Performance Review Body
Advice on the Union-wide target ranges for RP4

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Performance Review Body of the Single European Sky | Rue de la Fusée 96, Office 50.659, 1130 Brussels
Office Telephone: +32 (0)2 234 7824 | cathy.mannion@prb.eusinglesky.eu | prb-office@prb.eusinglesky.eu | wikis.ec.europa.eu/display/eusinglesky

REMARKS FROM THE CHAIR

In preparing its advice for RP4 target ranges, the PRB is well-aware of the shortcomings relating to some of the KPIs adopted in RP3. However, as there are no currently agreed changes to the KPIs to be used in RP4, the PRB is preparing its RP4 target ranges report on the basis of the existing KPIs.

This report proposes target ranges for RP4 which runs from 2025 until the end of 2029. In preparing this report, the PRB took the opportunity to reflect on the ambitions set out in its RP3 target ranges report, the set RP3 targets and observed performance of ANSPs, and on the challenging events during RP3. In particular, the PRB has considered the impact of the COVID-19 pandemic and Russia's war of aggression against Ukraine on the performance of ANSPs during RP3 when setting priorities for the next reference period. In relation to the latter point, it is not possible to predict when hostilities will cease, therefore the target ranges have been set based on the current status. However, this should not be interpreted as a prediction on the part of the PRB of any future evolution of the hostilities in Ukraine.

PRB Observations: Many of the points highlighted by the PRB in its 2018 RP3 target ranges report remain as pertinent now as they did then. It is disappointing that the necessary changes were not delivered in the intervening period and it remains surprising that the traffic downturn did not enable an improvement of environmental performance. Points that the PRB then considered crucial still remain. In 2018, the PRB highlighted that some ACCs were providing insufficient capacity to manage the growing levels of traffic, leading to high levels of delays that impaired the performance of the entire network. The PRB also noted that ANSPs needed to invest in operations, staff and technology to meet the requirements of growing traffic. As we approach the end of RP3, traffic continues to increase post pandemic but, while there is considerable variation between Member States, on a Union-wide basis traffic levels remain some 17% below 2019 levels. In its latest monitoring report, the PRB made clear that the bottlenecks caused by some ACCs in the core of Europe continue to cause delays well in excess of the capacity targets set for RP3. This is despite, in some specific cases, deviations from the cost efficiency targets being granted to enable the investment required to achieve capacity targets.

PRB priorities: Safety, of course, remains the first priority and the PRB will continue to promote targets for safety management that support this priority. A meaningful response to climate change has become a similarly important objective. The EU's commitment to reduce greenhouse gas emissions by 55% by 2030 (Fit for 55) and to be carbon neutral by 2050 highlights the absolute need for all sectors to effectively contribute. The PRB proposes to prioritise the achievement of ambitious targets for the environment Key Performance Area. However, this will not be achieved in isolation because there are interdependencies between environment, capacity and cost that need to be considered in their globality when setting target ranges. The PRB's recent study into the interdependency between capacity and environment Key Performance Areas represents a good start in quantifying the impact of capacity shortfalls and hence delays on additional flight distances. The environmental performance targets can only be achieved if investment and flexible staffing programmes are delivered to facilitate fuel optimum routes and sufficient capacity to minimise delays and avoid re-routings. The associated costs need to be taken into consideration when setting the cost efficiency target range.

As set out in this report, the PRB proposes a balanced and demanding set of targets to minimise excess distance flown and its impact on the environment, supported by adequate staffing and investment to eliminate endemic capacity shortfalls, with sufficient funds to deliver these improvements and provide a more cost-effective service to airspace users. To be effective, these priorities should be supported by meaningful incentives that have a material impact in order to improve performance.

Cathy Mannion, PRB Chair

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1 INTRODUCTION

1 Under Commission Implementing Regulation (EU) 2019/317 (herein referred to as the Regulation), the assistance to the Commission when setting the Union-wide performance target ranges is one of the primary tasks of the Performance Review Body (PRB). The legal basis for the setting of the Union-wide performance targets is defined in Article 9 of the Regulation:

- At the latest 19 months before the start of the reference period (i.e. end of May 2023), the national supervisory authorities (NSAs) should provide initial cost data and information about traffic forecasts.
- At the latest 15 months before the start of the reference period (i.e. end of September 2023), the Commission shall publish indicative target ranges for the Union-wide performance targets.
- Stakeholders shall be consulted on these target ranges.
- At the latest seven months before the start of the reference period (i.e. end of May 2024), the Commission shall adopt the Union-wide performance targets.

2 This report is the PRB advice on the Union-wide target ranges for fourth reference period (RP4, 2025-2029) which provides the evidence considered, the analyses carried out, and the rationale related to the setting of the target ranges of each key performance area (KPA) for RP4.

3 The stakeholders' consultation will follow the publication of this report, and the PRB will consider the output of this consultation in developing its advice on the Union-wide targets for RP4.

4 The PRB advice on the target ranges for RP4 main report (this document) is complemented by four annexes:

- Annex I – Detailed analysis per KPA;
- Annex II – Academic study on cost-efficiency;
- Annex III – Impact of Russia's war of aggression on horizontal flight efficiency; and
- Annex IV – Common Project 1 performance impact.

5 For the advice on the target ranges for RP4, the PRB used data provided by Member States (i.e. monitoring data and initial cost data), Eurocontrol (Aviation Intelligence Unit (AIU) and Statistic and Forecast Service (STATFOR)), the Network Manager, the European Union Aviation Safety Agency (EASA), and the SESAR Deployment Manager (SDM).[1]

6 The PRB closely collaborated with EASA regarding the safety KPA and with the Network Manager regarding the capacity and environment KPAs. The PRB relied on academics for the estimation of the cost efficiency (Annex II) used as part of the evidence for the cost-efficiency KPA, on Eurocontrol for the estimation of the impact on KEA of the Russia's war of aggression against Ukraine (Annex III), and on the SDM for the analysis of the common project benefits for RP4 (Annex IV).

[1] Detailed references to the source of the data are included in this document.

2 PRB APPROACH TO SETTING TARGET RANGES FOR RP4

7 During the third reference period (RP3, 2020-2024) the aviation industry has been deeply impacted by the traffic volatility due to the COVID-19 pandemic, the strong rebound of air travel, and Russia's war of aggression against Ukraine. Even though the path to recovery of Union-wide traffic by now is more predictable, uncertainties remain on air traffic flows in the Union airspace due to the consequences of Russia's war of aggression against Ukraine. Moreover, high inflation rates and the probability of a recession impacting air travel demand cast uncertainty on the aviation market. As in previous target setting activities, the PRB relied on the traffic forecast published by Eurocontrol.

8 The actual data from 2020 to 2022 indicate that some of the problems ANSPs experienced in RP2 from air traffic management planning and operations have remained. Delays were above the targets and environmental performance did not comply with the targets (extension of routes remained). The picture was different during 2020 but this was the year of peak impact of the pandemic when the traffic level was uncharacteristically low. The following can be concluded:

- **Safety:** Considering the developments up to 2022 and the planning of the ANSPs and the Network Manager, the RP3 safety targets should be reached by 2024. This is on the basis that ANSPs continue to improve their performance as planned, and that their maturity does not degrade.
- **Environment:** Union-wide targets were only achieved in 2020, when the traffic downturn led to enough capacity enabling airspace users to fly more efficient routes, contributing to an improvement of KEA. Following this, performance deteriorated, and the targets were missed year-on-year. This indicates that the periods of low traffic were not used as an opportunity to improve airspace availability to prepare for the traffic rebound, to offer more direct routes, to remove route restrictions, or to improve en route to terminal interfaces. In 2022, a shift in trajectories due to Russia's war of aggression against Ukraine, combined with a stronger traffic recovery than the previous year and capacity disruption resulted in significant flight trajectory extensions and the highest year on year deterioration in KEA in ten years. While the target ranges for RP4 will factor in some of those impacts, Member States must adapt to the situation and address underlying inefficiencies in their airspace and the lack of capacity forcing airspace users to reroute from flight optimum trajectories.
- **Capacity:** In the first years of RP3, the downturn of traffic caused an oversupply of capacity. ANSPs were expected to be able to meet more ambitious delay targets. However, ANSPs are currently falling behind schedule with the implementation of new ATM (air traffic management) systems and other capacity enhancement measures, as well as their plans to recruit and train additional air traffic controllers, leading the PRB to be highly concerned about likely capacity shortfalls during RP4. In this regard, the PRB encourages ANSPs to resolve ATC (air traffic control) capacity and staffing issues by the end of RP3.
- **Cost-efficiency:** In 2020 and 2021 ANSPs were able to only adjust partially their costs in response to the traffic downturn. The cost-efficiency targets up to 2022 have been exceeded at Union-wide level. ANSPs were able to manage more traffic than forecast, at lower cost than planned. This indicates that more stringent targets would have been realistic and achievable.

2.1 PRB objectives for RP4

9 The target setting process has the ultimate purpose of improving performance at a Union-wide and local level. The PRB objectives to be reached by the end of RP4, which are the pillars of the advice on the target ranges, are the following:

- **Safety** remains of paramount importance, to take account of the impacts from other KPAs, to control the impact from widespread changes to ATM functional systems, and to progress regulatory compliance. This approach continues in RP4.
- **Environment** is the priority for RP4 in line with the EU's green agenda. ANSPs need to greatly improve in terms of environment. Reducing

CO_2 emissions is a top priority for the European Union and society as a whole. ANSPs must offer the best level of capacity aiming at reducing excess flight trajectories and enabling emission reductions to reach a higher level of environmental efficiency by the end of 2029. For the coming reference period, the PRB considers the environment KPA as the top priority, and advises for ambitious but achievable target ranges.

- Environmental performance, traffic recovery and growth need to be sustained by better **capacity performance**. Member States must provide the required capacity to minimise the impact on airspace users in terms of delays, and on society in terms of avoidable CO_2 emissions.
- **Cost levels** must support the delivery of safety, environment, and capacity performance improvements, while remaining at an efficient level.

2.2 PRB key principles

10 The PRB key principles in advising the Commission on the target setting process for RP4 are the following:

- **Independence:** The PRB is independent from any financial, corporate, or political interests. All PRB members are independent experts, with decisions taken by the PRB as whole. The PRB is also supported by an independent support team dedicated permanently and exclusively to the PRB.
- **Analytical rigour:** The evidence presented in this document is based on thorough analysis. The PRB has involved EASA and the Network Manager to contribute to and validate the analysis carried out. The PRB has also involved Eurocontrol in the estimation of the impact on KEA of the war in Ukraine, and leading academics for the assessment of the level of efficiency of air navigation service providers.
- **Consultation:** The PRB is committed to consulting with stakeholders as much as possible within the target setting process and will consider all stakeholder comments received in the consultation process.
- **Achievable ambition:** The PRB recognises that the stakeholder community may have diverging views on targets for RP4. The PRB commits to analysing evidence carefully in a balanced approach so that targets are ambitious, but importantly, achievable and sustainable.
- **Interdependencies**: The PRB recognises the existence of direct and indirect interdependencies between key performance areas, especially between capacity and environment. In proposing the target ranges, the PRB accounted for such interdependencies both quantitatively and qualitatively.
- **Outcome-oriented targets:** While the targets proposed by the PRB will recommend the outcome for Union-wide performance, it is the Member States and their ANSPs who will define how to achieve these targets.

3 TRAFFIC FORECAST

- IFR movements and en route service units are forecast to increase from 2024 to 2029.
- The increase of IFR movements and en route service units during RP4 is forecast to be relatively homogeneous across Member States and slower than experienced in the past.
- Several Member States will not reach the levels of 2019 IFR movements and service units by the end of RP4.

3.1 STATFOR forecast

11 The latest available traffic forecast has been published by Eurocontrol on 31st March 2023. The STATFOR seven-year forecast 2023-2029 is based on the most recent traffic trends and considers as inputs the most up-to-date forecasts of economic growth, population, low-cost market share growth, load factors, future events, future high-speed rail network as well as future airport capacities. The methodology applied by Eurocontrol reverted to that used pre-pandemic, meaning that the uncertainty in the forecast is expressed by different scenarios (i.e. low, base, and high).

12 The differences between the scenarios forecast are symmetric for both IFR movements and service unit forecasts. The differences between the values of the scenarios are reaching in 2029 +/- 10% for IFR movements forecast and +/-12% for service units forecast.

13 As defined by the Regulation, the STATFOR base forecast is the basis for the target setting process and preparation of the performance plans. Therefore, the analysis carried-out in this section is focused on the base scenario forecast.

14 The next publication of the STATFOR forecast is planned for autumn 2023. The updated figures will be considered in the PRB advise on the targets for RP4.

3.2 IFR movements forecast

15 The Union-wide IFR movements are forecast to be 10.6M in 2029. These amounts will be the highest managed by the system to-date. The 2019 levels (10M), the previous highest recorded level, is expected to be reached by 2025 and in 2029 the Union-wide IFR movements is forecast to be 6.1% higher than in 2019 (Figure 1).

16 The rate of increase will be mostly concentrated in the remaining years of RP3: +11% and +6.2% year-on-year in 2023 and in 2024, respectively. From 2024 onwards, the Union-wide increase is forecast to be relatively slower, being on average +1.5% per year (from 2024 to 2029). By comparison, the average increase for 2014-2019 was +2.8%. In RP4, Member States will be expected to manage a steady but relatively slow increase of traffic.

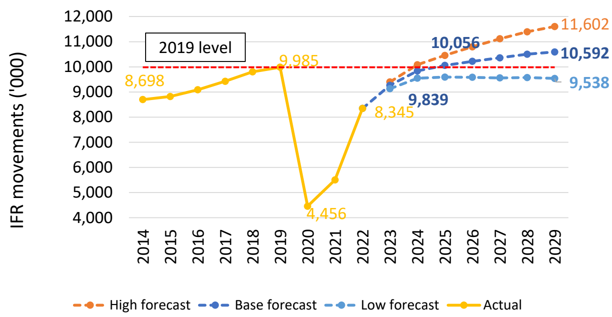

Figure 1 – Union-wide IFR movements actuals from 2014 to 2022, and STATFOR March 2023 forecast from 2023 to 2029 (source: PRB elaboration on STATFOR forecast).

17 When analysed at Member State level, the situation is more varied. On their base forecast, eight Member States are forecast to not reach the 2019 level of IFR movements by the end of 2029 (Czech Republic, Denmark, Estonia, Finland, Latvia, Lithuania, Poland, and Sweden), while all other Member States are forecast to reach 2019 levels no later than in the early years of RP4.

18 When analysing the average increase of traffic from 2024 to 2029, Member States are forecast to have an average increase of around 1.7%. Only three Member States deviate significantly from the average: Norway with traffic that is forecast to remain almost flat during RP4 (+0.3%), and Malta and Cyprus showing the greatest growth (+2.5% and 3.0%). However, these are relatively small differences than were experienced in the past. By comparison, 2014-2019 recorded wider traffic disparities between Member States. The average Member State growth during RP2 was +3.9%, with the extremes being Norway (-0.9%) and Croatia (+6.6%).

3.3 En route service units forecast

19 The Union-wide en route service units are forecast to be 143M in 2029. As for the IFR movements, these amounts will be the highest ever managed by the system to-date. The 2019 levels (125M), the highest recorded to date, will be reached before the start of RP4 (in 2024). In 2029, the Union-wide service units are forecast to be +14% higher than in 2019 (Figure 2).

20 As for expected IFR movements, the rate of increase of the service units is forecast to be concentrated in the remainder of RP3: +11% and +7.3% year-on-year in 2023 and in 2024, respectively. From 2024 onwards, the increase is forecast to be relatively slow, at an average +2.0% per year (from 2024 to 2029). By comparison, during the years 2014-2019 the average increase was +4.2%.

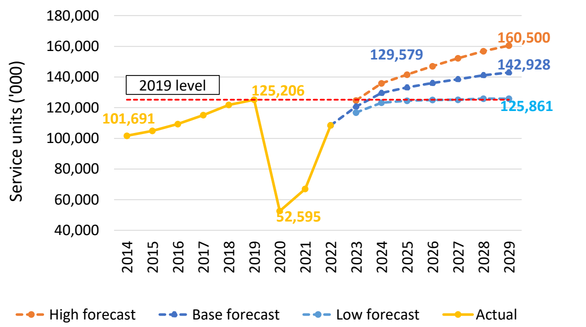

Figure 2 – Union-wide en route service units actuals from 2012 to 2022, and STATFOR March 2023 forecast from 2023 to 2029 (source: PRB elaboration on STATFOR forecast).

21 When analysed at the Member State level, 11 Member States are forecast to not reach the 2019 level of service units by the end of 2029 (Czech Republic, Denmark, Estonia, Finland, Latvia, Lithuania, Malta, the Netherlands, Poland, Slovakia, and Sweden).[2] The majority of the other Member States are forecast to reach 2019 levels before the end of RP3, or in the first year of RP4.

