 – EUROCONTROL's National Unit Rates 2020 overview made by data grouping method [9]

Furthermore, to facilitate later discussion and more easily identify methodological shortcomings, Figure 2 gives a conceptual overview of the process of the creation of Figure 1. Hence, a sense of data distribution among the values of an interest (in this case unit rate values) was determined by grouping data. Based on the (*1*) report containing unit rate values, (*2*) data manipulation was executed. Data manipulation was done according to equations presented within previous chapter (with the addition that the difference between classes was expressed by colour gradation). Lastly, (*3*) data visualization followed where, instead of being presented in form of histogram, the data was visualised using a map.



Distribution	f_i
Below 40	16
40 - 50	9
50 - 60	6
60 - 70	5
70 - 80	1
Above 80	2



(*1*) Report (*2*) Data manipulation (*3*) Data visualization

Figure 2 – Conceptual framework overview of conventional approach

4. NOVEL APPROACH OF DATA MANIPUALTION

In theory, the functionality of ATM system in Europe is based on collaborative and coordinated airspace and Air Traffic Flow Management (ATFM) [10]. However, in practice performance interdependencies between ANSPs are continuously occurring and affect day-to-day operations. The main reason why is that so is due to high level of inter-connectivity between ANSPs. For example, on average 93.43% of total number of Air Navigation Services provided during 2017 were delivered in cooperation of two or more neighbouring ANSPs [11]. Within such system, in case of occurrence of e.g. capacity shortage at area of responsibility of one ANSP, such event will also reflect on neighbouring areas (as aircraft will go through neighbouring areas instead of through originally planned area). This was recognised also by Button and Neiva [12] by arguing that since the different national ATM systems are not independent of their neighbours, there might be issues of spatial autocorrelation - meaning that the efficiency of one ANSP is dependent on the efficiency of neighbouring ANSPs. Furthermore, another example supporting the need for introduction of novel approach of data manipulation can be demonstrated by observing AUs' flight planning practice. As the result of differences between unit rate values of neighbouring ANSPs, AUs may prefer to fly through cheaper area with potentially longer trajectory, rather than on shorter and more expensive trajectory [13]. Accordingly, it can be concluded that spatial distribution of aeronautical data has important role in understanding the functionality of ATM system in Europe. However, as the current practice of data distribution analysis doesn't consider spatial distribution, it needs to be modified. Thereby, it should be modified by a novel approach of data manipulation which conceptual assumptions will lead to inclusive, smart and spatially-oriented growth. Such a novel approach of data manipulation should overcome conventional approach by solving its methodological flaws. Firstly, that refers to fact that within a conventional method data isn't georeferenced before it's processed. That's problematic because 80% of information requirements of policy makers are related to spatial location [14, 15]. Second methodological shortcoming is that findings (data distribution according to their attribute similarity) are shown by a map (and not by a histogram - what would be more proper). That's problematic because there are numerous analytical methods which, unlike conventional data manipulation method, are based on application of the spatial statistics. Thereby, that means that their conceptual assumption is set up so that every value needs to be processed in respect to its neighbouring values. Figure 3 shows an example of conceptual framework of novel approach of data manipulation with such conceptual assumption. Briefly, after defining variable of interest every variable is placed in context of its neighboring values. One of the ways how that can be done is by creating spatial weight matrix W_{ij}, i.e. square $n \times n$ matrix. As such data manipulation framework places focus on close neighborhood and considers spatial component of every variable (before its processing), it provides information that are reflecting real-world situations more precisely.

