Volume XXVI, 50 – No.1, 2024, DOI:10.35116/aa.2024.0006

EUROPEAN ATM KEY PERFORMANCE METRICS EVOLUTION

Nikola GÉDROVÁ*, Milan DŽUNDA, Peter DZUROVČIN, Lucia MELNÍKOVÁ
Department of Air Transport Management, Technical University of Košice, 040 01 Košice, Slovakia
**Corresponding author.* E-mail: nikola.gedrova@student.tuke.sk

Abstract. The aviation industry is one of the most sensitive sectors to external factors. Key performance indicators are quantifiable measures that can perfectly describe the current status of the observed object against a set of targets and objectives. This article aims to assess the evolution of key performance indicators in European but mainly Slovak air traffic management systems. The goal is to emphasize the need for the implementation of measures that can improve the effectiveness of the system. The related research was carried out by the data analysis method. The main goal of the research was to provide a comprehensive insight into the key performance evolution for the last decade and describe the actual status of air traffic management related to airspace overload.

Keywords: performance indicators; KPI; flight efficiency, evolution,

1. INTRODUCTION

The rapid technological development of air traffic with no change in airspace capacity, has led to a gradual oversaturation of air traffic and related problems. Insufficient capacity and flexibility in combination with airspace fragmentation are among the major shortcomings of the current air traffic management system. Central Office of Delay Analysis (CODA) recorded a disproportionate increase in delays in contrast to increased flights in the year 2018 [1]. The adverse effect was mitigated by the devastating consequences of the COVID–19 (January 2020, Declaration of Global Public Health Emergency) and the Russian invasion of Ukraine (February 2022).

The key performance of European air traffic faced the greatest challenges in the last four years. War in Ukraine and the devastating consequences of COVID-19 disease harmed the European aviation market. COVID-19 caused a nearly 90% drop in air traffic in April 2020, another challenge came in February 2022 due to the Russian invasion of Ukraine, at a time, when the aviation market was not far from recovering. Traffic recovery was slowed down by related increased prices of energy and negative economic impacts, but the general trend will still follow upwards. Based on Eurocontrol´s forecasts, we could expect traffic volume recovery in the period of the years 2023 – 2024 and surpass levels from the year 2019 in the year 2025 [2]. Key performance outcomes based on Network Manager data point up to 83% traffic return of 2019 levels in 2022, which was underpinned by strong low-cost market recovery. Traffic levels in the summer of 2022 were just under 90% of pre-pandemic 2019 levels, and the most important is to underline about 20% less European airspace availability due to the war situation and up to 30% above the 2019 traffic levels in the most significant network parts [3]. Otherwise, the impact of both crises relieved network congestion that the network has faced for the last decade.

As stated, the key performance indicators of air transport faced the biggest challenge in the last four years, an almost 90% air traffic decrease over Europe was recorded in April 2020. The least affected, air freight sector, compared with the previous year, recorded a positive growth rate of + 2,3% (towards the end of 2020). The cargo sector, typically representing 3% of total transport, accounted for 30% of total operations during the first wave of a pandemic, due to severe restrictions, increasing e-commerce and medical flights [3]. Although painful for the aviation market, the crisis led to the consolidation of PBN (Performance Based Navigation) operations as a result of the changing post-pandemic economy. This required changes in the used aircraft fleets and the retirement of older aircraft with fewer GNSS (Global Navigation Satellite System) capabilities [4]. The pandemic and

military conflict thus provided a time reserve, but European air traffic service providers have to accelerate the implementation of new solutions and technologies if they want to adapt to the increasing demand in the long term.