22 When analysing the evolution of traffic from 2024 to 2029, Member States are forecast to have an average increase of around +1.9%. The increase in traffic is homogeneous across all the Member States, being within 1p.p. (percentage point) around the average (between +1.2% in Norway, Denmark, and the Netherlands, and +3.0% in Cyprus). By comparison, for 2014-2019, the average Member State growth was +4.6%, with the extremes being Norway (+1.9%) and Bulgaria (+8.0%).

[2] Malta, Slovakia, and the Netherlands are almost reaching the 2019 values in 2029.

4 CONTRIBUTION OF CP1

23 Commission Implementing Regulation (EU) 2021/116 on the establishment of the Common Project One (CP1) supporting the implementation of the European ATM Master Plan aims to accelerate the digitalisation of European ATM towards a more efficient and technologically advanced industry. The deployment of such technologies translates into projects providing tangible and quantifiable benefits to European ATM.

24 The SESAR deployment manager (SDM) is responsible for the coordination of the implementation of the most essential operational improvements through the concept of Common Projects. A Common Project is an extraction from the European ATM Master Plan, based on mature SESAR solutions to be deployed in a synchronized and timely manner across Europe (as defined in Commission Implementing Regulation 2021/116). Whilst the European ATM Master Plan is non-binding, the Common Project binds the Member States and their operational stakeholders.

25 The CP1 Regulation introduced a fixed implementation deadline for all its ATM functionalities, which is set as 31st December 2027; this date is within the timeframe (2025-2029) of RP4. Therefore, it is expected that the full potential of CP1 will be materialised during the next reference period, especially in terms of operational and performance benefits. The benefits on the key performance areas are forecast and monitored by the SDM. The PRB has considered these benefits in its RP4 target ranges proposal. More details are included in the Annex developed by the SDM (Annex IV of this report).

4.1 Expected benefits considered in the target ranges

26 The deployment of new technology monitored by the SDM provides a wide range of benefits, which are quantified for each year and for each implementing entity. Benefits are quantified by the SDM across several KPIs covering environment, capacity, operational efficiency, and cost-efficiency. For the purpose of the target setting process, the PRB considered two KPIs relating to environment and capacity: En route fuel savings and en route ATFM delay savings. These two KPIs are the most related to the performance and charging scheme KPIs, on which the targets are based. As benefits are calculated by the SDM against a no-action scenario, it is not possible to factor them directly into the target ranges.

27 The European Route Network Improvement Plan (ERNIP) considers the flight efficiency improvements stemming from approximately 340 packages of airspace proposals scheduled for implementation for the Summer seasons 2022 – 2030. The projects within the ERNIP include the majority of projects that will be implemented under CP1, which are being coordinated by the SDM. As the benefits of CP1 are a subset of the ERNIP measures, the PRB has considered the benefits from the ERNIP when proposing target ranges to avoid double counting. The implementation of these proposals has the potential to significantly improve flight efficiency. By considering the improvements as described in the ERNIP, the PRB indirectly factors into the target ranges the benefit expected from CP1 for the environment key performance area.

28 The projects included in CP1 and overseen by the SDM are (or should be) part of the capacity improvement measures planned by ANSPs (for projects which are implemented at an ANSP/ACC level). The Network Manager also considers the impact of these measures when preparing the Network Operations Plan (NOP). Moreover, there may be additional benefits over and above those included in the NOP due to network effects and implementation actions taken by other stakeholders (e.g. airspace users). For the purpose of the capacity target ranges, the measures included in the NOP are considered within the timeframe of the current edition of the NOP (2023-2027). Therefore, in relation to the capacity target ranges, the benefits estimated by the SDM are factored in as indirect evidence when determining the level of ambition for RP4.

5 SAFETY

- All the ANSPs and the Network Manager are expected to achieve RP3 targets by the end of RP3.
- Safety performance needs to continue to improve over RP4.
- Targets are advised to be a minimum level of maturity D in safety risk management, and C for the other EoSM Management Objectives.

5.1 *Introduction to the safety KPA*

29 Safety within the performance and charging scheme serves two roles:

- Safety as a key performance area (KPA) to monitor and drive further improvements in safety performance; and
- Safety as a control mechanism to address impacts foreseen from targets set on the other KPAs: Environment, capacity, and cost-efficiency.

30 As set out in the Regulation, the safety KPI is the minimum level of the effectiveness of safety management (EoSM) to be achieved by air navigation service providers certified to provide air traffic services. The KPI measures an ANSP's ability to implement and manage an effective safety management system (SMS) by measuring the level of implementation (maturity) of the following safety Management Objectives (MOs):

- Safety culture;
- Safety policy and objectives;
- Safety risk management;
- Safety assurance; and
- Safety promotion.

The level of maturity for each of these Management Objectives is defined from level A to level D (D being the best).

31 For the purpose of target setting, the Union-wide EoSM targets are set for the final year of the reference period (2029), with ANSPs required to provide intermediate levels for each year of the reference period. The targets for the safety KPI have been developed by the PRB in close cooperation with EASA, as per Article 6 and 9 of the Regulation.

RP4 Safety KPI

32 In January 2022, the European Commission has requested EASA to develop, together with the relevant stakeholders, a potential set of Safety (key) performance indicators (S(K)PIs) for RP4. The technical report was published at the end of April 2023 and included a proposal for the continuation of the EoSM as the sole safety KPI. The EASA working group proposed to:

- Revise the current EoSM questionnaire to better address the challenges expected during RP4, and to allow for any potential negative impact on safety from other KPAs.
- Update the EoSM Management Objectives based on the CANSO Standard of Excellence (SoE) in safety management. As for RP3, the related questionnaire has been revised to reflect the modern safety management approaches.
- Create two versions of the EoSM questionnaire to reflect the applicability to both ANSPs and the Network Manager. This differentiation is needed to recognise the differing roles and responsibilities of these two respondent groups.
- Base the Network Manager EoSM questionnaire on a sub-set of the EoSM questionnaire applicable to the ANSPs.
- Align the verification mechanism with the EASA Management System Assessment Tool to compare the results reported via the EoSM questionnaires and the intelligence gathered by EASA through their oversight.

33 The revised EoSM questionnaire is expected to be available late 2023.

5.2 *Analysis of the safety KPA*

RP2 evolution

34 The EoSM targets for RP2 were set at level C for safety culture, and at level D for all the other safety Management Objectives. As shown in Figure 3 (next page), 28 out of 31 ANSPs achieved the RP2 targets. The Network Manager also achieved its RP2 targets.

35 The results show that safety targets were realistic and achievable. For some Management

Objectives (e.g safety culture) it transpired that the targets were not challenging enough; having already been reached by the majority of the ANSPs during the first year of the reference period. Given that the majority of the ANSPs achieved the RP2 targets, the EoSM needed to be updated to continue the improvement of safety management in RP3.

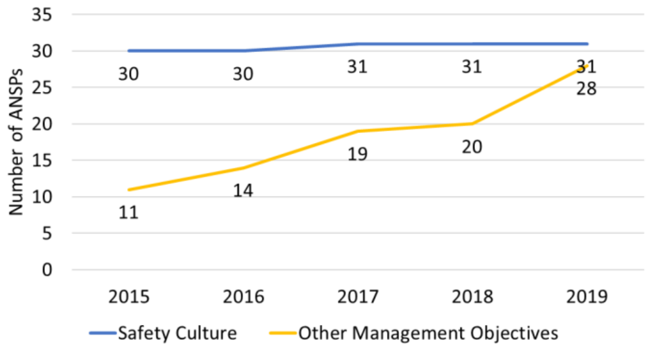

Figure 3 – Number of ANSPs achieving the Management Objectives during RP2 (source: PRB elaboration).

RP3 evolution to date (2022)

36 The Regulation (i.e. for RP3) retained the safety key performance indicator from RP2: The Effectiveness of Safety Management (EoSM) of air navigation service providers. The EoSM questionnaire was substantially modified between RP2 and RP3 (among other changes) to align it with the CANSO Standard of Excellence (SoE- v.2), and to ensure consistency with the Commission Implementing Regulation (EU) 2017/373 (common requirements Regulation).

37 The EoSM targets for RP3 were set at level D for safety risk management, and at level C for all the other safety Management Objectives. The targets were set to be achieved by the end of RP3, expecting ANSPs to show a gradual improvement over RP3 to achieve the targets in 2024, at the latest.

38 The revised Union-wide targets for RP3, following the exceptional measures Regulation, did not modify the safety targets originally set for the reference period.[3] Despite the impact of the COVID-19 pandemic, the PRB still considered the targets achievable and relevant for RP3. Safety remained the highest priority. The ANSPs were expected to maintain high attention to safety management ensuring to adapt and scale depending on the specific situation.

39 Figure 4 shows the maturity levels planned by the ANSPs over RP3, and the achievement level in the first three years of RP3. While ANSPs were expected to achieve the target for safety risk management late during RP3, they are ahead of their plans with 18 ANSPs already reaching the RP3 target in 2022 (out of 36). For other Management Objectives, the achieved maturity levels follow closely the expected evolution over RP3, with 23 ANSPs that planning to achieve the RP3 target in 2020, and with two ANSPs planning to reach the target during the last year of RP3.

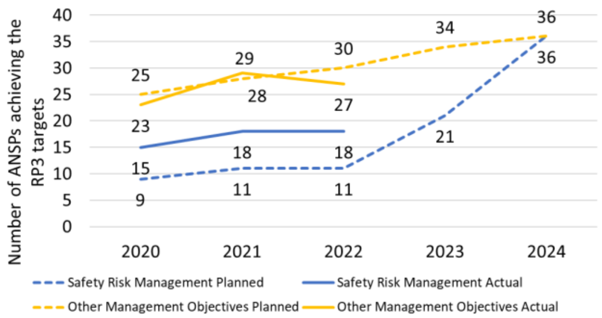

Figure 4 - Planned and actual number of ANSPs achieving the EoSM targets during RP3 (source: PRB elaboration).

RP3 outlook (2023-2024)

40 None of the ANSPs are currently much behind achieving the RP3 targets: All ANSPs not yet on target are one maturity level below, and most ANSPs only need to improve on two or three questions to meet the targets. The main area for improvement is safety risk management, with eight ANSPs needing to improve on all three questions under the Management Objective. 11 ANSPs need to improve on safety risk management while already reaching the target relating to the other Management Objectives.

41 With the developments seen up to 2022, combined with the planning of the ANSPs, the PRB forecast that all ANSPs will achieve the RP3 targets by 2024.[4] EoSM targets for RP4 should be set on the assumption that the RP3 targets will be achieved by all the ANSPs.

[3] Commission Implementing Regulation (EU) 2020/1627 of 3 November 2020 on exceptional measures for the third reference period (2020-2024) of the Single European Sky performance and charging scheme due to the COVID-19 pandemic.

[4] It remains the risk that few ANSPs might not achieve the targets, as just failing one small part of one question under a given Management Objectives will cause the ANSP to miss the target on the minimum level of maturity.

42 The Network Manager has performed as planned over RP3 and is expected to reach its safety targets by the end of RP3.

5.3 Safety targets advice

43 It has been proposed that the EoSM questionnaire will be based on the revised CANSO SoE (revision from February 2023). The updated CANSO questionnaire is organised by different objectives. These objectives can be linked to the five Management Objectives of the EoSM, including also transversal objectives related to interdependencies.

44 To assess the level change between the revised CANSO SoE and the RP3 EoSM, the PRB and EASA have jointly performed a comparative analysis, also considering potential adjustments coming from the PRB/EASA priorities. This is used to determine the expected level of maturity ANSPs would achieve at the end of RP3. The assessment concluded that the revised CANSO SoE is incrementally more challenging than the RP3 EoSM questionnaire, therefore:

- An average ANSP is assumed to start RP4 one level lower than when ending RP3. Hence: (i) For other Management Objectives, ANSPs would start on level B even if already satisfying several of the conditions to reach level C; (ii) for safety risk management, ANSPs would start on level C, provided the ANSPs have ensured compliance with Regulation (EU) No 2017/373 in respect to fatigue-risk management and human contribution to risks.
- ANSPs achieving a minimum maturity level C or D at the end of RP3 need to implement improvements to retain the same level of minimum maturity using the updated EoSM questionnaire.
- ANSPs not achieving the targets for RP3 for Management Objectives other than safety risk management would start RP4 with the same maturity level.

45 For the Network Manager it is expected that the EoSM in RP4 will also be more challenging than in RP3. While the EoSM in RP4 will be better tailored to the specifics of the Network Manager, the Network Manager will start RP4 at a lower level of maturity.

46 Annex I of this report provides a detailed analysis of the historical performance and a description of the approach outlined above.

PRB and EASA approach

47 Given the strong links between the different key performance areas, the interdependencies between the performance targets need to be considered for the purposes of target setting. Ensuring a continued, high level of safety performance remains the highest priority in the target setting process.

48 The safety KPI acts both as a vehicle to improve safety performance and as a control mechanism. As a control mechanism it helps to manage the impact of actions and decisions taken under the other three KPAs, known as interdependencies, and on changes implemented on a wider scale in the ATM functional system or in airport systems. When changes occur, it is important to ensure risk is not transferred, and that risks to safety are not increased. Widespread implementation may be difficult to manage and may require, for example, a strengthening of the methodologies applied, an increased monitoring to detect degrading safety levels, and/or increased awareness.

49 Russia's war of aggression against Ukraine causes an increased pressure on safety management, notably on the adjacent Member States. Such pressures include the diversion of traffic flows resulting from airspace closure, the increased operation of unmanned aerial vehicle and military flights, increased cyber security risks, and potential attacks. While it is not possible to predict the evolution of the conflict, the ANSPs need to have a safety management system that is sufficiently agile and adaptable to effectively identify and control these types of change. Against this background, the maturity of the safety management systems needs to continue to improve, especially in the areas of safety risk management and safety assurance.

50 The targets put in place should support the progress towards regulatory compliance with Regulation (EU) 2017/373 and its recent amendments. This includes regulations already proposed and becoming effective during RP4 (i.e. Unmanned Aerial Systems (UAS) and management of Security). This also includes Human performance already covered by Regulation 2017/373 but not specifically addressed by the current EoSM. Finally, the EASA working group underlined the

complementary nature of the performance scheme and the actions defined in the EASA European Plan for Aviation Safety (EPAS). The targets should be considered to support the implementation of the EPAS actions.

51 Considering the above and the expected developments for RP4, the PRB and EASA jointly concluded that, to ensure safety levels are retained and where possible improved, targets need to be set to ensure continued improvements of safety performance. The PRB and EASA recommend safety targets for RP4 as shown in Table 1. The same targets are proposed for the Network Manager, using the tailored RP4 EoSM.

Union-wide safety targets for RP4	
Management Objectives	**2029 maturity levels**
Safety culture	C
Safety policy and objectives	C
Safety risk management	D
Safety assurance	C
Safety promotion	C

Table 1 – RP4 Union-wide targets for the Effectiveness of Safety Management.

6 ENVIRONMENT

- To align with the EU's green agenda, the PRB prioritises environmental performance for RP4, with target ranges to support the EU's ambition of a carbon-neutral economy.
- KEA performance last improved in 2020 during the period of low traffic and has deteriorated in 2021 and 2022. Actual KEA performance has not reflected the improvements to the route network design that have been implemented during this period.
- The PRB recommends the Member States to define an environmental incentive scheme and additional environment targets based on the most appropriate KPI, which best reflects the contribution ATM makes to improve flight inefficiencies.

6.1 Introduction to the environment KPA

52 The KPI within the environment KPA is the average en route flight efficiency of the actual trajectory (KEA). The indicator aims to drive positive behaviours and limit environmental impact by measuring the additional distance flown beyond the great circle distance. This additional distance flown is influenced by the actions of ANSPs, but also by the route choices of airspace users, airspace restrictions, and network measures. The higher the KEA value, the worse the performance.

53 KEA is the only environment indicator with targets for Union-wide and local performance. The indicator, and the related targets, are defined for the whole calendar year and for each year of the reference period (i.e. 2025 to 2029 inclusive for RP4).

54 The target ranges for the environment KPI have been developed by the PRB in close cooperation with the Network Manager.

RP4 KPI

55 There are no changes foreseen with regards to the environment KPI for RP4. The target ranges are therefore based on the environment KPI as currently defined by the Regulation.

6.2 Analysis of the environment KPA

RP2 evolution

56 For RP2, there were two environment KPIs defined by the performance and charging schemes; KEA (which remained unchanged for RP3) and KEP, which was changed to a performance indicator for Member States in RP3 (i.e. without binding targets).

57 Figure 5 shows how KEA performance evolved over RP2 and RP3 to date, relative to targets and compared to traffic levels. During RP2, environmental performance, as measured by KEA, remained stable with a series of minor improvements and degradations. As a result, targets which were set to be gradually more challenging were missed in 2018 and 2019.

58 While performance did not follow the ambition set by the targets, the stable trend was achieved over a period of increasing traffic and delays. This suggests that ANSPs were able to employ measures and procedures, and network measures were implemented, to mitigate the impact of increasing traffic on KEA during RP2.