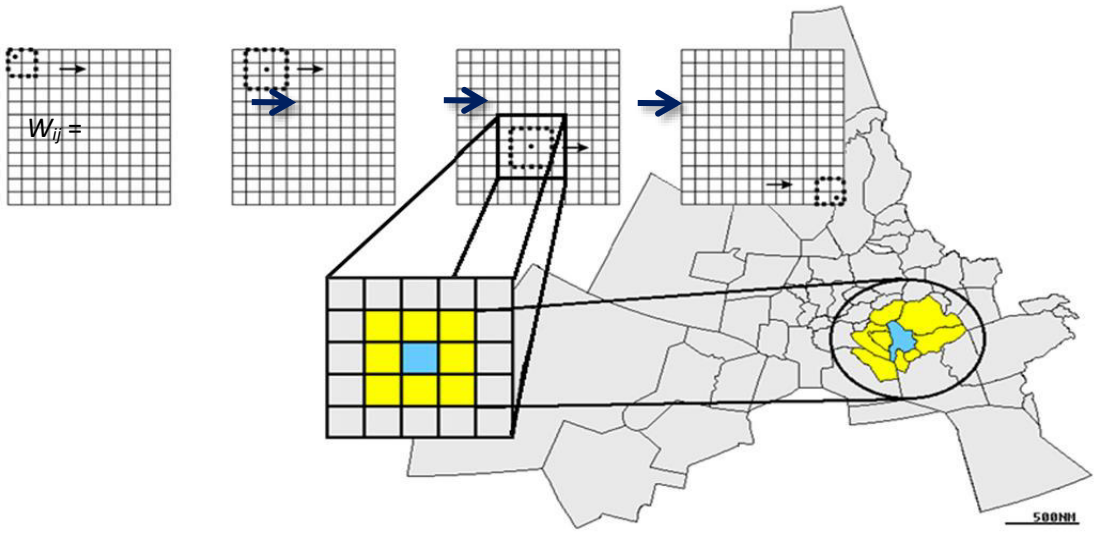


Figure 3 – Conceptual framework overview of novel approach of data manipulation

Furthermore, two more methodological flaws of application of conventional approach needs to be pointed out - and which both can be solved by application of novel approach. Firstly, the conventional method of data manipulation is conceptually quite static. Accordingly, it gives no information about the similarity level between neighbouring areas (since the similarity level is determined in respect to attribute similarity). Hence, it can't quantify performance interactions or interdependencies. Thereby, the failure to accurately capture performance interaction represents significant methodological drawback. As result, problems of partial understanding of (*1*) business environment, (*2*) improvement areas, (*3*) performance interdependencies, (*4*) trade-offs, (*5*) goal conflicts etc. occurs. Furthermore, when applying conventional approach, i.e. when grouping data, it's mandatory to determine the number of classes *k*. That number depends on the size of the data set *N* and the difference between the maximum x_{max} and minimum value x_{min} - and this is where the problem occurs. That's problematic as in case of existence of extremely high or low values, obtained results can be misleading. In cases with such data distribution, findings will indicate that, beside few outlier values, the most of values will fall into the same class. As they will be colored by same color' gradient, one may conclude that those values represent areas of similar modality x_i. Such a situation can be noticed on the example from ATM domain presented by Figure 4. In the most of cases the conventional approach of data manipulation will result with approximately symmetric data distribution (examples *a* and *d*). Opposite to that, data distribution of examples *b* and *c* is right-skewed, i.e. positively skewed. However, there is big difference between those two examples. Unlike example *c*, in case of an example *b*, the extremely high value exists and it differs significantly from the rest of values. As the difference between performances will be only indicated in case of different classes, most of them would be defined as areas of similar values. With the application of a novel approach, such situations won't happen. As the result, the benefits of application of a novel approach of data distribution analysis within ATM domain should be significant. For example, as expected benefits of application of novel approach it's possible to single out the possibility of (*1*) identification of homogeneous areas, (*2*) clearer identification of performance gaps, (*3*) easier identification of trade-offs situations, (*4*) identification of stakeholders which can achieve significant benefits with minor performance changes, (*5*) increase of the level of understanding of current and future ATM system design, (*6*) better understanding of cause-effect relationships, etc. Hence, the application of novel approach can be of great value to e.g. ANSPs in cases when it's needed to represent their interests at various meetings with other ANSPs, AUs, National Supervisory Authority (NSA), Functional Airspace Block meetings etc.