2. ATM OPERATIONAL PERFORMANCE – KEY PERFORMANCE INDICATORS

Key performance indicators serve to identify areas for improvement, help provide meaningful measures of progress, and are essential for managing complex systems. The International Civil Aviation Organization identified 11 KPA (Key Performance Areas) for monitoring ATM (Air Traffic Management) performance. These can be found in the documents:

- Doc 9854 (Global Air Traffic Management Operational Concept Report)
- Doc 9883 (Manual on Global Performance of the Air Navigation System)

Most ANSP (Air Navigation Service Provider) reports refer to the KPA provided by Doc 9883, which focuses on efficiency, predictability, and capacity. Performance monitoring and periodic reviews are essential for accounting performance gaps, and identifying areas of improvement in a harmonized manner. Continuous improvement requires data collection and appropriate KPIs in all segments of the flight. Common KPIs should be used throughout the whole industry. Each phase of the flight is measured against an ideal benchmark, which, of course, may not be feasible in the full system [5].

Total operational performance has to be measured against the ideal model in purpose to identify potential improvement. Differences between ideal performance and actual real performance are usually described as benefit pools which represent the theoretical potential of the system. However, it is necessary to realize, that those do not consider the structure needed to maintain safety, to avoid adverse weather or other aspects. The difference between actual and efficient flight is the efficiency gap, which has to be addressed within the scope of the total air traffic management system. The new Global Air Navigation Plan defined 23 KPIs [5].

The paper [6] introduces a new method for defining safety performance indicators through the Composite Risk Index, applicable to European Air Traffic Management. Another research project, APACHE, has investigated a new approach to optimization and simulation tools to enhance the performance assessment of various Key Performance Areas (KPAs) [7].

2.1. Performance Indicators – KEP, KES, KEA

Horizontal flight Indicators known as KEP, KEA, and KES are key performance indicators used as part of reporting and performance monitoring mainly in the Performance Review Report (Eurocontrol), Annual Performance Report (SES IR317/2019), and SES eDashboard. Horizontal flight efficiency describes a comparison between the flight length and the shortest distance between two endpoints. The final formula compares achieved and flown distance, considering all portions of the flight:

$$HEF_J = \frac{\sum L_{fjp} - \sum H_{fjp}}{\sum H_{fjp}} \% = \left(\frac{\sum L_{fjp}}{\sum H_{fjp}} - 1 \right) \% \tag{1}$$

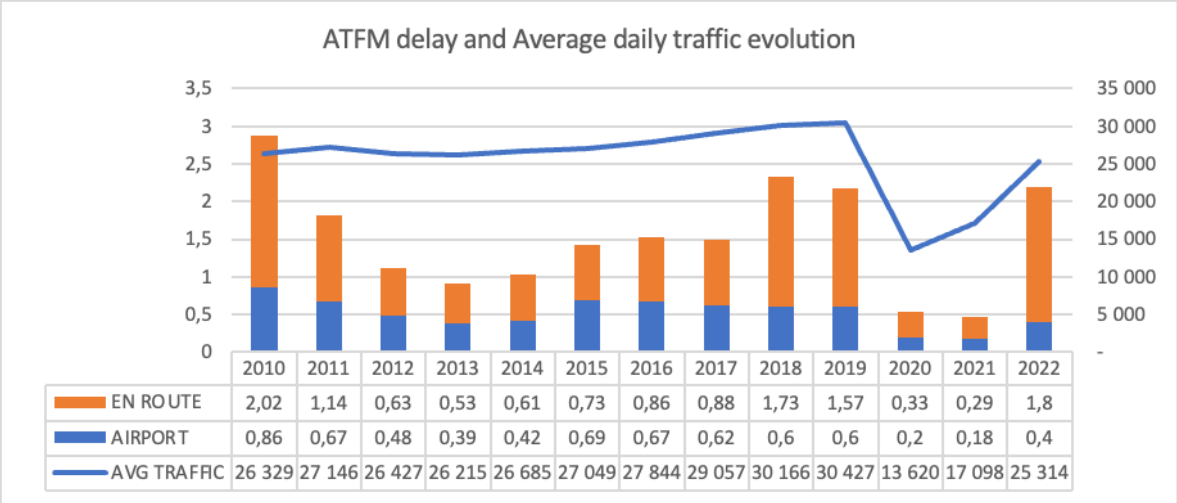
The methodology of calculating particular indicators is the same, the main difference is the source of data. The KEA indicator is calculated based on trajectories obtained via radars, the KEP indicator uses last flight plans, and the KES indicator considers the shortest route available during flight planning [8].