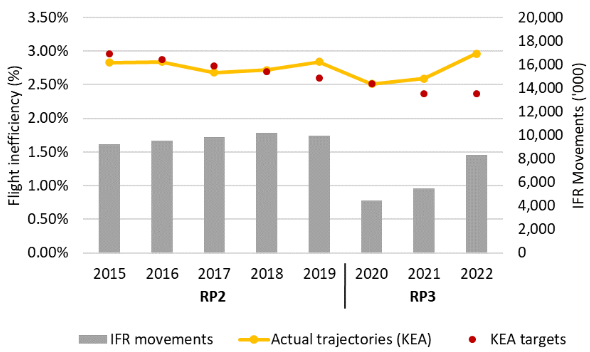

Figure 5 – Union-wide KEA performance and targets over RP2 and RP3 (source: PRB elaboration).

RP3 evolution to date (2022)

59 The initial Union-wide targets for KEA for RP3 were set building on those for RP2 with a gradual increase in the level of ambition: 2.53% in 2020, 2.47% in 2021, 2.40% in 2022, 2023 and 2024. The COVID-19 pandemic, and the related traffic decrease, led to a revision of the targets from 2021 onwards (following the exceptional measures Regulation). Lower traffic led to the opportunity for improved KEA, and therefore targets were revised with a higher level of ambition for 2021 and 2022

(2.37%), while remaining as previously set for 2023 and 2024 (2.40%).[5]

60 The lower traffic during the COVID-19 pandemic showed that horizontal flight efficiency improves when capacity is higher than traffic demand. Whilst the target for 2020 was only just achieved (by 0.02 percentage points (pp) with an actual KEA of 2.51%), the KEA values for both March 2020 to February 2021, and April 2020 to March 2021 were both equal to 2.41% over these 12-month periods. KEA then degraded from May 2021 as traffic recovered. This performance demonstrates that with sufficient capacity the ambitious targets set for RP3 were achievable.

61 The Union-wide situation changed once again in 2022, following Russia's war of aggression against Ukraine. The circumnavigation of Ukrainian, Belorussian, and Russian airspace led to substantial changes in traffic flows and overflights across the SES area and considerably more inefficient trajectories on certain routes. This shift in trajectories, combined with strong traffic recovery and capacity constraints in the summer of 2022 resulted in the highest year-on-year deterioration in KEA (reaching a value of 2.96%), which exceeded 2019 values (2.95%) and the target set for 2022 (2.37%).

RP3 outlook (2023-2024)

62 The Union-wide KEA performance target for the remaining years of RP3 is 2.40%. These years will be characterised by growing traffic levels, increased military activity and a likely continuation of the circumnavigation of Ukrainian, Russian, and Belorussian airspace.

63 The PRB anticipates that KEA performance is likely to remain at values above the targets as flights circumnavigate the closed airspace leading to unavoidably higher Union-wide KEA values than planned.

6.3 Environment target ranges advice

64 To support the setting of the environment target ranges, the PRB considered four pieces of evidence:

- Evidence 1: Analysis of the historical KEA performance;
- Evidence 2: The estimated benefit defined in the ERNIP;
- Evidence 3: The PRB study on the capacity and environment interdependencies; and
- Evidence 4: The impact on Union-wide KEA of Russia's war of aggression against Ukraine.

65 The detail of Evidence 1 to 3 is provided in Annex I, while details of Evidence 4 are provided in Annex III.

Evidence 1 – Analysis of historical KEA performance

66 The KEA values during 2020-2021, specifically during rolling years ending March 2021 and April 2021, demonstrate that ambitious targets within the range proposed for RP3 (2024 upper bound 2.40%, and 2024 lower bound 2.20%) were achievable if sufficient capacity was provided. Furthermore, the route efficiency of the network design (RTE-DES) has improved from 2.22% in 2020 to 1.88% in 2022, with further improvements to 1.84% expected by the NM in 2023.[6]

67 Target ranges for RP4 must also take account of the fact that traffic levels are forecast to exceed those of 2019 during RP4 and that action must, therefore, be taken to increase capacity to accommodate flights. Moreover, targets must also consider the implementation of free route airspace, improved airspace management, and other projects within the European Route Network Improvement Plan (ERNIP) that will improve horizontal flight efficiency.[7]

Evidence 2 – Estimated benefit defined in the ERNIP

68 The ERNIP estimates that the packages of airspace proposals scheduled for implementation will reduce inefficiency of route network design to 1.80% by 2030.

[5] Commission Implementing Decision (EU) 2021/891 setting revised Union-wide performance targets for the air traffic management network for the third reference period (2020-2024) and repealing Implementing Decision (EU) 2019/903.
[6] RTE-DES (Flight Extension due to Route Network Design) is calculated by measuring the difference between the shortest route length (from TMA exit and entry points) and the great circle distance. For this KPI the RAD is not taken into account and all the CDR routes are considered as open.
[7] PRB Advice to the Commission in the setting of Union-wide performance targets for RP3 (2018).

69 The ERNIP also shows that RTE-DES reduced to 1.88% in 2022, meaning that much of the reduction in route design efficiency anticipated by 2030 has already been achieved. The Network Manager estimates that RTE-DES will be 1.84% in 2023 and that the minimum achievable RTE-DES is approximately 1.75%.[8]

70 Assuming that the RTE-DES remains at 1.84% by the end of RP3, the expected benefits to materialise by the end of RP4 are expected to be between:

- -0.04pp, a conservative estimate of the route design inefficiency reducing from 1.84% to 1.80% in 2030; and
- -0.09pp, an optimistic estimate of the route design inefficiency reducing from 1.84% to 1.75% by 2030 as estimated by the Network Manager.

71 The PRB proposes to consider a gradual materialisation of the benefits over RP4. The resulting yearly lower and upper bound allowances for RP4 are illustrated in Table 2, ramping up to the expected values in 2029.

Year	Upper bound impact	Lower bound impact
2025	0pp	-0.01pp
2026	-0.01pp	-0.03pp
2027	-0.02pp	-0.05pp
2028	-0.03pp	-0.07pp
2029	-0.04pp	-0.09pp

Table 2 – Yearly KEA decrease based on assumed ramp up of ATS Route Network (ARN) benefits for the upper and lower bound of the target ranges.

Evidence 3 - PRB study on the capacity and environment interdependencies

72 The PRB study into the interdependency between capacity and environment demonstrates that ATFM delays have a negative impact on horizontal flight efficiency, and quantified the interdependency between the environment and capacity KPIs.[9] The targets for RP4 must account for this interdependency. The capacity targets have to be challenging to minimise the impact of delay and to support the PRB's focus on environmental performance. Hence, the PRB proposes targets to minimise the adjustments to the environment targets by setting ambitious, but realistic, capacity targets. Doing so supports the delivery of challenging and achievable environment target ranges, in line with ambitions.

73 It is estimated that an increase of one minute of average en route ATFM delay per flight causes an increase of 0.14pp to horizontal flight efficiency. Based on this figure, the lower and upper bound KEA adjustments for capacity for each year of RP4 are shown in Table 3.

Year	Upper bound adjustment	Lower bound adjustment
2025	+0.07pp	+0.06pp
2026	+0.07pp	+0.05pp
2027	+0.07pp	+0.05pp
2028	+0.06pp	+0.05pp
2029	+0.06pp	+0.04pp

Table 3 – Yearly KEA adjustments for the upper and lower bound of the target ranges due to interdependency with capacity.

Evidence 4 - The impact on Union-wide KEA of Russia's war of aggression against Ukraine

74 The closure of Ukraine's airspace, and the unavailability of Belorussian and Russian airspace to most carriers has caused considerable extensions of routes beyond the great circle distance. While this effect is most pronounced for Member States bordering these areas, there is also a wider impact.

75 Eurocontrol has conducted an analysis estimating that such impact has led to a Union-wide KEA deterioration of approximately 0.24 percentage points (Annex III). The analysis also shows that not all Member States are impacted by the situation (most impacted are those in the East and North of the SES area). 11 Member States have had a relative increase of KEA of over 25% in 2022, translating to absolute increases of between 0.52pp and 9.20pp.[10]

76 While it is not possible to predict the evolution of the conflict and the geopolitical climate, the PRB assumes as a starting point that route extensions resulting from Ukrainian, Belorussian, and Russian

[8] Estimates provided by Network Manager in bilateral discussions.
[9] https://wikis.ec.europa.eu/display/eusinglesky/EU+Single+Sky+Performance
[10] In order of relative impact on KEA: Finland, Lithuania, Latvia, Estonia, Poland, Slovakia, Sweden, Romania, Hungary, Bulgaria, Czech Republic.

airspace closures will remain in place for the entirety of RP4.

77 When computing the local KEA reference values, the PRB will work with the Network Manager to ensure that any allowance for the situation in Ukraine is allocated only to those impacted.

PRB approach

78 To align with the European Union's green agenda, the PRB proposes to prioritise environmental performance for RP4. By following ambitious environmental targets, ANSPs can drive the development and implementation of sustainable practices within the aviation industry and contribute to lowering aviation's impact on the environment. In 2019, the European Commission published the European Green Deal, which aims for the EU to become the first climate-neutral continent by 2050, and it is accompanied by an intermediate goal of the Fit for 55 package to reduce net greenhouse gas emissions by 55% by 2030.[11]

79 The environment target range proposed in this report is in line with the EU's ambition of a carbon-neutral economy, to which all sectors are expected to contribute. Aviation is no exception. Furthermore, an ambitious environment target is also dependent on ambitious capacity targets, as adequate capacity provision enables better horizontal flight efficiency.

80 The PRB proposes target ranges for 2029 that build on the original ambition for the end of RP3 (2024) (Evidence 1), while accounting for the benefits of recent and future improvements from ATM measures and ongoing updates to the European network (Evidence 2), and for the interdependency between environment and capacity in the environmental target ranges (Evidence 3).

81 The resulting target ranges for 2029 following this approach are:

- Upper bound 2029 target range (less ambitious): 2.40% - 0.04% (ERNIP benefits) +0.06% (interdependency) = 2.42%; and
- Lower bound 2029 target range: 2.20% - 0.09% (ERNIP benefits) + 0.04% (interdependency) = 2.15%.

82 This target range of 2.15% to 2.42% for KEA is more stretching than that for RP3 (despite the higher bound being slightly above that of RP3). This is consistent with the PRB ambitions and the increased importance of strong environmental performance.

83 The PRB proposes to include the impact of Russia's war of aggression against Ukraine on KEA. However, when defining the local targets, such an impact should be only considered for a limited number of affected Member States (Evidence 4).

84 The resulting KEA ranges for 2029 adding the estimated impacts are:

- Upper bound 2029 target range (less ambitious): 2.42% + 0.24% = 2.66%; and
- Lower bound 2029 target range: 2.15% + 0.24% = 2.39%.

85 In order to set the target ranges for the years 2025-2028, the PRB proposes target ranges evolving based on the ramp up of ERNIP ARN improvements and interdependency with the capacity targets. The resulting yearly Union-wide KEA ranges are shown in Table 4 (next page).

86 To drive environmental performance improvement over RP4, the PRB strongly recommends the Member States to define an environmental financial incentive scheme and additional environment targets based on the most appropriate KPI as specified in articles 10 (3) and 11 (4) of the Regulation. As part of this work, Member States should consider arrangements that incentivise ATM related actions to reduce emissions. Such arrangements should best reflect the contribution that ATM can make to improve flight inefficiencies and schemes to assess the effectiveness of ATM in helping airspace users to achieve their, environmentally supportive, optimum trajectory. The PRB remains available to support Member States during the process.

[11] Compared to 1990 levels.

Union-wide environment target ranges					
KEA	2025	2026	2027	2028	2029
Targets upper bound	2.71%	2.70%	2.69%	2.67%	2.66%
Targets lower bound	2.49%	2.46%	2.44%	2.42%	2.39%

Table 4 - Union-wide environment target ranges.

7 CAPACITY

- Capacity provision must support the environmental targets and ensure a low level of delays for the airspace users.
- Most of the delays could be eliminated by solving staffing issues and realising system implementation plans.
- ANSPs need to commit to and implement more ambitious capacity improvement plans.

7.1 Introduction to the capacity KPA

87 As per the Regulation, the capacity KPI is the average minutes of en route ATFM delay per flight attributable to air navigation services. The indicator, and the related targets, are defined for the whole calendar year and for each year of the reference period (i.e. 2025 to 2029 included).

88 En route ATFM delays are pre-departure delays, which occur when the traffic demand exceeds airspace capacity in a block of airspace. The indicator measures the difference between the time an aircraft was estimated to leave its parking stand (Estimated Off-Block Time, EOBT) at the airport and the actual time it left the parking stand (Actual Off-Block Time, AOBT). These differences are averaged over the number of flights which flew in the airspace following Instrument Flight Rules (IFR).

89 The capacity KPI measures the lack of capacity rather than the actual capacity provided by ANSPs, thus it is an indicator of underperformance: Higher values indicate worse performance. While the average en route ATFM delay per flight is the only KPI used for Union-wide target setting, local target setting also uses the terminal capacity KPI of average airport arrival ATFM delay per arrival. This indicator is similar to the en route indicator, but measures delays which occur when traffic demand exceeds airport/aerodrome capacity. While terminal capacity is monitored via this KPI on the Union-wide level, this report only focuses on the en route capacity KPI.

90 The target ranges for the capacity KPI have been developed by the PRB in close cooperation with the Network Manager.

RP4 KPI

91 There are no changes foreseen as regards the capacity KPI for RP4. The target ranges are therefore based on the capacity KPI as currently defined by the Regulation. The PRB will however continue to monitor capacity provision also on the basis of sector-opening hours, sector capacities, and various other metrics.

7.2 Analysis of the capacity KPA

RP2 evolution

92 In RP2 the capacity KPI was identical to the current KPI; except that average delay figures were calculated on a slightly different geographical reference. In RP2, the methodology considered the area of the flight information regions (FIR) whereas in RP3, the geographical basis of the calculation is the area of responsibility of the ANSPs (AUA). Datasets for both methodologies are available publicly. The following analysis is provided with the AUA reference.

93 In RP2 the Union-wide target for en route capacity was set at 0.5 minutes of average en route ATFM delay per flight, for each year between 2015 and 2019. The target took account of the economic optimum level of delays, as well as the performance from the first reference period. The targets were considered ambitious but realistically achievable.

94 During the first three years of RP2 (2015-2017), the actual performance did not achieve the target by 0.23-0.43 minutes per flight. This was a considerable margin, but indicated that with more effort, the target could be achieved. However, in 2018, it became apparent that there were structural issues and significant unresolved capacity problems in some of the ANSPs, resulting in record-high delays of 1.79 minutes per flight. This triggered a response from the Network Manager in the form of more targeted, special strategic measures to reduce delays during the summer of 2019. However, despite these efforts, average en route ATFM delays remained high by the end of RP2 (Figure 6, next page).

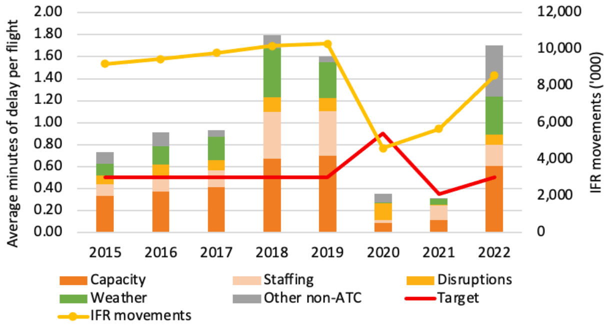

Figure 6 - Evolution of en route capacity performance and targets over RP2 and RP3 to date (source: PRB elaboration).

RP3 evolution to date (2022)

95 The original capacity targets for RP3 were set following a stepwise approach: The targets for 2020 and 2021 equal to 0.9 minutes per flight, 0.7 minutes per flight for 2022, and at 0.5 for 2023 and 2024. The rationale behind this approach was to strike a balance between setting ambitious and challenging targets, which were also realistically achievable within the given timeframe.

96 The COVID-19 pandemic, and the related drastic decrease of traffic, led to a revision of the targets from 2021 onwards (following the exceptional measures Regulation). The revised capacity targets which currently apply are: 0.35 minutes per flight in 2021 and 0.5 minutes per flight for all remaining years of RP3. Figure 6 shows the revised RP3 targets and the actual values for 2021 and 2022.

97 2020 and 2021 were the only two years in the history of the Performance and Charging Scheme when the Union-wide target for en route capacity was met. This was enabled by the major drop in traffic levels due to COVID-19 pandemic. In 2022, seven ANSPs did not manage to improve their capacities and did not resolve longstanding issues. When traffic levels reached around 80% of 2019 levels, en route ATFM delays increased dramatically once again. Some 45% of en route ATFM delays were due to ANSPs not being able to offer the number of sectors required by traffic demand and which were offered on other days during the year. These delays could have been resolved without the need for long-term measures and investments.