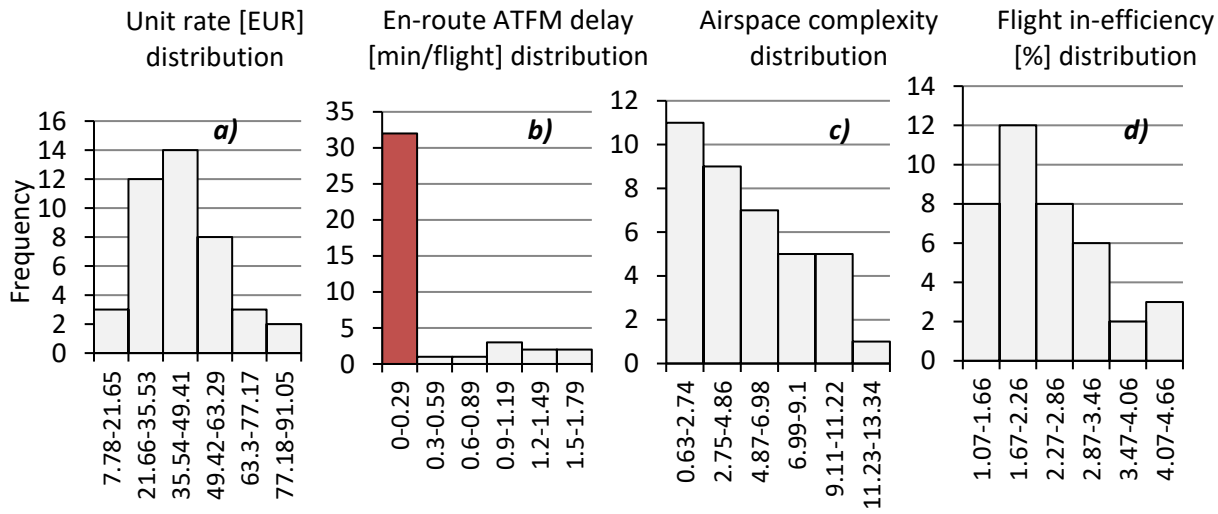


Figure 4 – Application of conventional approach on some of ATM related performance indicators [16, 17]

5. DISCUSSION

Nowadays, many successful businesses manage to grow simply because they understand their business environment, i.e. market strengths, weaknesses, opportunities and threats. Hence, it's not surprising that many executives, usually on the monthly basis, look for business reports with information about their business environment and development potentials. Thereby, since ATM system in Europe is a dynamic business environment characterized by its complexity and performance interdependencies, it's often the case that business reports need to provide a simple answer on complex issues.

The quality of a business report depends mostly on how much realistic do they reflect real-world situations. Then again, that depends on how much are credible applied performance indicators, metrics etc. So, in general, it could be defined that the main prerequisite of creation of any business report is credible performance measurement system. As such, performance measurement system provides a set of measures (financial and non-financial) that can support the decision-making process by collecting, processing and analysing quantified data of performance information [18]. Accordingly, the better the performance measurement system, the better will be the quality of the business reports.

The purpose of performance measurement system within ATM domain, as one of tools of strategic planning, is to provide information, primarily to ANSPs, but also to the AUs and NSA, in which direction ANSP goes, which and where corrective measures needs to be applied etc. Thereby, in order to have effective performance measurement system it's necessary to have reliable distributer of (*1*) input data describing business environment, (*2*) efficient communication and reporting network and (*3*) end-user who will know how to interpret received data or information. Although such a framework may sound quite simple, mistakes are often made in practice. This is so mainly due to poor inputs (garbage in, garbage out), misunderstanding of the data or information received, poor communication and reporting network, not knowing how to utilise obtained information etc. In case of recognition of such situations it's important to correct them. And, that brings us to the purpose of this paper.