2.1. Performance indicator EN – ROUTE ATFM delay per flight

The capacity indicator known as en-route ATFM (Air Traffic Flow Management) delay per flight, comprises en–route and airport ATFM delays.
Depending on the entity responsible for the location that is protected by ATFM regulation, is delay classified and attributed to en-route or airport facilities and FIR containing particular capacity constraints. Delay is calculated as the difference between the estimated take-off time and the calculated take-off time that is allocated by the ATFM central unit [9].

If we focus on ATFM delay data from the period 2010 to 2022 (Network Operational Report, Eurocontrol), we can see in 2010, the average delay per flight was 2.9 minutes, 2.0 minutes attributed to en-route delay. Total delay, compared to the previous year 2009, increased by a serious 82% (related to Air Traffic Management). ATFM delay has a significant impact on the punctuality of aircraft operators. The total average delay of 80% in 2010 represents an accumulative variation of more than 51% from the year 2005. Concerning moderate traffic increase, just 0.9% we can see a significantly high elasticity factor in the relation between delay variations and traffic, in comparison with previous periods. The main reasons for ATFM delays were ATC (Air Traffic Control) delays, which nearly doubled to +95.5% and represented 63%. The main factor was ATC capacity representing 58% of ATC delays and contributing 37% of total delays [3].

The year 2018 marked a change in the ATFM delay trend, as shown in the next chart. The average ATFM delay per flight was in total 2,33 minutes, with 1,73 minutes of en-route ATFM delay (97% increase in comparison with the previous year), and airport ATFM delay which represented 0,60 minutes per flight (3% decrease). There were over 1,3 million flights delayed, third of them were delayed more than 15 minutes. The main reasons for the en-route ATFM delay were ATC capacity, weather, and ATC staffing. However, traffic volumes were 13% lower than the previous year. Despite the slight improvement recorded in 2019, the level of overall delay was still at high levels.
The Network traffic in the years 2020 and 2021 reached unprecedented levels due to disruption caused by the pandemic on global traffic. There was a 12% increase in ATFM delay compared to 2020 but an 88% drop compared to 2018 in 2021 [3].