98 Part of the capacity performance in 2022 was also impacted by the outbreak of Russia's war of aggression against Ukraine and the implementation of major ATM system upgrades in the core area of Europe. Overall, capacity performance in 2022 has shown little improvement, if any, compared to 2018 and 2019. Due to these facts, actual performance in 2022 is not considered as a valid baseline for target setting for RP4.

RP3 outlook (2023-2024)

99 The first months of 2023 already show average en route ATFM delays higher than 2022, indicating that, without the full implementation of the resource and investment plans and major interventions, the capacity performance in 2023 will further deteriorate. The PRB anticipates that ANSPs will continue to struggle to provide the necessary capacity in the remaining two years of RP3 unless immediate actions are taken by Member States.

100 ANSPs are falling behind schedule with the implementation of new ATM systems and other capacity enhancement measures, as well as their plans to recruit and train additional air traffic controllers (the actual number of ATCOs in OPS FTEs at the end of 2022 was 2% below the planned value). If ANSPs fail to speed up the implementation of these measures and do not start to realise their benefits, capacity performance may deteriorate further by the end of RP3. As these issues are fully under the control of ANSPs, the PRB urges ANSPs to resolve ATC capacity and staffing issues by the end of RP3. The PRB assumes that this has occurred within the RP3 timeframe when considering RP4 target ranges.

7.3 Capacity target ranges advice

101 To support the setting of the capacity target ranges, the PRB considered three pieces of Evidence:

- Evidence 1: Historical capacity performance of ANSPs, especially focusing on delays with ATC capacity and ATC staffing reasons;
- Evidence 2: Historical occurrence of non-ATC disruptions-related and adverse weather-related delays; and
- Evidence 3: Capacity improvement plans included in the European Network Operations Plan 2023-2027 Edition April 2023 (NOP), the analysis conducted by the SESAR Deployment Manager on the expected benefits of the implementation of CP1 ATM functionalities, and the RP3 performance plans and monitoring reports submitted by the Member States.

102 The detail of each evidence is provided in Annex I.

Evidence 1 - Historical capacity performance

103 The past ten years has shown that when traffic is growing (and not subject to demand-side shocks such as COVID-19), the European ATM network had insufficient capacity to handle increasing volumes of traffic without frequent and often long delays. However, despite the overall unsatisfactory capacity performance, there were some ANSPs who successfully managed to implement capacity enhancement measures and improve their capacity performance. This indicates that even ambitious capacity targets are possible to achieve.

104 When analysing capacity constraints and delays in the European ATM network, it is apparent that over the past years, most of the en route ATFM delays were generated by five to ten area control centres (ACCs). Moreover, ATC capacity and ATC staffing reasons were the key drivers of en route ATFM delays, although adverse weather and ATC-related disruptions have, on occasion, generated significant delays.

105 The PRB assumes that ANSPs will be able to resolve their ATCO training and recruitment issues, to implement investment as planned, as well as to implement best practices in staffing and rostering by the end of RP3.

Evidence 2 - Allowance for adverse weather and non-ATC disruptions

106 Adverse weather phenomena, failures in the technical equipment of airports, and industrial action at non-ATM stakeholders can also cause network disruption and generate ATFM delays. As ANSPs have little influence on delays of this nature, it is reasonable to allow for such delays when defining the Union-wide target ranges for capacity.

107 The allowance for weather and non-ATC-related disruption delays is calculated on the basis of historical averages. The allowance for weather-related delays is estimated between 0.20 and 0.27 minutes per flight at the Union-wide level, while the allowance for non-ATC disruptions is between 0.01 and 0.03 minutes per flight (details on the estimation are provided in the Annex I).

Evidence 3 - Capacity improvement plans and benefits of CP1 ATM functionalities

108 Evidence 3 provides the analysis of the capacity improvement plans and the planned capacity profiles of each of the ACCs in the Single European Sky area. The current edition of the NOP includes capacity improvement plans for the period 2023 to 2027, covering the first three years of RP4. Most ACCs which, historically, were significant contributors to en route ATFM delays are planning to implement state-of-the-art, new ATM systems and advanced ATC tools in the timeframe of the current NOP. The PRB expects that these investments will result in significant improvements in the capacity performance of these ACCs, allowing them to minimise en route ATFM delays in the last two years of RP4. Moreover, the implementation of new ATM systems and advanced ATM functionalities should enable ANSPs to realise the benefits of dynamic cross-border demand-capacity balancing to alleviate the pressure on ATCO recruitment and training.

109 The SESAR Deployment Manager analyses the expected impact of the implementation projects under the CP1 umbrella. While the calculations used to describe the benefits are not directly applicable to the target exercise due to the differences in the methodologies, the overall conclusion from the analysis is that SDM expects that, during RP4, the implementation of CP1 projects will be a major contributing factor to capacity improvement and delay reduction. The projects monitored by the SDM are part of the capacity improvement measures of the ANSPs as included in the NOP.

110 As the PRB highlighted in the monitoring report, some ANSPs may have to revise their current capacity improvement plans and commit to more ambitious capacity enhancement measures in order to close the forecast capacity gaps.

PRB Approach

111 Given the interdependency between capacity and flight efficiency, the top priority for the capacity KPA in RP4 is to enable and support environmental performance in the European ATM network by eliminating ATFM delays as much as reasonably possible. Moreover, the capacity KPA must ensure a low level of delays experienced by airspace users.

112 The PRB assumes that ANSPs will resolve delays due to sector-opening gaps and lack of ATCOs by the end of RP3 and that ANSPs will be able to eliminate most en route ATFM delays by the end of 2027 by implementing the measures included in the NOP.

113 However, aiming and anticipating zero ATC-related delays is neither reasonable nor realistic. Therefore, the PRB proposes the capacity target range as the sum of the allowance for weather-related delays, the allowance for the non-ATC disruptions, and a system resilience buffer which allows for minor delays.

114 To define the target ranges, the PRB defined two levels of ambition in reducing delays:

- The less ambitious approach (upper bound of target ranges) assumes that ANSPs with the most delay minutes are able to eliminate 75% of delays by 2029 compared to 2022.
- The more ambitious approach (lower bound of target ranges) assumes that the same ANSPs are able to eliminate 90% of delays by 2029, compared to 2022.

115 The Union-wide target range for 2029 is therefore calculated as follows:

- **Upper bound 2029 target range** (less ambitious): 0.27 minutes/flight (weather allowance) + 0.03 minutes/flight (disruption allowance) + 0.10 minutes/flight (system resilience buffer) = **0.40 minutes/flight.**
- **Lower bound 2029 target range**: 0.20 minutes/flight (weather allowance) + 0.01 minutes/flight (disruption allowance) + 0.10 minutes/flight (system resilience buffer) = **0.31 minutes/flight.**

116 The PRB advises to not include any allowance related to the impact of the war in Ukraine. While it is not possible to predict the evolution of the conflict, the PRB assumes that ANSPs fully adapt to the current status by the end of RP3.

117 The PRB considers that ANSPs should implement all capacity improvement measures included in the current version of the NOP by 2027. The PRB proposes to take this into account in the system resilience buffer of the target range, but with a different level of ambition as regards the pace of the improvement.

118 For the upper bound of the target ranges, the PRB proposes to keep both the weather and disruption allowances constant for each year of RP4 (i.e. 0.27 and 0.03 minutes/flight). With respect to the system resilience buffer, the PRB proposes to consider a system resilience buffer for 2025, 2026, and 2027 of 0.20 minutes/flight, and to decrease it to 0.10 for, 2028, and 2029, once all the capacity improvement measures from the NOP are implemented by the ANSPs. Therefore, the upper bound of the target ranges starts from a target of 0.5 minutes/flight, as the current Union-wide capacity target for 2024.

119 For the lower bound of the target ranges, the PRB proposes to keep both the weather and disruption allowances constant for each year of RP4 (i.e. 0.20, and 0.01 minutes/flight). With respect to the system resilience buffer, the PRB proposes to consider a yearly decrease of 0.03 minutes/flight for 2026 and 2027, when most of the NOP measures will be implemented by the ANSPs. As for 2028 and 2029, the PRB proposes a yearly reduction of 0.02 minutes/flight in the system resilience buffer, as capacity improvement will be more organic, to follow traffic growth in those years. Thus, the system resilience buffer would start from 0.2 minutes/flight in 2025 and decrease to 0.1 minutes/flight in 2029.

120 The resulting target ranges proposed by the PRB for the RP4 Union-wide en route capacity targets are shown in Table 5.

Union-wide capacity target ranges					
Average Delays (min/flight)	2025	2026	2027	2028	2029
Targets upper bound	0.50	0.50	0.50	0.40	0.40
Targets lower bound	0.41	0.38	0.35	0.33	0.31

Table 5 – Union-wide en route capacity target ranges.

8 COST-EFFICIENCY

- The RP4 priority for cost-efficiency is to ensure that safety, environment, and capacity performances are delivered.
- The cost base should gradually become more efficient.
- The PRB proposes to recover a substantial part of the ANSPs' cost base inefficiency by the end of RP4.

8.1 Introduction to the cost-efficiency KPA

121 As per the Regulation, the cost-efficiency KPI is the year-on-year change of the average Union-wide determined unit cost for en route air navigation services. The determined unit cost is calculated as the ratio between the en route determined costs and the en route expected service units for a given year. For the purpose of target setting, the service units applied are included in latest available STATFOR base forecast (for the target ranges, STATFOR March 2023).

122 The Regulation requires the definition of the starting point for the year-on year change at Union-wide level (baseline value) for determined costs, and determined unit costs for the year preceding the start of the reference period (i.e. 2024). The Regulation specifies that the baseline value "shall be estimated by using the actual costs available and adjusted to take into account the latest available cost estimates, traffic variations, and their relation to costs".

123 The target ranges for the cost-efficiency KPI have been developed by the PRB taking into consideration the academic support (Annex II).

RP4 KPI

124 There are no changes foreseen with regards to the cost-efficiency KPI for RP4. The target ranges are therefore based on the cost-efficiency KPI as currently defined by the Regulation.

8.2 Analysis of the cost-efficiency KPA

RP2 evolution

125 The Union-wide cost-efficiency KPI for RP2 was defined as the average Union-wide determined unit cost for en route air navigation services in value (and not the year-on-year change of this value as from RP3). The targets were provided for each year of the reference period as the ratio between the en route determined costs and the en route forecast traffic.[12]

126 During RP2, the en route cost-efficiency Union-wide targets have been achieved in each year of the reference period. The Union-wide actual unit cost decreased by -13% over the reference period (from 52.87€$_{2009}$ to 44.61€$_{2009}$) and has been on average 5€$_{2009}$ (-9%) below the determined unit cost within the RP2 decision.[13] Higher service units and lower actual costs than the determined cost allowed Member States to achieve the Union-wide targets for each year of the reference period (Figure 7).

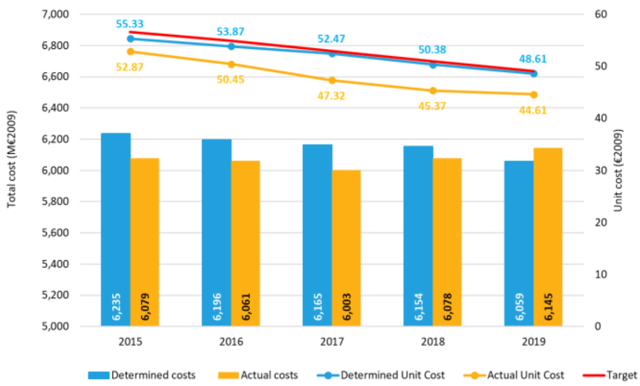

Figure 7 – Union-wide en route unit and total cost actual vs performance plans during RP2.

127 The lower actual costs have signalled a deficiency in the planning process, in which some ANSPs prioritised accounting conservatism over the ambition of more efficiency and the provision of more capacity. Moreover, the lower actual unit cost indicated that the targets lacked ambition. Both reasons have led to the situation in which the system was far from optimal.

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[12] The cost-efficiency Union-wide targets for RP2 were: 56.64€$_{2009}$ for 2015, 54.95€$_{2009}$ for 2016, 52.98€$_{2009}$ for 2017, 51.00€$_{2009}$ for 2018, and 49.10€$_{2009}$ for 2019. The aggregation of the plans (i.e. the sum of the costs and traffic as in the performance plans) resulted in slightly lower Union-wide determined DUC: 55.33€$_{2009}$ for 2015, 53.87€$_{2009}$ for 2016, 52.47€$_{2009}$ for 2017, 50.38€$_{2009}$ for 2018, and 48.61€$_{2009}$ for 2019.

[13] On average 4€$_{2009}$ below the determined unit cost of the aggregated performance plans.

128 Actual costs remained flat over the reference period (on average 6.1B€$_{2009}$) and below the determined cost, with the only exception of 2019. The 2019 result may be an indication of the regulated entities increasing the cost base in preparation for the subsequent reference period (the 2019 was the baseline used for the RP3 targets).

129 During RP2, Member States lagged behind in terms of delivering on their investment plans. The delays in investments resulted in actual costs related to investments (i.e. depreciation and cost of capital) being lower than the determined values. During RP2, a total amount of 371M€$_{2009}$ was charged to airspace users for investments that were not realised. This amount was retained by most of the ANSPs under the cost sharing mechanism, while some ANSPs voluntarily returned the unspent costs related to investments.[14] The Regulation (for RP3) corrected this issue by extending the cost sharing mechanism to include investment costs, requiring any differences to be reimbursed to airspace users.

RP3 evolution to date (2022)

130 The Regulation (for RP3) modified the cost-efficiency performance KPI. From the average en route determined costs (in value), the RP3 cost-efficiency KPI became the year-on-year change of the average Union-wide determined unit cost for en route air navigation services (which is expressed in percentage).

131 The original cost-efficiency targets for RP3 were set as a -1.9% decrease of the Union-wide en route determined unit costs for each year of the reference period. The COVID-19 pandemic, and the related drastic decrease of traffic, led to a revision of the targets (following the exceptional measures Regulation). The revised cost-efficiency targets which are currently applied are: +120.1% for the combined years 2020/2021, -38.5% for 2022, -13.2% for 2023, and -11.5% for 2024. The variation in the magnitude of the targets is due to the drop in traffic in the first year of the reference period, and the forecast recovery in the following years.[15]

132 The Union-wide targets have been met for 2020/2021 and 2022. The aggregated results show that Member States decreased actual costs by -516M€$_{2017}$ (-2.8%) compared to the level of determined costs. At the same time, the targets have been mostly met because, at Union-wide level, the actual traffic exceeded the forecasts used for the performance plans.

133 In addition, the forecasts used for the performance plans were based on a more optimistic update of the STATFOR forecast used for the Union-wide targets. On average, in the combined year 2020/2021, the traffic in the performance plans was +9% higher compared to the STATFOR November 2020 base scenario, and +25% higher for 2022. The evolution of the cost-efficiency performance to date is shown in Figure 8.

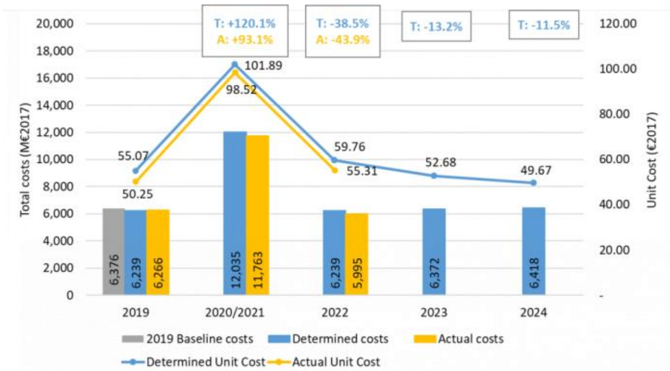

Figure 8 – RP3 targets, Union-wide en route unit and total cost actual vs performance plans during RP3.

RP3 outlook (2023-2024)

134 The RP3 evolution to date shows Union-wide level actual costs to be lower than determined and this trend could continue for 2023. In 2024, actual costs may rise above the determined valued as occurred in the last year of RP2. The PRB urges Member States to make efficient use of the available financial resources to support the delivery of necessary capacity by achieving the staff recruitment and investment measures as defined in the performance plans.

8.3 Cost-efficiency target ranges advice

135 To support the setting of the cost-efficiency target ranges, the PRB has taken three pieces of Evidence into consideration:

[14] The value includes both en route and terminal.

[15] The aggregation of the plans (i.e. the sum of the costs and traffic as in the performance plans) resulted in the following Union-wide determined DUC: 101.89€$_{2017}$ for 2020/2021, 59.76€$_{2017}$ for 2022, 52.68€$_{2017}$ for 2023, 49.67€$_{2017}$ for 2024. At the time of writing this report, the draft performance plan of Belgium-Luxembourg has still not been adopted, therefore the aggregated values may slightly change.