Humans think visually, therefore spatially. Hence, it's often the case that by various options of data visualization it's depicted how certain variable of interest is distributed across area of interest. Since maps are a great way to do so, they represent one of most utilised option of data visualisation. This is so because maps usually allow summarization of the complex information in form of a clear and compact presentation. Moreover, maps are frequently used because (*1*) people understand

maps (at least, think they do), (*2*) because people like maps since they attract attention and (*3*) because they brighten up business reports and/or presentations. Thereby, in most cases maps tend to be intuitive to the readers or audience. However, their accurate interpretation can sometimes be very challenging. Particularly in cases when well-placed questions arise.

The main objective of maps is to deliver the right information. Accordingly, it can be defined that they are used as a mean of the communication. Thereby, two things are frequently forgotten. Firstly, presentation of statistical data on the map has its limits. Secondly, mapping statistical data correctly isn't an easy task. Map creation concerns making choices of the mapping method, the aggregation level, the area or discipline of study, the type of data, the graphic variables to be used etc. Besides that, it's frequently forgotten the difference between terms geographic and spatial data. Briefly, geographic data represents a collection of information that are used for graphical presentation of some feature and phenomena with relation to Earth's surface. On the other hand, spatial data is used to indicate some feature or phenomena related to space, but is distributed in three-dimensional space (any space, not only the Earth's surface), and, thus, have physical, i.e. measurable dimensions. Accordingly, spatial data has broader meaning, encompassing the term geographic data. Figure 5 shows an example of aforementioned where by removing the background (national borders), a spatial data is obtained.

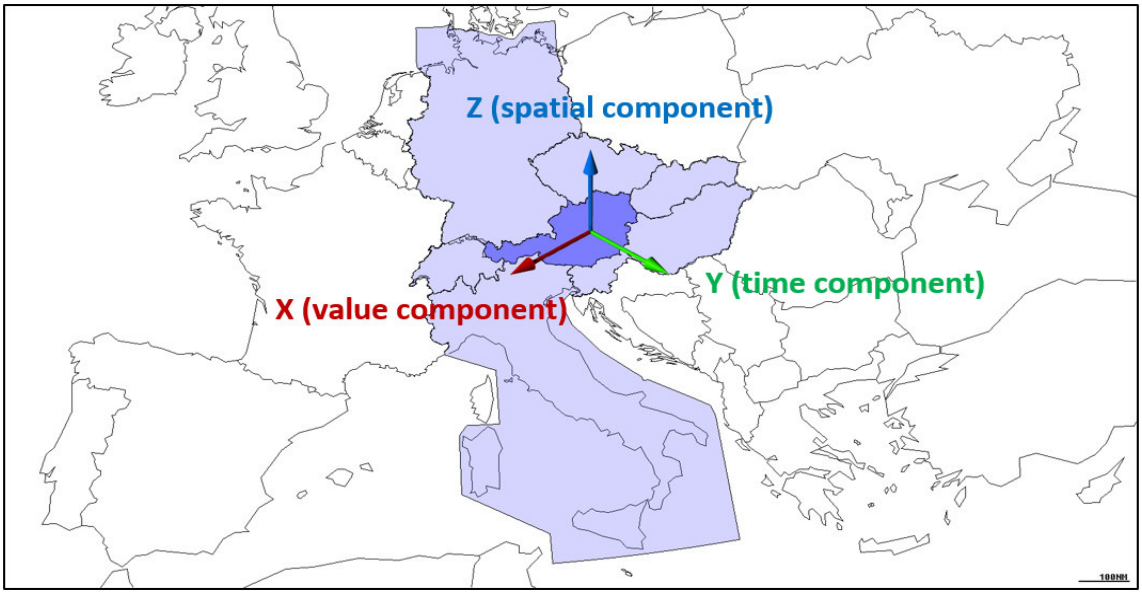


Figure 5 – An example of appreciation of all three aeronautical data features

Unlike humans, mathematics is very exact. Accordingly, it differs spatial statistics from traditional (or non-spatial) statistics that is typically used. Spatial statistics includes various analytical methods specifically designed for manipulation of spatial data. Thereby, in case that data needs to be presented on the map, spatial statistics and its analytical methods go beyond the analytical methods of traditional statistics. Since spatial statistics and its analytical methods use space-area, length, proximity, direction, orientation, notion of how the features interact with each other (through e.g. spatial autocorrelation measurement) right in the mathematics, their application results with more comprehensive findings.