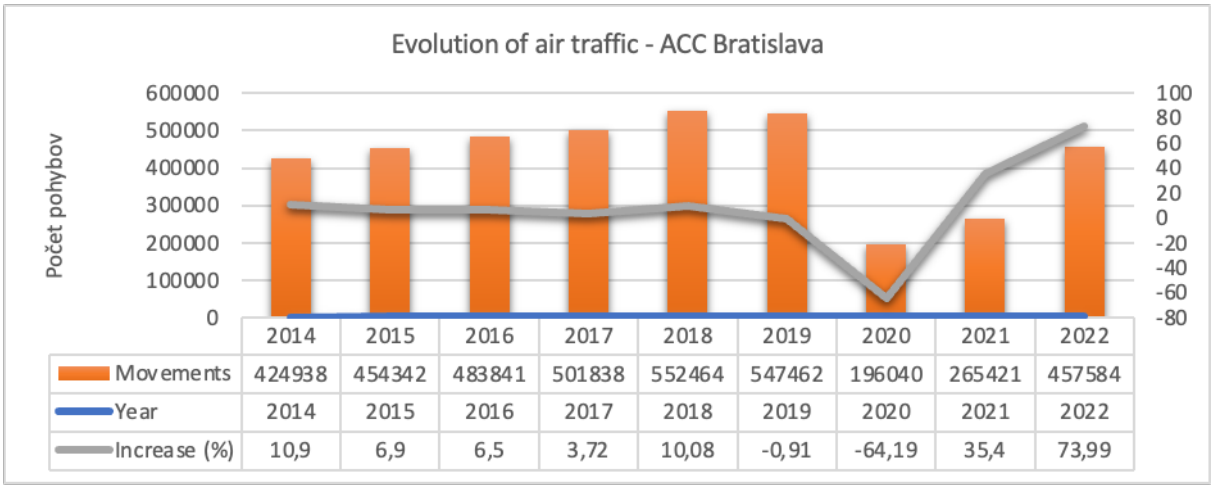


	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
EN ROUTE	2,02	1,14	0,63	0,53	0,61	0,73	0,86	0,88	1,73	1,57	0,33	0,29	1,8
AIRPORT	0,86	0,67	0,48	0,39	0,42	0,69	0,67	0,62	0,6	0,6	0,2	0,18	0,4
AVG TRAFFIC	26 329	27 146	26 427	26 215	26 685	27 049	27 844	29 057	30 166	30 427	13 620	17 098	25 314

Figure 1 ATFM delay and Average daily traffic evolution

In the data analysis related to Slovak airspace, we focused on the period 2014 – 2022 due to the absence of Key Performance Indicators data in the annual reports from previous years. The development of operations in Slovakia recorded a continuous increase until 2020, the ACC (Area Control Centre) Bratislava recorded a percentage increase of 3.7% (2017) to 10.9% (2014) between 2013 and 2021. The situation in Ukraine (conquest of strategic positions and infrastructure in the Ukrainian territory of Crimea), caused a complete overflight of Ukraine´s airspace [10].

The positive trend continued in the following years, which is proof of the pan-European increase in the volume of air traffic, which is also reflected in the airspace of the Slovak Republic. The first decrease in the volume of air traffic occurred in 2019, representing a decrease of 0.9% compared to the previous year. The reason was the regulation and redirection of flights outside Slovak airspace by the Hungarian air traffic service provider [10].



	2014	2015	2016	2017	2018	2019	2020	2021	2022
Movements	424938	454342	483841	501838	552464	547462	196040	265421	457584
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Increase (%)	10,9	6,9	6,5	3,72	10,08	-0,91	-64,19	35,4	73,99

Figure 2 Development of air traffic – ACC Bratislava

Concerning air navigation services, performance in the period 2014 – 2022 in key performance areas was assessed as follows. In 2018, KPA/CAP (capacity) was not met for the first time, when the increase of traffic expressed by the number of IFR movements was 0.5% higher than the performance plan. Among the delays, 36% were caused by weather conditions [10].

LPS š.p. focused on the shortage of ATCO (Air Traffic Control Officer) personnel and implemented short-term and long-term measures to increase capacity and improve operational efficiency which helped to fulfill the set goals. There has been a significant change in the selection strategy and training process of ATCOs, the training process has been shortened through more efficient planning and individual approach. It focuses on training the ability to handle and to be prepared for long–term trends of increased traffic.

Short-term operational measures that significantly contributed to the achievement of the goals were horizontal reconfiguration of sectors (East-West), optimization of sector opening times, finalization of the upgrade of the ATM system, and extension of the time of use of SEEN FRA – cross border use of free track space [10].

Table 1 Average en-route ATFM delay per flight

KPA CAP	***KPI Average en-route ATFM delay per flight***								
KPI Average en-route ATFM delay per flight	2014	2015	2016	2017	2018	2019	2020	2021	2022
Metrics	min/flight								
Target	0.19	0.10	0.10	0.10	0.11	0.10	-	-	0.07
Actual	0.14	0.07	0.5	0.03	0.21	0.07	-	-	0.03
Measures imposed	n/a	n/a	n/a	n/a	a	n/a	-	-	n/a