- Evidence 1 – Cost forecast based on Member States submissions. This evidence considered the information provided by the States.
- Evidence 2 – Cost forecast based on historical data. This evidence applies statistical methods to forecast the costs for each year from 2024 to 2029.
- Evidence 3 – Cost inefficiency estimated by the Academic group. As for RP3, the PRB asked a group of Academics to estimate, through benchmarking, a range of ANSP cost inefficiency observed in the current system.

136 Evidence 1 and 2 provide a forecast of the cost base for the RP4 baseline and each year of RP4. Evidence 3, combined with the PRB level of ambition, provides a range of Union-wide reduction of the cost inefficiencies for each year of RP4. By dividing the resulting costs by the Union-wide service units base forecast, the related DUCs (determined unit cost) are calculated. The target ranges (i.e. year-on-year change) are computed based on these values. Annex I of this report provides the detailed information on the calculation of Evidence 1 and 2. Annex II of this report describes Evidence 3.

Evidence 1 – Member States submission

137 Evidence 1 is based on the Member States initial RP4 data submissions. The PRB aggregated the values as submitted by the Member States in order to estimate the costs for the years 2025-2029 (Table 6). The detailed analysis of the amounts can be found in Annex I.

138 The costs, as submitted by the Member States, start from 6,959M€$_{2022}$ and increase over RP4 reaching 8,023M€$_{2022}$ (CAGR +2.9%).

Union-wide en route costs – States submission (M€$_{2022}$)					
2024	2025	2026	2027	2028	2029
6,959	7,433	7,603	7,774	7,932	8,023

Table 6 – Aggregation of Member States cost forecasts.

Evidence 2 – PRB cost forecasts

139 Evidence 2 is based on a determined cost forecast based on two statistical models. Starting from the historical actual costs, the PRB forecast the Union-wide en route costs for the years 2024-2029.[16] Details on the data, statistical models, and forecast are provided in Annex I.

140 The summary of the cost estimates at Union-wide level is presented in Table 7. The two series of forecast costs are very similar in each year and differ on average by 0.5% (i.e. 36M€$_{2022}$). The forecast Union-wide cost for 2024 is between 7,173M€$_{2022}$, and 7,206M€$_{2022}$, increasing to between 7,470M€$_{2022}$ and 7,513M€$_{2022}$ in 2029, respectively (CAGR +0.8% for both the forecast).

Union-wide en route costs Forecast based on service units (M€$_{2022}$)					
2024	2025	2026	2027	2028	2029
7,206	7.319	7,385	7,436	7,481	7,513
Union-wide en route costs Forecast based on IFR movements (M€$_{2022}$)					
2024	2025	2026	2027	2028	2029
7,173	7,287	7,351	7,400	7,444	7,471

Table 7 – Union-wide en route costs PRB forecast.

Evidence 3 – Cost base inefficiency

141 Evidence 3 is based on the Academic study. The study (Annex II of this report) defined a distribution of inefficiencies (i.e. the percentage of costs that can be reduced based on benchmarking). The results show that the inefficiency in the cost base of the ANSPs is on average 16%.

142 Despite the dramatic decrease of traffic due to COVID-19 pandemic, and the opportunity ANSPs had to implement responsive cost reduction measures, ANSPs did not appear to efficiently adapt their cost base and did not implement innovative or radical changes within their operations. The PRB assumes that the estimated level of cost inefficiency in the cost base remained unchanged during RP3, therefore the results can be applied to the forecast costs for RP4. The PRB proposes to recover part of the inefficiency in the ANSPs' cost base by the end of RP4, between 5% to 10% (i.e. corresponding to 1/3 and 2/3 of the inefficiency identified in Annex II).

PRB Approach

143 The RP4 priority is to ensure that safety, environment, and capacity performance improvements are delivered. The achievement of the environment target needs to be supported by a consistent

[16] The cost category of the exceptional items, costs for exempted VFR flights, NSAs and Eurocontrol costs have not been forecast, but included as submitted by the Member States.

capacity target and facilitated by an appropriate cost efficiency target. For RP4, in order to further support the delivery of the environmental and capacity performances, the PRB proposes to recover some of the ANSPs' inefficiency in the costs as estimated in Evidence 3. The cost inefficiency not recovered should be used by the ANSPs to improve operational performances. The PRB proposes to recover between 5% to 10% (i.e. corresponding to 1/3 and 2/3 of the inefficiency identified in Annex II) of the inefficiency in the ANSPs' cost base by the end of RP4. The PRB considered that additional means may be needed by some Member States to improve capacity (under certain conditions). While these costs are not reflected in the target ranges, they should be allowed on a case-by-case basis.[17]

144 Given the sobering RP3 experience to date, the PRB is already signalling to the Member States that the local capacity targets must be supported by a very strong and impactful financial incentive scheme. Incentives to ensure delivery of a specified outcome need to be set at an appropriate level, especially when a deviation from the cost-efficiency trends is requested.

145 With respect to the environmental performance, the PRB strongly advises the Member States to make use of the possibility provided by the Regulation to set financial incentive schemes for environment targets. The PRB remains available to support Member States during the process.

146 Finally, the PRB included the cost for the NSAs as submitted by the Member States. This will allow the NSA to further improve their effectiveness as local authorities, especially in respect to the monitoring of the implementation of recruitment and investment plans, and of safety, environmental and capacity performances.

147 The PRB proposes to set the year-on-year change of the average Union-wide determined unit cost as a constant and equal percentage over the RP4 years. The range should be based on the average change from the 2024 baseline to the 2029 forecast determined unit costs, where:

- **2024 baseline** calculated as the average of the baselines estimated in each evidence (55.61$€_{2022}$).[18] When advising the Commission on the cost-efficiency targets for RP4, the PRB will revise the baseline value in light of the new traffic forecast, the updated inflation forecast, the latest available information, and the outcomes of the stakeholder consultation;
- **Upper bound 2029 unit cost of the range** calculated as the aggregation of Member States forecast costs, factoring in a 5% recovery of inefficiency, and divided by STATFOR base forecast (53.58$€_{2022}$); and
- **Lower bound 2029 unit cost of the range** based on the PRB cost forecast (forecast based on the IFR movements), factoring in a 10% recovery of inefficiency, and divided by STATFOR base forecast (47.49$€_{2022}$).

148 The resulting year-on-year change of the average Union-wide determined unit cost ranges are for the **upper bound -0.7%**, for the **lower bound -3.1%** (Table 8, next page).

[17] As defined in Annex IV of the Regulation.
[18] Average between: Evidence 1 - State submission 53.77$€_{2022}$; Evidence 2 - Service unit based forecast 55.68$€_{2022}$; Evidence 2 - IFR based forecast 55.42$€_{2022}$; Maximum of evidence 1 and 2 57.58$€_{2022}$;

Union-wide cost-efficiency target ranges	
2024 baseline	55.61€2022 / 7,198M€2022

y-o-y change of Union-wide determined unit costs	2025	2026	2027	2028	2029
Targets upper bound	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
Targets lower bound	-3.1%	-3.1%	-3.1%	-3.1%	-3.1%

Table 8 – Union-wide cost-efficiency target ranges.

9 PRB ADVICE ON RP4 TARGET RANGES

Safety

Union-wide safety targets RP4	
Management Objectives	2029 maturity levels
Safety culture	C
Safety policy and objectives	C
Safety risk management	D
Safety assurance	C
Safety promotion	C

Environment

Union-wide environment target ranges					
KEA	2025	2026	2027	2028	2029
Targets upper bound	2.71%	2.70%	2.69%	2.67%	2.66%
Targets lower bound	2.49%	2.46%	2.44%	2.42%	2.39%

Capacity

Union-wide capacity target ranges					
Average Delays (min/flight)	2025	2026	2027	2028	2029
Targets upper bound	0.50	0.50	0.50	0.40	0.40
Targets lower bound	0.41	0.38	0.35	0.33	0.31

Cost-efficiency

Union-wide cost-efficiency target ranges	
2024 baseline	55.61€$_{2022}$ / 7,198M€$_{2022}$

y-o-y change of Union-wide determined unit costs	2025	2026	2027	2028	2029
Targets upper bound	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
Targets lower bound	-3.1%	-3.1%	-3.1%	-3.1%	-3.1%

Performance Review Body
Advice on the Union-wide target ranges for RP4

Annex I - Detailed analysis per KPA

September 2023

Performance Review Body of the Single European Sky | Rue de la Fusée 96, Office 50.659, 1130 Brussels
Office Telephone: +32 (0)2 234 7824 | cathy.mannion@prb.eusinglesky.eu | prb-office@prb.eusinglesky.eu | wikis.ec.europa.eu/display/eusinglesky

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1 INTRODUCTION

1. Under Commission Implementing Regulation (EU) 2019/317 (herein referred to as the Regulation), the assistance to the Commission when setting the Union-wide performance target ranges is one of the primary tasks of the Performance Review Body (PRB). The legal basis for the setting of the Union-wide performance targets is defined in Article 9 of the Regulation.

2. This report is Annex I of the PRB advice on the Union-wide target ranges for RP4. This annex specifies, for each KPA, the methodology and calculation applied to set the target ranges.

2 SAFETY

2.1 *Introduction to the target setting*

3. Safety within the performance and charging scheme serves two roles:

- Safety as a key performance area (KPA) to monitor and drive further improvements; and
- Safety as a control mechanism to take into account the impacts from targets set on the other KPAs: Environment, capacity, and cost-efficiency.

4. As set out in the Regulation, the safety Key Performance Indicator (KPI) is the minimum level of the effectiveness of safety management (EoSM) to be achieved by air navigation service providers certified to provide air traffic services. The KPI measures an air navigation service provider's ability to implement and manage an effective safety management system (SMS) by measuring the level of implementation (maturity) of the following safety Management Objectives:

- Safety culture;
- Safety policy and objectives;
- Safety risk management;
- Safety assurance; and
- Safety promotion.

5. For the purpose of target setting, the Union-wide EoSM targets are set for the final year of the reference period (2029), where ANSPs are required to provide intermediate levels for each year of the reference period. The targets for the safety KPI have been developed by the PRB in close cooperation with EASA, as per Article 6 and 9 of the Regulation. The level of maturity (the target) for each of these Management Objectives is defined from level A to level D (D being the highest).

RP4 Safety KPI

6. In January 2022, the European Commission requested EASA to develop, together with the relevant stakeholders through a working group, a potential set of Safety (Key) Performance Indicators (S(K)PIs) for RP4. The technical report from the working group was published at the end of April 2023 and included a proposal for the continuation of the EoSM as the sole safety KPI. The EASA working group also proposed to:

- Revise the current EoSM questionnaire to better address the challenges expected during RP4, and to better address any potential negative impact on safety from other KPAs.
- Update the EoSM Management Objectives based on the CANSO Standard of Excellence (SoE) in safety management (revision from February 2023). As for RP3, the related questionnaire has been revised to reflect the modern safety management approaches.
- Create two versions of the EoSM questionnaire to reflect the applicability to both ANSPs and the Network Manager. This differentiation is needed to recognise the differing roles and responsibilities of these two respondent groups.
- Base the Network Manager EoSM questionnaire on a sub-set of the EoSM questionnaire applicable to the ANSPs.
- Align the scoring mechanism with the EASA Management System Assessment Tool to compare the results reported via the EoSM questionnaires and the intelligence gathered by EASA through their oversight.

7. The revised EoSM questionnaire is expected to be available in late 2023.

2.2 *Analysis of the safety KPA*

RP2 evolution

8. The EoSM targets for RP2 were set at level C for safety culture, and at level D for all the other safety Management Objectives. Out of the 31 ANSPs, 30 had already achieved the target for safety culture in 2015 (the first year of RP2) (Figure 1, next page). Similarly, 11 ANSPs achieved the targets for the other Management Objectives already in 2015.

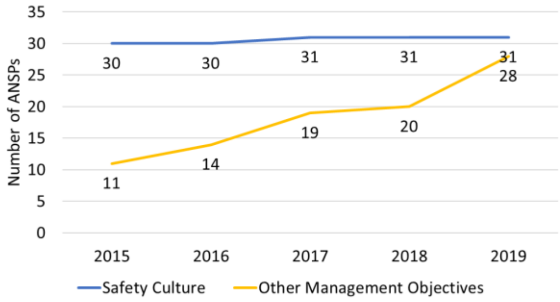

Figure 1 – Number of ANSPs achieving the Management Objectives during RP2 (source: PRB elaboration).

9. The analysis of the EoSM minimum maturity Level achieved by the 31 ANSPs shows that:

- At the end of RP2 all ANSPs achieved the target for safety culture, being Level C or above for this Management Objective. Since all but one ANSPs had already achieved the target in the first year of RP2, no major challenge was observed in this Management Objective. 27 of the ANSPs exceeded the target by the end of RP2 (i.e. reach a higher level of maturity than the target).
- 28 out of 31 ANSPs achieved the RP2 targets for all other Management Objectives, as they achieved level D or above. Three ANSPs (CY-ATS, LFV, LGS) failed to achieve the RP2 targets:
- CYATS achieved the target for safety culture the first year of RP2, but needed to improve the other four Management Objectives by one level.
- LGS needed to improve safety policy and objective by one level.
- LFV needed to improve safety risk management and safety assurance by one level.

10. The Network Manager achieved the targets in 2018, one year ahead of the end of RP2.

11. The targets have been shown to be achievable. For some Management Objectives (e.g. safety culture) the targets were not challenging enough as they were reached by the majority of the ANSPs during the first year of the reference period. With the majority of the ANSPs achieving the targets by the end of RP2 and with the objective to continue the improvement of safety management, the EoSM needed an update if it was to be used in RP3.

RP3 evolution to date (2022)

12. The Regulation retained the safety Key Performance Indicator from the RP2 Regulation: The Effectiveness of Safety Management (EoSM) of air navigation service providers.[1] However, the EoSM questionnaire was substantially modified between RP2 and RP3 (among other changes) to align it with the CANSO SoE v.2, and to ensure consistency with the Commission Implementing Regulation (EU) 2017/373 (common requirements Regulation).[2] Therefore, the comparison of performance across reference periods should be viewed with caution. In general, the maturity levels were expected to fall by one level (e.g. if achieving level D during RP2, the same ANSP would be expected to achieve level C at the start of RP3).

13. The EoSM targets for RP3 were set at level D for safety risk management, and at level C for all the other safety Management Objectives. The targets were set to be achieved by the end of RP3, expecting the ANSPs to show a gradual improvement to reach the targets in 2024, at the latest. Since the more challenging target was set for Safety Risk Management, it was anticipated that ANSPs would reach this target later than for the other Management Objectives.

14. The revised Union-wide targets for RP3, following the exceptional measures Regulation, did not modify the safety targets that were originally set for the reference period.[3] The reason was that the EoSM is not designed to address individual safety

[1] Commission Implementing Regulation (EU) No 390/2013 of 3 May 2013 laying down a performance scheme for air navigation services and network functions.

[2] Commission Implementing Regulation (EU) 2017/373 of 1 March 2017 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011, as amended.

[3] Commission Implementing Regulation (EU) 2020/1627 of 3 November 2020 on exceptional measures for the third reference period (2020-2024) of the single European sky performance and charging scheme due to the COVID-19 pandemic.

issues that fall outside the normal measuring and monitoring of the Safety Key Performance Indicator and other safety performance indicators (SPI) as defined in Regulation 2019/317. The management of safety is not assigned to the ATM performance scheme. As a result, particular issues were addressed by EASA through their Safety Risk Portfolio and ultimately the European safety risk management Process. In addition, despite the impact of the COVID-19 pandemic, the PRB still considered the target achievable and relevant for RP3. Safety remained the highest priority and changes to targets for other KPAs did not affect the safety KPA. ANSPs were expected to keep a focus on safety management, and ensure it was adapted/scaled to the particular situation.

15. Figure 2 shows the maturity levels planned by the ANSPs over RP3, and the achieved level in the first three years of the reference period. The ANSPs planned to achieve the target for safety risk management in the last years of RP3. However, ANSPs are currently ahead of their plans with 18 ANSPs having already reached the target (out of 36). For other Management Objectives, the achieved maturity levels follow closely the expected evolution over RP3, with 23 ANSPs achieving the target in the first year of RP3 and with two ANSPs planning to reach the target in the last year of RP3. The performance observed is better than originally anticipated when the RP3 targets were set. A total of 16 ANSPs achieved the targets for RP3 in 2022.

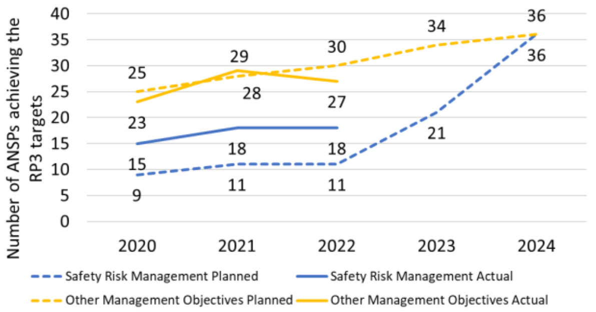

Figure 2 - Planned and actual number of ANSPs achieving the EoSM targets level during RP3 (source: PRB elaboration).