Furthermore, the main difference between traditional and spatial statistics is the assumption of spatial dependency. That means that within spatial statistics the location of data, with respect to one another, plays an important role. Opposite to that, the traditional statistics are based on the assumption that data are free of something called spatial autocorrelation. As an index, spatial autocorrelation provides information about a spatially distribution of phenomenon that can't be captured by any other form of statistical analysis, and which can be vital for correct interpretation. Moreover, spatial autocorrelation gives a precise and objective value to something which would

otherwise have to be perceived subjectively and probably inaccurately from the map. Considering that ATM system in Europe is highly interdependent system, the application of analytical methods that fall under spatial statistics should be prioritised.

To sum up, it should be noted that "events" that are captured by the performance measurement system happen in the space and time. By ignoring that fact, analysis, i.e. business reports are going to be incomplete, while the obtained results would be misleading or partial. Considering aforementioned, the application of conventional data manipulation approach within ATM context is problematic because it based on the analysis of the data distribution outside of their spatial context. Thereby, the most significant problem arises from the fact that data visualisation is depicted on the map (and not on the histogram). The difference arises because map shows "where is what," while a histogram summarizes "how often" measurements occur (regardless where they occur). Hence, in order to provide accurate information, appropriate analytical methods also must be applied. Accordingly, presentation of unit rate values (or any other performance indicator) distribution by conventional approach should be replaced by utilisation of analytical methods that fall under spatial statistics. Lastly, Table 1 below summarizes the conceptual difference between application of the conventional approach and novel approach that is based on application of spatial statistics.

Table 1 – Comparison between conventional and novel approach of data distribution analysis

	Conventional approach	**Novel approach**
1.	Based on outdated traditional analytics	Based on innovative approach
2.	Based on raw data processing	Based on georeferenced data processing
3.	Intended for senior managers	Based on information sharing
4.	Simple, but less accurate analytical method	Complex, but more robust analytical methods
5.	Extreme values may lead to misleading conclusions	Extreme values don't have impact on results
6.	Unintelligible to interpret	Easy to interpret
7.	Leads to Airspace Users' frustration, abuses etc.	Better understanding of business environment
8.	Has a fixed framework	Modular design (depends on needs)
9.	Based on fragmentary approach	Based on holistic approach
10.	Doesn't consider spatial component of data set	Takes in account spatial component of data set
11.	Doesn't consider performance interdependencies	Takes in account performance interdependencies
12.	Mainly used to show the condition	Intended to improve performance
13.	Not applicable within other management systems	Complementary with other management systems
14.	Hinders continuous improvement	Promotes continuous improvement

5. CONCLUSION

In order to increase the efficiency of ATM system in Europe it's mandatory to apply appropriate analytical methods, i.e. to have accurate assessment tools which can provide information that will lead to better system' efficiency. In that context application of conventional approach of data manipulation, as it has been presented within this paper, is problematic as it can lead to erroneous decision making. Therefore, in order to get information that more accurately reflects the real-world situations (and so improve decision making), it's necessary to apply proper analytical methods.

For years non-spatial statistics has been used to depict spatial features or phenomenon. The main drawback of such an approach is that a conventional (or non-spatial) approach is based on assumption of spatial independence. Since ATM environment is highly interdependent system where performance of one ANSP can have an effect on performances of neighbouring ANSPs, application of conventional approach should be considered as inappropriate. Opposite to that, by application of various analytical methods, the spatial statistics enable testing of the existence of spatial patterns, determination of their distribution and characteristics, identification of spatial interactions, etc. However, since such analytical methods haven't been yet applied within ATM business environment at large scale, their application can be seen as a novel approach of data manipulation.