Table 2 Terminal and Aerodrome ATFM flight delay

KPA CAP	***KPI Terminal and Aerodrome ANS ATFM flight delay***								
KPI Terminal and Aerodrome ANS ATFM flight delay	2014	2015	2016	2017	2018	2019	2020	2021	2022
Metrics	min/flight								
Target	-	0.00	0.00	0.00	0.00	0.00	-	-	-
Actual	-	0.00	0.00	0.00	0.00	0.00	-	-	-
Measures imposed	-	n/a	n/a	n/a	n/a	n/a	-	-	-

Long-term measures were mainly linked to the goals set for Reference Period 3. Specifically, these were the possibilities of creating sectors at the level of several countries (also at the FAB CE level) in cooperation with the Network Manager, intensive selection and training of ATCOs, use of various ATFCM techniques including STAM, streamlining and optimization of airspace, plan to open 7 sectors per year 2022. In the framework of KPA/ENV (environment), in 2018, the night cross-border use of free track area (SEEN FRA) was opened, the analysis of specific operational options, which depend to the greatest extent on airspace users (planning and requirements), meteorological conditions and Network measure Manager, which were external factors that cannot be greatly influenced [10].

Table 3 Horizontal en-route flight efficiency

KPA ENV	***KPI Horizontal en-route flight efficiency***								
KPI Horizontal en-route flight efficiency (determined at FAB level)	2014	2015	2016	2017	2018	2019	2020	2021	2022
Metrics	%								
Target	-	1.99	1.94	1.9	1.85	1.81	-	-	2.13
Actual	-	1.95	1,97	1,91	1.95	2.13	-	-	4.4
Performance	-	x	x	x	x	x	-	-	x
Measures imposed	-	n/a	n/a	n/a	a	a	-	-	n/a

As a response to not achieving goal KPA/ENV in 2019, was taken active analysis and preparation for more effective flight planning. In cooperation with the Network Manager, was LPS actively involved in projects that can have a positive impact on the goal. However, it is needed to note, that KPA/ENV depends on external factors such as meteorological conditions, preferences of users, and applied Network Manager scenarios, which are beyond ANSP´s control.

From the side of LPS, there were made constructive changes such as the cancellation of direct routing in the upper airspace (above FL245), the implementation of BRAFRA (the area of free routes within FIR Bratislava, the possibility of using the night cross border area of free tracks (SEEN FRA), and the initiated communication about the extension of the cross border FRA to H24 with partners with SEEN FRA, SECSI FRA, and BALTIC FRA. Due to the pandemic situation in the period of years 2020 and 2021, the data are not stated [10].

The most significant influence on the KEA indicators was the unprovoked and aggressive behavior of the Russian Federation towards Ukraine from 2022 till nowadays. Some operators decided to plan routes of more than 50 NM outside Ukraine's western borders. No flights were planned across the border between Ukraine and Slovakia. Another significant number of operators faced real challenges when submitting flight plans involving routes that needed to account for the ad-hoc activation of military-segregated areas. This resulted in large regions becoming inaccessible to civilian operations in neighboring states, including Slovakia, Poland, and Hungary [10].

3. CHALLENGES AHEAD – FORECASTS 2023 – 2029

The base for the further planning process is annual performance targets defined by Performance Framework 2022 – 2024 (RP3, Single European Sky) and targets published in Commission Implementing Decision (EU) 2021/891. Assessment of current plans indicates the need to give priority to staff management, flexible usage of resources, and solutions for FAB or European level. Delays are likely to remain above the planned levels for some years or the whole period. The biggest challenge seems to be the inflexible use of staff and the shortage of qualified air traffic controllers [11].

Looking beyond, there is expected flight growth of an average of 1,6% over the period 2025 – 2029, but there is a need to take into consideration the low forecast projecting stagnation from 2025 onwards [11].