RP3 outlook (2023-2024)

16. In order to assess the expected situation at the end of RP3, it is important to analyse which improvements are still needed for those ANSPs not achieving the targets level (i.e. whether the current minimum level achieved is caused by one question only, or whether the ANSPs need to improve on several questions to achieve the target).

17. Figure 3 shows how many questions within each Management Objective need to be improved by the ANSPs currently not achieving the targeted maturity level. ANSPs marked with an asterisk are trailing behind the maturity level defined in their performance plans (i.e. CYATS, IAA, LPS SR, NAVIAIR, SJSC, skeyes and ANA LUX). Other ANSPs do not achieve the RP3 targets, but are still following their plan for intermediate maturity levels, i.e. plan to achieve the target later than 2022.

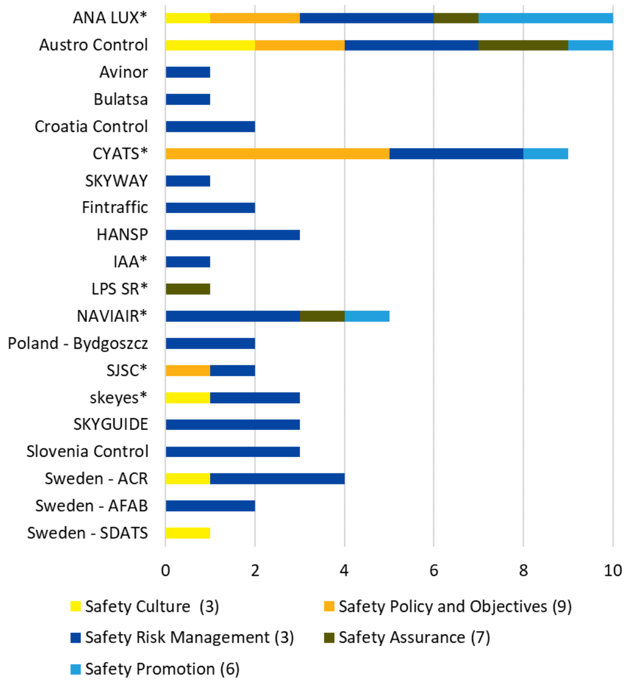

Figure 3 - Number of questions to be improved per Management Objective for each ANSP to reach the RP3 targets. The number of questions under the objective is shown in parenthesis (source: PRB elaboration).

18. Most of the ANSPs are in line to achieve the targets:

- Those ANSPs yet to achieve the targets are one maturity level below.
- 11 ANSPs need to improve performance in relation to one or two questions to achieve the targets.
- The main area requiring improvement is safety risk management, where eight ANSPs need to improve performance in all three

questions included under the Management Objective.

- 11 ANSPs need to improve in relation to safety risk management, while already achieving the targets for the other Management Objectives.

19. Through its annual monitoring reports, the PRB has recommended Member States to ensure that actions are taken to put in place measures needed to reach the RP3 targets. The PRB has also recommended that the verification of the achieved level of maturity must properly reflect the feedback received from the EASA and Member State standardisation oversight activities.

20. The maturity levels achieved by the ANSPs in 2022 and the maturity levels expected to be achieved at the end of RP3 are shown in Table 1 (RP3 target maturity levels are shown in bold). If an ANSP in 2022 exceeded the RP3 target, the PRB assumed it will retain this maturity level until the end of RP3. ANSPs planning to reach a minimum level C by the end of RP3, may have some questions where they are at level D already.

	RP3 maturity level		
Management Objective	Maturity	Achieved 2022	Expected 2024
Safety culture	B	5	
	C	20	25
	D	11	11
Safety policy and objectives	B	4	
	C	25	29
	D	7	7
Safety risk management	B		
	C	18	
	D	18	36
Safety assurance	B	4	
	C	23	27
	D	9	9
Safety promotion	B	4	
	C	24	28
	D	8	8

Table 1 – Number of ANSPs achieving maturity levels in 2022, and number of ANSPs expected to achieve a specific maturity level in 2024 (source: PRB elaboration).

21. With the developments observed up to 2022, combined with the planning of the ANSPs, the PRB expects that all ANSPs will meet the RP3 targets by the end of RP3. Two or three ANSPs run the risk of not achieving the targets, but only due to a lower maturity level for a few EoSM questions:

- ANA LUX plans to achieve the targets in 2023. However, it reported a reduced maturity on several questions between 2021 and 2022. ANA LUX will need to ensure planned measures are implemented and, where needed, ANA LUX will need to implement additional measures to reach the targets.
- AustroControl plans to achieve RP3 targets at the end of RP3 and hence is not behind its plan.
- CYATS planned to achieve the RP3 targets in 2021 and needs to ensure that its planned measures are implemented or additional measures put in place, in order to meet the RP3 targets.

22. The Network Manager has performed as planned over RP3 and is expected to reach the targets no later than by the end of RP3.

2.3 RP4 EoSM questionnaire

23. The EASA RP4 safety indicator Working Group, that proposed safety performance indicators for the coming reference period, recommended that the EoSM should be revised to reflect the revised CANSO SoE (revision February 2023). The working group also proposed that the revised EoSM address aspects such as human performance, cybersecurity, and consistency with Regulation 2017/373.In addition, an untargeted Management Objective related to Interdependencies is expected to be included. This additional Management Objective would address interdependencies between safety and the other three Key Performance Areas.

24. Compared with the previous version of the CANSO SoE (version 2), the revised version has been developed to:

- Align with the International Civil Aviation Organization's (ICAO's) Annex on Safety Management (Annex 19) 2nd Edition;
- Address feedback received from ANSPs and other industry bodies; and
- Include the latest developments in safety management thinking and practice.

25. The PRB and EASA have jointly performed a comparative analysis of the difference between the revised CANSO SoE and the RP3 EoSM to determine the expected level of maturity ANSPs should achieve at the end of RP4 applying the updated questionnaire. Tracing questions from the RP3 EoSM to the revised CANSO SoE indicated that some questions, which in the EoSM were allocated to a maturity level D (Assured), in the revised CANSO SoE would now be allocated to maturity level C (Managed). It also showed that additional questions were included in the revised CANSO SoE addressing new topics such as fatigue-risk management which were not covered in the current EoSM questionnaire. The main differences are:

- Safety culture: Further requirements related to Just Culture, planning, assessments and coverage of the organisation.
- Safety policy and objectives: Further requirements for integration of safety in the business planning process and adoption of and contribution to regional and international standards. Increased requirements related to emergency response procedures and planning.
- Safety risk management: Increased requirements to integrate fatigue-related risks management use of metrics and lessons learned from occurrences.[4] Requirements to change management extended.
- Safety assurance: Increased requirements related to human factors, systematic use of a risk classification process and explanatory factors and processes related to safety surveys. Requirements to change management extended.
- Safety promotion: Increased training requirements and the dissemination of safety data and lessons learned.

26. The aspects expected to be integrated in the RP4 EoSM, will increase requirements to achieve a certain level of maturity. Generally, an ANSP is assumed to start RP4 one level lower than when ending RP3. Hence:

- For safety risk management, ANSPs would start on level C, provided that the ANSPs had ensured some level of compliance with Regulation 2017/373 in respect of fatigue-risk management and human contribution to risks. Where such aspects have not been addressed, ANSPs would start at level B.
- For other Management Objectives, ANSPs would start on level B but would already probably satisfy several of the conditions to reach level C.
- ANSPs achieving a minimum maturity level C or D at the end of RP3 would need to implement improvements to retain the same level of minimum maturity using the updated EoSM questionnaire.
- ANSPs not achieving the targets for RP3 for Management Objectives other than safety risk management and with one or two questions still at maturity level B with the RP3 questionnaire, would start RP4 with the same maturity level.

27. The above has been used as the general assumptions, even though there can be particularities related to the implementation of safety management for an ANSP giving a higher or lower maturity level when starting RP4 (e.g. an ANSP may already have implemented fatigue-risk management as per regulatory requirements).

28. Following the recommendation to update the EoSM questionnaire for RP4 based on the revised CANSO SoE, EASA requested its standardisation oversight team to review the revised CANSO SoE. The review aimed at assessing if there were any requirements that would be considered excessive or too challenging for an ANSP to achieve during RP4. The EASA team concluded that the update would increase transparency and standardisation of the implementation across ANSPs. However, the EASA team also noted that some requirements would need additional effort by some ANSPs relating to:

- Increased involvement of internal and external stakeholders, use of external independent

[4] Consistent with Regulation (EU) 2017/373.

reviews, and routine coordination with external stakeholders;
- Increased requirements in relation to safety surveys (e.g. risk-based approach, observational techniques);
- Benchmarking or comparative analysis with other organisations, relating to topics such as Just Culture, Emergency Response Plans, and reporting and investigation processes;
- Inclusion of safety management and safety improvement activities in the annual ANSP business planning process; and
- Integration of more advanced Human Factor principles which may require additional expertise and potential research-type activities.

29. The EASA team also noted that some requirements may be too demanding for the maturity level allocated, and should potentially be allocated to a higher maturity level. In several cases, the comments relate to maturity levels which are not considered within the targets. The PRB concludes that the standardisation oversight team is supportive of the revised EoSM based on the CANSO SoE. The EASA team will consult with the standardisation oversight team when developing a revised EoSM to avoid unrealistically onerous requirements and to assist in defining requirements at the appropriate maturity level.

30. For the Network Manager, it is expected that the RP4 EoSM will also be more challenging than the current one. This means that while the EoSM in RP4 will be better tailored to the specifics of the Network Manager, the Network Manager is likely to start RP4 at a lower level of maturity.

31. Table 2 presents a simulation of achieved maturity level of ANSPs in 2022 and the level planned by ANSPs in 2024 using the RP3 EoSM, reducing the maturity level by one level (following the assumption described above).

	Comparable maturity level in 2022 and 2024 (updated EoSM)		
Management Objective	Maturity	Achieved 2022	Expected 2024
Safety culture	A	5	
	B	20	25
	C	11	11
	D		
Safety policy and objectives	A	4	
	B	25	29
	C	7	7
	D		
Safety risk management	A		
	B	18	
	C	18	36
	D		
Safety assurance	A	4	
	B	23	27
	C	9	9
	D		
Safety promotion	A	4	
	B	24	28
	C	8	8
	D		

Table 2 – Simulation of number of ANSPs reaching a specific Maturity level in 2022 and the planned level in 2024 assuming the application of the updated EoSM questionnaire (source: PRB elaboration).

2.4 Proposed targets

32. The targets for RP4 are defined considering the safety KPI being:

- A vehicle to improve the management of safety;
- A control mechanism for the impact from targets in the other KPAs;
- A control mechanism to manage the potential impact on safety from widespread implementation of changes to ATM functional systems;
- A support of the initiatives implemented by EASA under the EASA European Plan for Aviation Safety (EPAS); and
- A support to the progress ensuring regulatory compliance, namely with amendments to Regulation 2017/373.

Within each of these areas, there will be overlapping impacts.

Improved management of safety

33. The EoSM proposed by the EASA working group will include adjustments to the EoSM questionnaire to cater for recent developments in safety management thinking and practices and will support improvement of the management of safety.

Impact from other KPAs

34. The PRB priority for RP4 is environmental performance, which will need to be supported by greater capacity provision. With reference to the EASA safety working group on proposals for RP4 KPIs, and in particular the analysis related to interdependencies, the drive to achieve performance improvements in the environment and capacity KPAs may put pressure on established safety margins. In particular, some level of risk may emerge from changes to operating procedures in order to achieve KPA targets.

35. With respect to the setting of more demanding targets for other KPAs, targets using the improved EoSM would act as a control mechanism guarding against the potential impact on safety from changes implemented on a wider scale in the ATM functional system or in airport systems. Examples of wide-spread implementation of changes expected during RP4 are:

- Common Project 1 (System Wide Information Management (SWIM), Airport Safety Nets, Extended Arrival Management);
- Virtualisation;
- Digitalisation;
- Changes to Service Delivery Models;
- Dynamic Airspace Configuration; and
- Unmanned Aircraft Traffic System Management (UTM) & Unmanned Aerial Vehicles (UAV).

36. For these types of change, the regulatory approach should ensure that unacceptable risks at the ANSP level are not introduced. Nevertheless, the widespread implementation of many changes may be difficult to control and will require ANSPs to take actions such as strengthening and modernising the safety methodologies applied (adopting best practices), increasing the level of monitoring to detect degrading safety levels, and increasing the safety awareness by staff and stakeholders. The target setting for the Safety KPA should contribute to ensuring that the safety management systems of the ANSPs are improved to efficiently control the impact on safety, both during the transition of the changes and during the follow-on steady state operation.

37. The SDM provided a qualitative assessment of the potential safety benefits from the changes planned to be implemented during RP4 under CP1 (Annex IV of this report). The expectation is that, overall, the changes should support a reduction in the rate of occurrence of runway incursions and separation minima infringements. The SDM also notes that, "*without precise quantified justifications, the upmost importance of safety investments in the CP1 justifies that the target levels of safety should at least be maintained during RP4 like they were between 2014 and 2019*".

Impact of the Russian war of aggression

38. Russia's war of aggression against Ukraine is causing an increased pressure on safety management to alleviate the impact of changes caused by the war (e.g. diversion of traffic flows, increased operation of unmanned aerial vehicle and military flights, and increased cyber security risks). While it is not possible to predict the evolution of the conflict, ANSPs need to have an approach to safety management that is agile and adaptable to the impact of these changes and to effectively identify and control changes coming from the context in which the ANSP operates (change drivers). In this regard, the maturity of the safety management systems needs to continue to improve during RP4, in particular in safety risk management and safety assurance.

Initiatives from EASA's EPAS

39. The EASA RP4 safety indicator Working Group underlined the complementary nature of the performance scheme and the initiatives taken by EASA to address safety concerns. EASA Basic Regulation and the EPAS are the main instruments to manage and improve the safety of the aviation system in

Europe, including ATM/ANS.[5] Aviation safety is ensured not only through the application of minimum standards, but through a continuous cycle of challenging assumptions, investigating strengths and weaknesses and implementing system improvements. This cycle is the European safety risk management (SRM) process, and its output is the European Plan for Aviation Safety (EPAS). In this context, target setting complements the actions proposed under the EPAS. The PRB analysis of the EPAS 2022 – 2025 and the EPAS 2023 – 2026 identified the following actions (action number in brackets), which can be supported by the target setting and the revision of the EoSM questionnaire:

- Cyberattacks (SI-5017) (Amended Cybersecurity (SI-2013)); relating to the increase in cyberattacks that are associated with Russia's war of aggression against Ukraine. The proposed update of the EoSM will consider how to link safety and security, in particular related to safety risk management.
- Effectiveness of safety management system (SI-2026); aspects associated with the capability to detect and anticipate new emerging threats and associated challenges. The proposed update of the EoSM will increase the focus on adopting best practices to be used within the industry, carrying out comparative analyses, and assessing emerging risks (including disruptive technologies, drones, climate change, and urban mobility).
- New technologies and automation (SI-2015); addressing the relationship between humans and automation within the framework of a contemporary safety management system. The proposed update of the EoSM will increase focus on the human performance dimension of the safety management system.
- Understanding and monitoring system performance interdependencies (SI-2022); relating to the impact of external factors such as commercial pressure and demands associated with increasing capacity and environmental protection on the safety performance of ANSPs. The proposed update of the EoSM will consider this interdependency as a transversal area of the EoSM and strengthen the untargeted Management Objective of Interdependency already included in the RP3 EoSM.
- Flight route congestion (hotspots) (SI-5506) (New); covering potential increased ATCO workload and fatigue. The proposed update of the EoSM will increase the focus on human performance and fatigue-related risk management of the safety management system.
- Increased risk of airspace infringements by military unmanned aircraft systems (UAS), aircraft, or debris spilling over from conflict zones (SI-5515) (New) and other UAS related actions; aspects relating to airspace infringement by military UAS, increased presence of unresponsive and/or unidentified traffic and the unauthorised activity of drones in both take-off and approach paths of commercial airlines up to 5,000 ft. The pro-active nature of safety risk management and the increased involvement of relevant stakeholders in the safety management approach implemented by ANSPs under the improved EoSM will support this action.
- Reduced focus on, or prioritisation of safety (SI-5009). Using the Regulation and placing strengthened requirements on safety management through the improved EoSM and the associated targets should ensure that the necessary priorities and resources are allocated to safety performance.

40. The scope to address these areas is limited to their inclusion in the EoSM, where possible and appropriate.

Progressing regulatory compliance

41. The target setting should support the progress towards regulatory compliance on existing and proposed amendments to Regulation 2017/373,

[5] Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91.

which relate to management of safety. The EoSM shall, where possible and appropriate, reflect regulatory requirements and the target setting shall reflect the minimum maturity level corresponding to ANSPs being compliant with the requirements.