Lastly, it can be noted that presented issue mostly isn't yet recognized, and that within ATM domain one can often come across business reports that were created by application of conventional approach. Considering that, the question of quality of the information (business reports) provided arises. Hence, as the result, nowadays as advanced methodological frameworks can be distinguished ones that process aeronautical data based on spatial statistics - rather than on traditional statistics. Moreover, their application should be prioritised as they can provide more competitive information and so strengthen understanding of ATM business environment, identify performance interdependencies, trade-offs, goal conflicts, valorise the effects of applied strategies, concepts, projects etc. - what wasn't possible before, i.e. wasn't possible by the application of conventional approach of data manipulation.

REFERENCES

[1] Rezo Z, Steiner S. European Airspace Fragmentation Typology. International Journal for Traffic and Transport Engineering. 2020;10(1): 15-30.

[2] Rezo Z, Steiner S, Brnjac N. Cost Analysis of Air Traffic Flow Disruptions in Europe. Aviation Management and Economics Conference (AMEC). 6th November 2019, Vienna, Austria

[3] Rezo Z, Steiner S. South East Common Sky Initiative Free Route Airspace - implementation aftermath. Transportation Research Procedia. 2020;45: 676-683.

[4] Sturges H. The choice of a class interval. Journal of the American Statistical Association. 1926;21(153): 65-66.

[5] Pearson K. Contributions to the Mathematical Theory of Evolution II. Skew Variation in Homogeneous Material. Philosophical Transactions of the Royal Society of London. 1895;186: 343-414.

[6] Scott D. Sturges' rule. Wiley Interdisciplinary Reviews: Computational Statistics. 2009;1(3): 303-306.

[7] Hyndman R. The problem with Sturges' rule for constructing histograms. Monash University, Clayton, Victoria, Australia. 1995.

[8] Cogen M. An Introduction to European Intergovernmental Organizations. Routledge. New York, USA. 2016.

[9] EUROCONTROL. Enlarged Committee for Route Charges Information; paper Flimsy No. 4-REV [Internet]. [cited 2020 Jan 31]. Available from: https://www.eurocontrol.int/sites/default/files/2019-11/final-data-establishment-cost-bases-unit-rates.pdf

[10] Steiner S, Mihetec T, Rezo Z. Resolution of operational constraints imposed by fragmentation of European airspace. Proceedings of International Scientific Conference: Science and Traffic Development, 9-10 May 2019, Opatija, Croatia. p. 385-395.

[11] EUROCONTROL. Local Single Sky implementation monitoring (LSSIP) [Internet]. [cited 2020 May 2] Available from: https://www.eurocontrol.int/service/local-single-sky-implementation-monitoring

[12] Button K, Neiva R. Spatial autocorrelation in the European air navigation system. Applied Economics Letters. 2013:20(15): 1431-1434.

[13] Rezo Z, Steiner S, Škurla Babić R, Piccioni C. European airspace fragmentation: A cost-efficiency based assessment. ATRS 23rd World Conference, 1-5th July 2019, Amsterdam, Netherlands

[14] Biggs R, Garson D. Analytic Mapping and Geographic Databases. Sage Publications Inc. Newbury Park, USA. 1992.

[15] Franklin C, Hane P. An introduction to GIS: linking maps to databases. Database. 1992;15(2): 17-22.

[16] PRU Database [Internet]. [cited 2020 Feb 16] Available from: https://ansperformance.eu/data/

[17] Central Route Charges Office. Information on Conditions of Application of the Route Charges System, Conditions of Payment and Unit Rates. Brussels, Belgium, 2019.

[18] Gimbert X, Bisbe J, Mendoza X. The role of performance measurement systems in strategy formulation processes. Long Range Planning. 2010;43(4): 477-497.