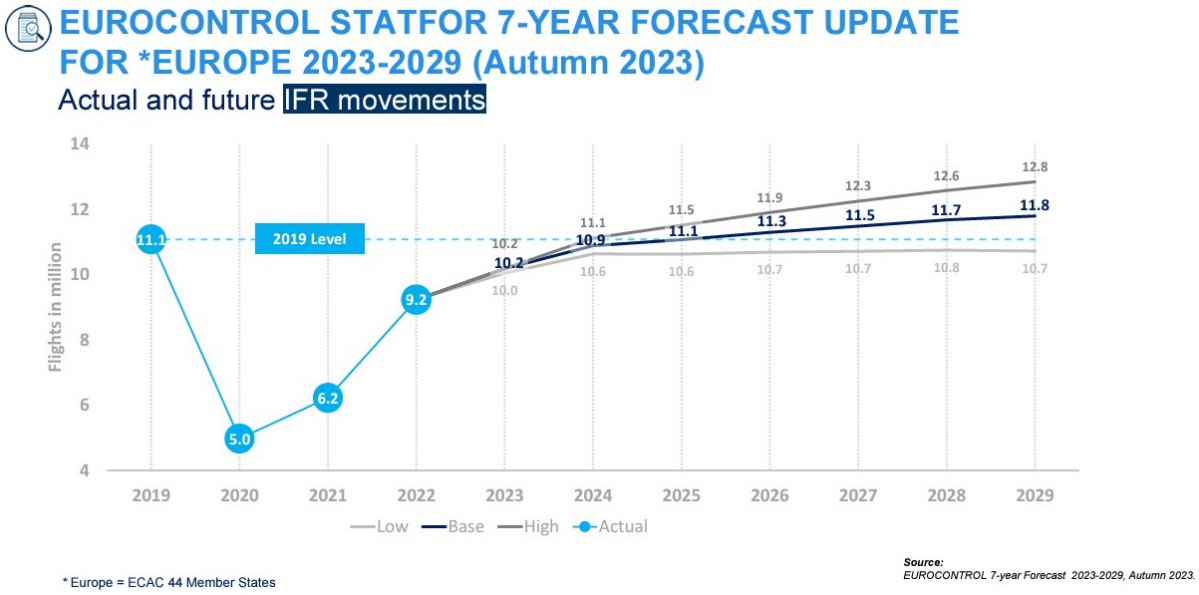


Figure 3 Eurocontrol Statfor Forecast for 2023 -2029 [11]

Residual risks that will impact forecasts are uncertainty and higher inflation triggered by the invasion of Ukraine. The duration of the conflict will disrupt energy markets and it would impact economic expansion. Among others, we can consider uncertain oil price outlook, environmental pressures, airliners changing decisions of the routes, increased military need for airspace.

4. CONCLUSION

The key performance of air traffic has faced major challenges in recent years. European aviation market recovery from the pandemic was unexpectedly hit by war conflict which caused another instability and a need for rapid response to the situation. Slovak airspace experienced a significant impact as one of the primary alternatives for flights avoiding Ukrainian airspace entirely. The post-pandemic recovery is expected between 2023 and 2024, total recovery is predicted for 2025. The trend of the number of flights in upcoming years will be strongly affected by the duration of geopolitical tensions, related inflation rates, or oil price evolution. The KPA/CAP indicator, reflecting the ATFM delay in Slovakia, was not achieved for the first time in 2018. In response, the air traffic service provider introduced both short and long-term measures, primarily addressing the shortage of air traffic controllers, enhancing ATC capacity, and providing additional training to manage the increased traffic volume. Horizontal en-route flight efficiency (KPA/ENV) was over the target from 2016, but there is a huge impact of external factors such as meteorological conditions, operational options, or Network

measures manager, which can not be impacted by LPS š.p. The overall trend in Europe, where traffic demand is expected and anticipated to exceed available capacities, was affected and mitigated by unexpected situations. We assume, that the negative consequences of war and pandemic situations extended reaction time to prepare for further traffic growth. There is a need to focus on ATC capacity and the flexible usage of ATC staff and mitigate its impact on ATFM delays. The implementation of progressive technologies based on GNSS possibilities has to be a key element of future development.

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Received 05, 2024, accepted 06, 2024