42. Nevertheless, the EoSM goes beyond the basic requirements contained within the SES implementing regulations and the ICAO Annex 19 framework and aims for a high level of safety performance. EoSM, its updates, and the target setting processes aim to move beyond simply complying with regulations by, in addition, focussing on continuous improvement.

Targets

43. The PRB and EASA jointly concluded that, to ensure that safety levels are retained and where possible improved, targets need to be set to ensure continued improvements of safety performance. The safety targets proposed for RP4 are shown in Table 3. The same targets are proposed for the Network Manager, using the specific RP4 EoSM.

RP4 EoSM targets	
Management Objectives	**2029 maturity levels**
Safety culture	C
Safety policy and objectives	C
Safety risk management	D
Safety assurance	C
Safety promotion	C
Interdependencies	No target

Table 3 – Union-wide Effectiveness of Safety Management targets.

3 ENVIRONMENT

3.1 *Introduction to the target setting*

44. To define the environment target ranges, the PRB has relied on four pieces of evidence:

- The historical horizontal flight efficiency (KEA) performance and targets;
- The European Route Network Improvement Plan (ERNIP) ATS Route Network (ARN) benefit estimates;
- The study on the interdependency between the capacity and environment KPAs;[6] and
- The estimated quantification of Russia's war of aggression on Ukraine (Annex III).

45. Each piece of evidence contributes to an element of the stepwise approach established to propose a range for the RP4 environment targets.

3.2 *Evidence 1 – Analysis of historical KEA performance*

46. Since the adoption of KEA at the beginning of RP2, the KPI has remained relatively stable, with a series of decreases (improvements) and increases (deteriorations) against a background of increasing traffic levels. RP2 finished in 2019 with a KEA value of 2.84%, exceeding the target of 2.60% and being 0.01pp higher than at the start of the period. This was mainly attributable to high levels of delay.

47. The beginning of RP3 was marked by the COVID-19 pandemic, which led to low traffic and low delays. The latter enabled significant improvement in KEA and for targets to be met due to less congestion and fewer airspace restrictions. However, as traffic began to recover and delays increased, KEA followed a similar trend, exceeding target levels (Figure 4). Further deterioration to yearly KEA values was seen in 2022. This was driven by changes in traffic flows due to Russia's war of aggression against Ukraine combined with capacity provision not keeping pace with strong traffic recovery. This resulted in the targets being missed by a substantial margin in 2022.

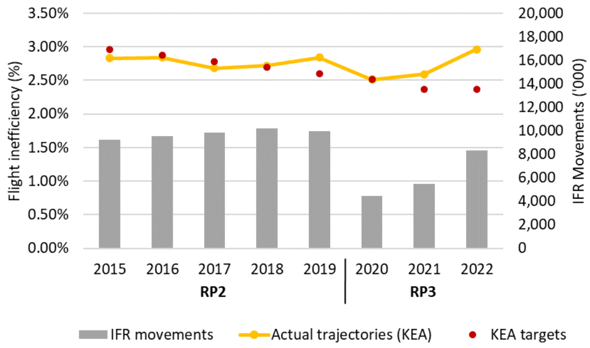

Figure 4 – Union-wide KEA performance and targets over RP2 and RP3 (source: PRB elaboration).

48. The analysis of Member State performance over RP2 and RP3 reveals a mixed evolution of local KEA values. While the methodology for measuring KEA is the same, comparing performance from one Member State to another can be challenging due to varying airspace characteristics (e.g. geographic layout, structure, traffic patterns, complexity, military activity, and ATM systems). Consideration of these characteristics are reflected in the reference values set out by the Network Manager in the European Route Network Improvement Plan (ERNIP). The relative evolution of each Member State's performance provides a better benchmark for progress. Table 4 (next page) shows the Compound Annual Growth Rate (CAGR) of each Member State for RP2 and RP3.[7]

49. Union-wide performance during RP2 achieved a CAGR of 1.3%, indicating a gradual deterioration of KEA during the reference period. In RP3, this increased to 8.6%, which represents the extent of degradations as a result of the combined traffic recovery and route extensions due to closures of Ukrainian, Belarusian, and Russian airspace to European traffic.

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[6] The interdependency between the environment and capacity KPIs of the performance and charging scheme of the Single European Sky (2023).

[7] $CAGR = \left(\frac{KEA\ final\ year}{KEA\ first\ year}\right)^{\frac{1}{number\ of\ years}} - 1$

Member State	RP2 KEA CAGR	RP3 KEA CAGR
Austria	+0.7%	+4.3%
Belgium	-0.4%	+2.3%
Bulgaria	+17.6%	+13.4%
Croatia	+4.2%	+0.7%
Cyprus	+21.3%	+4%
Czech Republic	+3%	+8.2%
Denmark	+1.1%	+4.8%
Estonia	+1.3%	+112.4%
Finland	+2.9%	+93.1%
France	-0.9%	+0.5%
Germany	+1.5%	+7.9%
Greece	+7.3%	-3.7%
Hungary	+4.1%	+19.9%
Ireland	-1.0%	+0.4%
Italy	-2.1%	+2.3%
Latvia	+3.4%	+124.7%
Lithuania	+4.7%	+153.5%
Malta	+16.3%	-13.3%
Netherlands	+1.3%	+7.5%
Poland	+3.4%	+69.4%
Portugal	+5.7%	-7.9%
Romania	+20%	+24.4%
Slovakia	+5.4%	+34.9%
Slovenia	+0.6%	+6.7%
Spain	-1.5%	+3.3%
Sweden	+1.6%	+28.5%
Switzerland	-2.3%	+3.5%
Norway	+6.5%	-6.8%
Union-wide	+1.3%	+8.6%

Table 4 –Union-wide and local CAGR of KEA values for RP2 (2015-2019) and RP3 (2020 to 2022) (source: PRB elaboration).

50. In RP2, Cyprus, Romania, Bulgaria, and Malta had notably higher (poorer) CAGRs than others. This is mainly due to shifts in the south-east traffic axis, airspace reservations, geopolitical issues and – in summer 2018 and 2019 – the results of the network measures to minimise delay by adjusting traffic flows.

51. Switzerland, Italy, and Spain had notably lower CAGRs, although the scale of these improvements (negative values) were much smaller than the overall degradations (positive values). This highlights how Member States struggled to improve environmental performance with increasing traffic and delays.

52. In RP3 (up to end 2022), the CAGRs of Lithuania, Latvia, Estonia, and Finland were very high. This is because these States had low KEA values in 2020 (achieving the local reference values) but have been severely affected by the closure of Belarusian airspace to European carriers in 2021 and the subsequent closure of Ukrainian and Russian airspaces in 2022 (further detailed in Evidence 4).

53. Malta, Portugal, Norway, and Greece are the only Member States that have a negative CAGR (improving KEA) for RP3 thus far. This is due in part to airspace improvements and low impacts to traffic flows from the situation in Ukraine. These Member States show that it is possible to improve environmental performance despite the traffic recovery.

54. While the Union-wide RP3 targets were missed in all but one year, performance values during rolling years ending March 2021 and April 2021 (Table 5) demonstrate that ambitious targets for those years, based on the range proposed for the end of RP3, were achievable when sufficient capacity was provided.

Rolling year ending	Union-wide KEA
31 January2021	2.47%
28 February 2021	2.42%
31 March 2021	2.41%
30 April 2021	2.41%
31 May 2021	2.43%

Table 5 – Union-wide KEA values for rolling years ending 31 January to 31 May 2021 (source: PRB elaboration).

55. Since then (2020), the route network has been significantly improved. In 2022, route extension due to airspace design (RTE-DES) reduced to 1.84% from 2.22% in December 2020, a reduction of 0.38 percentage points.[8] This reduction means that trajectories throughout the route network can be closer to the great circle distance than in the past. If capacity can match demand, flights can make use of the improved route network and improve KEA. Therefore, the proposed target ranges for 2029

[8] The indicator used to measure this is RTE-DES (the route extension due to airspace design), which is calculated by measuring the difference between the shortest route length (from TMA exit and entry points) and the great circle distance, disregarding the route availability document (RAD) and assuming all conditional routes (CDRs) are open.

build on the original ambition for the end of RP3 (2024):

- 2.40% upper bound; and
- 2.20% lower bound.

3.3 Evidence 2 – Estimated benefit defined in the ERNIP

56. The ERNIP is a rolling plan established and implemented by the Network Manager in coordination with Member States and the operational stakeholders. The objective of the ERNIP Part 2 - ARN Version 2022 - 2030 is to improve ATM capacity, flight efficiency and environmental performance.[9] Projects include the implementation of Free Route Airspace (FRA), ATS route network developments, re-sectorisation actions, actions aimed at simplifying the usage of the ATS route network and civil/military airspace structures.

57. The ERNIP provides a network-consolidated picture of network and local projects and the evaluation of their contribution to the European network performance targets and local environment reference values. As a result, the Network Manager states that the performance targets will be met if the proposed measures are implemented and if further improvements take place with respect to flight planning.

58. The ERNIP estimates that the projects scheduled for implementation by 2030 will reduce the inefficiency of route network design from 2.18% in December 2020 to approximately 1.80% by 2030. This is measured by the RTE-DES indicator.

59. RTE-DES is not the same as KEA as it is a theoretical value. In reality, route availability document (RAD) restrictions, conditional routes (CDRs), weather, and airspace user preferences can all contribute to the higher values seen in KEA measurements. However, as both indicators are based on horizontal flight efficiency (measuring deviation from the great circle distance), route network improvements that are captured by RTE-DES should support improvements in KEA. However, this improvement does not always materialise because airspace restrictions, weather, ATFM measures, and airspace user preferences can hinder the benefits expected from route network improvements. The ERNIP shows how RTE-DES has gradually reduced from 2.29% in 2018 to 1.88% in 2022 because of continuous improvements to the network, which support improvements in KEA.

60. Table 6 (next page) shows that much of the reduction in route design efficiency anticipated by 2030 will be achieved by the end of RP3. This reduction is mainly due to the benefits from the deployment of free route airspace (FRA) which was implemented in most of European airspace by the end of 2022, and those of cross border FRA due to be implemented by end of 2025 as per Commission Implementing Regulation 2021/116 (i.e. the CP1 Regulation). In proposing the target ranges, the PRB assumes that the RTE-DES will reach 1.84% by the end of RP3. This value is a forecast for the end of 2023, provided by the Network Manager, and represents the best estimate for a baseline at the time of writing.[10]

61. Following the ERNIP forecast for 2030, the benefits expected to materialise over RP4 would yield a 0.04pp reduction (improvement) to the KEA performance, providing a value for the upper bound of the target ranges. The Network Manager estimates that the minimum achievable RTE-DES is approximately 1.75%.[11] This value would be achievable with a new ERNIP in response to ambitious performance targets, which would recommend further investment and improvement in the route network in RP4. The PRB proposes this benchmark for the lower bound of the target ranges. The benefits expected to materialise over RP4 are estimated to yield a 0.09pp reduction (improvement) to the historical KEA performance, providing a value for the lower bound of the KEA target ranges.

[9] Network Operations Report 2022, Eurocontrol (2023).
[10] Estimates provided by Network Manager in bilateral discussions.
[11] Estimates provided by Network Manager in bilateral discussions.

Year	RTE-DES
2018	2.29%
2019	2.24%
2020	2.22%
2021	2.14%
2022	1.88%
2023 (forecast)	1.84%
2030 (ERNIP forecast)	1.80%
2030 (optimum achievable)	1.75%

Table 6 – Union-wide RTE-DES values per year (source: Network Operations Report 2022, and bilateral discussions between PRB and Network Manager).

62. The Network Manager expects a gradual ramp up of the above benefits over RP4. This is replicated in the upper and lower bound decreases to the KEA target ranges for each year of RP4, as shown in Table 7:

- For the upper bound ramp up, the PRB proposes no improvements in 2025, followed by a linear decrease of KEA by 0.01pp per year starting in 2026, totalling a 0.04 decrease at the end of RP4.
- For the lower bound ramp up, the PRB proposes an initial KEA decrease of 0.01pp in 2025, followed by a 0.02pp decrease per year starting in 2026, totalling a 0.09 decrease at the end of RP4.

63. Stronger improvements are proposed in both bounds starting from December 2025, as cross border FRA is due to be fully implemented by the end of 2025 as per the CP1 Regulation.

Year	Upper bound ramp up	Lower bound ramp up
2025	0pp	-0.01pp
2026	-0.01pp	-0.03pp
2027	-0.02pp	-0.05pp
2028	-0.03pp	-0.07pp
2029	-0.04pp	-0.09pp

Table 7 – Yearly KEA decrease based on assumed ramp up of ARN benefits for the upper and lower bound of the target ranges.

3.4 Evidence 3 – PRB study on the capacity and environment interdependencies

64. The lower traffic during the COVID-19 pandemic provided evidence that KEA decreases (improves) with sufficient capacity. While traffic was at historical lows in 2020, ANSPs had an abundance of capacity due to the unplanned nature of the pandemic. This is demonstrated in Evidence 1 (Table 5) by KEA values for rolling years ending February 2021 and March 2021, of 2.41% over these 12-month periods. KEA increased (degraded) from May 2021 as traffic recovered and delays increased.

65. The PRB report on the interdependency between the environment and capacity KPIs, published in June 2023, quantified the interdependency between the environmental and capacity key performance areas and analysed the factors influencing such interdependency.[12] The analysis conducted in the study demonstrates that high ATFM delays from various contributing factors have a negative impact on horizontal flight efficiency, proving the existence of an interdependency between the environment and capacity KPIs of the performance and charging scheme. Moreover, the level of impact on horizontal flight efficiency is found to relate to both the cause and location of the delay.

66. Statistical models were developed to investigate the influence of different delay variables on horizontal flight efficiency. The results show that an increase of one minute of average en route ATFM delay per flight causes an increase of 0.14 percentage points to horizontal flight efficiency.

[12] https://wikis.ec.europa.eu/display/eusinglesky/Latest+Developments?preview=/44148878/90279580/230606_The%20interdependency%20between%20the%20environment%20and%20capacity%20KPIs_published.pdf

67. The targets for RP4 must account for this interdependency. The capacity targets have to be sufficiently challenging to minimise the impact of delay and to support the PRB's focus on environmental performance. Hence, the PRB proposes to minimise adjustments to the environment targets by setting ambitious, but realistic, capacity targets.

68. The adjustments to the upper and lower bounds of the environment targets are based on the ambitious capacity target ranges for RP4 (next section), which are shown in Table 8.

Year	Upper bound CAP target and ENV adjustments	Lower bound CAP target and ENV adjustments
2025	0.50min/flight	0.41min/flight
	+0.07pp	+0.06pp
2026	0.50min/flight	0.38min/flight
	+0.07pp	+0.05pp
2027	0.50min/flight	0.35min/flight
	+0.07pp	+0.05pp
2028	0.40min/flight	0.33min/flight
	+0.06pp	+0.05pp
2029	0.40min/flight	0.31min/flight
	+0.06pp	+0.04pp

Table 8 – Yearly KEA adjustments for the upper and lower bound of the target ranges due to interdependency with capacity.

3.5 Evidence 4 – The impact on Union-wide KEA of Russia's war of aggression against Ukraine

69. In 2021, following the incident involving Ryanair Flight 4978, EASA Member States and the UK instructed aircraft operators with their principal place of business in their territories to cease operations in Belorussian airspace.[13] As a result of Russia's military aggression, in February 2022 Ukraine closed its airspace to civilian flights. As a consequence, the EU, Norway, Switzerland, and the UK, among others, put sanctions in place, closing their own airspace to Russian operated and owned aircraft. Russia soon implemented reciprocal measures.

70. As a result, Ukrainian, Belarusian, and Russian airspace is now fully closed to European traffic, meaning that flights previously flying over this airspace now need to take different, less direct routes, affecting KEA in multiple ways, notably:

- European flights to and from Asia, are now routing over Turkey and the Middle East, or north on polar routes via Alaska;
- Flights between Turkey and Russia continue, but are avoiding Ukraine, adding inefficiency to the Eastern SES and Baltic States;
- Belorussian and Russian flights to and from Kaliningrad are flying in SES airspace over the Baltic Sea, exercising freedom to fly over the high seas as per UN conventions;[14]
- International carriers still using Russian airspace are keeping further North, passing through Estonia and Latvia rather than Lithuania.

71. Considerable disruption has been caused to SES traffic flows and flight efficiency as a number of city pairs between SES States and the UK (overflying the SES) are, hence, considerably longer.

72. Eurocontrol estimates that this has led to a Union-wide KEA deterioration of approximately 0.24 percentage points. Annex III provides a detailed analysis of the calculations.

73. The analysis shows that not all Member States have been impacted, with the most affected seeing a year-on-year relative KEA increase of over 25% in 2022 (Table 9, next page). While it is not possible to predict the evolution of the conflict, when computing the local KEA reference values, the PRB will work closely with the Network Manager to ensure that any allowance for the impact of Ukraine is allocated to the Member States affected.

[13] EASA Safety Directive 2021-02.
[14] United Nations, Convention on the High Seas (1958).

Member State	Year-on-year KEA evolution In 2022
Finland	+326%
Lithuania	+306%
Latvia	+286%
Estonia	+282%
Poland	+106%
Slovakia	+76%
Sweden	+63%
Romania	+51%
Hungary	+32%
Bulgaria	+32%
Czech Republic	+26%

Table 9 – Member States most affected by route extensions due to Russia's war of aggression against Ukraine (source: PRB elaboration).

3.6 Combining the Evidence

74. The PRB proposes target ranges for 2029 that build on the original ambition for the end of RP3 (2024) (Evidence 1), while accounting for the benefits of recent and future improvements from ATM measures and ongoing updates to the European network (Evidence 2), for the interdependency between environment and capacity in the environmental target ranges (Evidence 3), and the impact of Russia's war of aggression against Ukraine (Evidence 4).

75. The four pieces of Evidence are combined to define the yearly target ranges of Union-wide KEA for RP4. The PRB priority for RP4 is to improve environmental performance, supported by the provision of sufficient capacity to meet demand.

76. The target ranges for 2029 are obtained following a stepwise approach. The PRB proposes to set the 2029 ambition starting from the target ranges as proposed for RP4 (Evidence 1):

- Upper bound 2029 (less ambitious): 2.40%; and
- Lower bound 2029: 2.20%.

77. The PRB proposes to factor in the benefits of recent and future improvements from ATM measures and ongoing updates to the European network, as shown in Evidence 2:

- Upper bound 2029: -0.04pp; and
- Lower bound 2029: -0.09pp.

78. The PRB proposes to adjust the KEA target ranges based on the interdependency with capacity, as described in Evidence 3:

- Upper bound 2029: +0.06pp; and
- Lower bound 2029: +0.04pp.

79. Considering Evidence 1, 2, and 3, the Union-wide KEA performance target range for 2029 provides a lower bound of 2.15% and an upper bound of 2.42%. The target ranges proposed are more ambitious than that for RP3.

80. While it is not possible to predict the evolution of the conflict, the PRB proposes to include the impact of Russia's war of aggression against Ukraine on KEA in both the upper and lower bound of the targets (+0.24pp in each year of RP4). However, when defining the local targets, the impact should only be considered for affected Member States (Evidence 4).

81. The resulting KEA ranges for 2029 adding the estimated impacts are:

- **Upper bound 2029 target range** (less ambitious): 2.42% + 0.24% = **2.66%**; and
- **Lower bound 2029 target range**: 2.15% + 0.24% = **2.39%**.

82. To set the target ranges for the years 2025-2028, the PRB proposes target ranges evolving based on the ramp up of ERNIP ARN improvement benefits (Evidence 2) and on the interdependency with capacity targets (Evidence 3) (Table 10, next page).

KEA (upper bound)	2025	2026	2027	2028	2029
Evidence 1 – Analysis of historical KEA performance (starting point)	*2.40%*	*2.40%*	*2.40%*	*2.40%*	*2.40%*
Evidence 2 – Estimated benefit defined in the ERNIP (yearly ramp up to -0.04pp)	*0pp*	*-0.01pp*	*-0.02pp*	*-0.03pp*	*-0.04pp*
Evidence 3 - PRB study on the capacity and environment interdependencies (yearly allowance for CAP targets)	*+0.07pp*	*+0.07pp*	*+0.07pp*	*+0.06pp*	*+0.06pp*
Evidence 4 - The impact on Union-wide KEA of Russia's war of aggression against Ukraine (flat allowance)	*+0.24pp*	*+0.24pp*	*+0.24pp*	*+0.24pp*	*+0.24pp*
Targets upper bound	2.71%	2.70%	2.69%	2.67%	2.66%

KEA (lower bound)	2025	2026	2027	2028	2029
Evidence 1 – Analysis of historical KEA performance (starting point)	*2.20%*	*2.20%*	*2.20%*	*2.20%*	*2.20%*
Evidence 2 – Estimated benefit defined in the ERNIP (yearly ramp up to -0.09pp)	*-0.01pp*	*-0.03pp*	*-0.05pp*	*-0.07pp*	*-0.09pp*
Evidence 3 - PRB study on the capacity and environment interdependencies (yearly allowance for CAP targets)	*+0.06pp*	*+0.05pp*	*+0.05pp*	*+0.05pp*	*+0.04pp*
Evidence 4 - The impact on Union-wide KEA of Russia's war of aggression against Ukraine (flat allowance)	*+0.24pp*	*+0.24pp*	*+0.24pp*	*+0.24pp*	*+0.24pp*
Targets lower bound	2.49%	2.46%	2.44%	2.42%	2.39%

Table 10 –Union-wide environment target ranges.

4 CAPACITY

4.1 *Introduction to the target setting*

83. To support the setting of the capacity target ranges, the PRB considered three pieces of Evidence:

- Historical capacity performance of ANSPs, especially focusing on delays with ATC capacity and ATC staffing reasons;
- Historical occurrence of non-ATC disruptions-related and adverse weather-related delays; and
- Capacity improvement plans included in the European Network Operations Plan 2023-2027 Edition April 2023 (NOP), the analysis conducted by the SESAR Deployment Manager on the expected benefits of the implementation of CP1 ATM functionalities, and the RP3 performance plans and monitoring reports submitted by the Member States.

84. The pieces of Evidence are analysed separately and then combined to form PRB's proposals for Union-wide RP4 target ranges for the average en route ATFM delay per flight.

4.2 *Evidence 1 – Historical capacity performance*

85. The PRB considers data on en route ATFM delays for the period of 2012-2022. During this period, the Union-wide target on average en route ATFM delays was only met in the two years affected by the COVID-19 pandemic: In 2020 and 2021.[15] In all other years, actual performance was consistently above the target level.

86. During the years of RP1 (2012-2014), the PRB notes that ANSPs were able to manage more IFR flights with significantly lower average delays than in 2022, almost achieving the 0.5 minutes per flight target. Figure 5 shows the capacity performance of the past ten years.

87. Despite ten years of capacity improvement measures and investments, it appears that ANSPs are offering less capacity than at the beginning of RP1. This suggests a clear lack of ambition and/or focus of ANSPs and it also shows that the 0.5 minutes per flight target is realistically achievable.

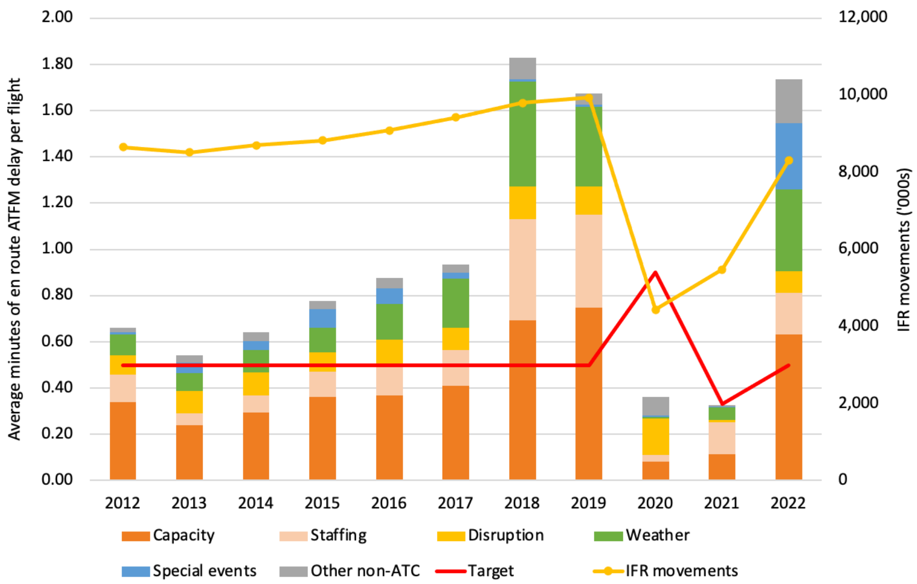

Figure 5 - Overview of the capacity performance of 2012-2022. The Union-wide capacity target was only met in 2020 and 2021, during the COVID-19 pandemic (source: PRB elaboration on data from AIU of Eurocontrol).

[15] For the years of RP1 (2012-2014) there was no binding capacity target defined at Union-wide level.

Analysis of delay reasons

88. When analysing the distribution of delays across the different delay reasons, ATC capacity and staffing are the two leading delay reasons. Despite the fact that these two delay reasons are under the direct influence of ANSPs, these types of delay have consistently increased since 2014, with the exception of 2020 and 2021. Resolving ATC capacity and staffing issues and thereby eliminating these delays (to the extent possible) would already result in a capacity performance close to or under the 0.5-minute-per-flight threshold.

89. In addition to ATC capacity and staffing, weather-related delays also increased during the observed period, being especially high in 2018, 2019, and 2022. These delays are analysed in detail in Evidence 2, together with non-ATC disruptions.

90. The results also show that en route ATFM delays in 2022 were impacted by the outbreak of Russia's war of aggression on Ukraine, in addition to some system transition projects which had strong network effects. This indicates that the level of delays in 2022 may have been higher than would normally be expected. Most of these impacts are reflected in the unusually high levels of delays related to special events and other non-ATC causes.

91. The impact on en route ATFM delays from Russia's war of aggression on Ukraine was most significant in the months following the outbreak of the war. During this period, military operations in the SES area ramped up, and civilian ANSPs had to adapt to the altered traffic flows and new complexities. Following this initial adaptation period, en route ATFM delays due to the impact of the war subsided.

92. The European Aviation Crisis Cell was activated in relation to the outbreak of the war between 24th February and 23rd May 2022. NSAs reported a total of 379,043 minutes of ATFM delay exclusively due to this exceptional event, which corresponds to a 0.05 minute per flight correction to the Unio-wide average en route ATFM delay per flight, resulting in an adjusted value of 1.69 minutes per flight.

Contribution of ANSPs

93. The analysis of the contribution of ANSPs to en route ATFM delays reveals that during the past ten years, most of the delays were generated by a relatively small number of ANSPs: On average, 66% of delays were generated by the top three contributing ANSPs, and some 77% generated by the top five contributing ANSPs. When considering only the average of the last five years, an even higher concentration ratio can be observed: 72% and 79% for the top three and top five contributors, respectively. The evolution of the concentration ratio of delays is shown in Figure 6.

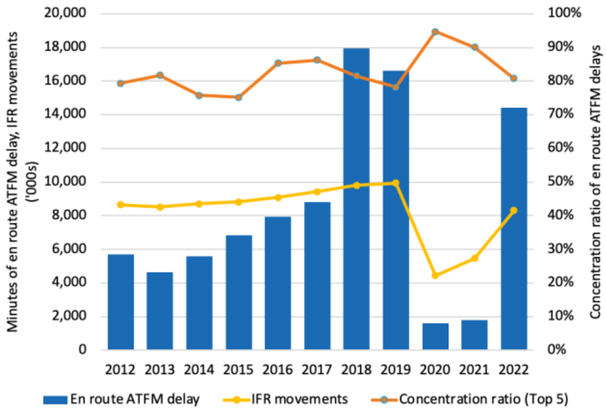

Figure 6 - Evolution of the top 5 concentration ratio of en route ATFM delays, showing that a relatively high share of delays has been generated by the five largest contributing ANSPs (source: PRB elaboration).

94. Table 11 (next page) shows the average contribution of ANSPs to en route ATFM delays during the past five and ten years. DSNA, DFS, and ENAIRE were the top three contributors in most years. Between 2012 and 2022, HASP, MUAC, and DCAC Cyprus also had contributions of at least 10% in one or more years. ANS CR, PANSA, and HungaroControl had outlier years when their contribution was significantly higher than their respective averages, but never higher than 10%.

ANSP	Average delay contribution past five years (ten years)
DSNA	36% (35%)
DFS	26% (21%)
ENAIRE	10% (10%)
HASP	4% (4%)
HungaroControl	3% (2%)
Austro Control	3% (2%)
MUAC	2% (5%)
Skyguide	2% (2%)
Croatia Control	2% (2%)
NAV Portugal	2% (3%)
ANS CR	2% (1%)
PANSA	2% (4%)
DCAC Cyprus	1% (5%)
Skeyes	1% (1%)
ENAV	1% (1%)

Table 11 - Average contribution of ANSPs to en route ATFM delays in the past five and ten years shown in brackets (source: PRB elaboration).

95. While the delay contribution of most ANSPs was relatively stable between 2012 and 2022, there were notable examples where ANSPs managed to significantly improve their capacity performance and eliminate most of their en route ATFM delays. Such examples are MUAC and DCAC Cyprus, both being able to reduce their contribution of delays from around 10% to 1-3% during the period. There were other ANSPs which managed to improve their performance and keep their contribution decreasing over time.

96. While the analysis of the contribution to en route ATFM delays shows an important aspect of capacity performance, it is noted that ANSPs with higher numbers of IFR movements would have a higher contribution to delays even if all ANSPs performed at the same average level. Therefore, it is important to analyse how the rank of each ANSP in delay contribution compares to its rank in relation to the number of IFR movements (Table 12).

97. Table 12 shows the difference between the rankings of each ANSP in delay contribution and the number of IFR movements. A positive number indicates that the delay contribution ranking of the ANSP is lower (i.e. it has lower delay contribution) than the IFR movements ranking. In other words, the delay contribution of the ANSP is lower than ANSPs with lower number of IFR movements. On the other hand, a negative number indicates that the contribution of delays for the ANSP is higher than that of ANSPs with less IFR movements.

98. There are no differences in the rankings of the top three contributors but there are several ANSPs where the rankings are significantly different. For ENAV, MUAC, Skyguide, and PANSA the delay contribution ranking is lower than the IFR movement ranking. For DCAC Cyprus, NAV Portugal, Croatia Control, skeyes, HASP, HungaroControl, and Austro Control, the figures are negative, indicating a higher delay contribution ranking than the respective IFR movement ranking.

99. Considering that ENAV, MUAC, and ENAIRE have a comparable number of IFR movements, and their delay contribution rankings are still highly different, the amount of IFR movements controlled cannot be an explanation for delay contribution.

ANSP	Rank difference
DSNA	0
DFS	0
ENAIRE	0
HASP	-4
HungaroControl (EC)	-4
Austro Control	-1
MUAC	3
Skyguide	2
Croatia Control	-5
NAV Portugal (Continental)	-6
ANS CR	-1
PANSA	1
DCAC Cyprus	-10
Skeyes	-5
ENAV	10

Table 12 - Difference between the rank of the ANSP in delay contribution and the number of IFR flights as average of the last 5 years) (source: PRB elaboration).

Sector-opening gaps and delays

100. In addition to an analysis of delay reasons and delay contribution, the PRB assessed how en route ATFM delays correlated with sector-opening gaps of ANSPs in 2022. For the calculation of the sector-opening gap, the maximum number of sectors that were open at the same time over the year

was calculated for each ACC. This value was compared to the daily maximum number of concurrent sectors. The difference between the two figures, expressed in the percentage of the yearly maximum number of sectors, is defined as sector-opening gap.[16]

101. The PRB measured the sector-opening gap for each ACC for each day in 2022 and aggregated the results to the level of ANSPs (the number of sectors and thus sector-opening gaps are additive). These ANSP level results were then compared with the daily en route ATFM delay minutes generated by the ANSP under the delay reasons ATC capacity and ATC staffing.[17] The maximum number of sectors an ANSP was able to open during a year indicates an important aspect of its realistic maximum capacity (or the maximum that was required to meet traffic demand). If delays occurred when the ANSP was not able to offer its yearly maximum number of sectors, it indicates issues in the pre-tactical planning and tactical execution of capacity provision, rather than general capacity constraints.

102. In addition to calculating the minutes of delays which occurred on days when the ANSPs had a sector-opening gap (sector-opening gap delays, SOG delays), the ratio of such delays (SOG ratio) within the total minutes of en route ATFM delay was also calculated for each ANSP for 2022. The SOG metrics can be interpreted as the amount (or the ratio) of delays that can be resolved or avoided in a relatively short time frame. In other words, delays could be resolved without requiring extensive investment or large-scale efforts in recruiting and training controllers.

103. Table 13 shows the results of the 2022 SOG metrics calculation per ANSP and at Union-wide level. There are significant differences in both the total SOG delay minutes and the SOG ratios of ANSPs. LFV had the highest SOG ratio in 2022, however the impact was negligible on the network level. On the other hand, DSNA had a relatively low SOG ratio of 26% but was a top contributor to total delays (see also previous section), and had the second-highest value of SOG delays.

104. At Union-wide level, 43% of all en route ATFM delays were identified as SOG delays (6.16 million minutes). These are the delays that could have been avoided if pre-tactical planning and tactical execution issues were resolved. Had these delays been avoided in 2022, the average en route ATFM delay per flight would have been 1.00 minutes per flight, instead of 1.74 minutes per flight. The PRB considers the delays which were not related to sector-opening gaps as base delays. Base delays may be associated with longer term issues, which require more time to be resolved. These are the delays which can be regarded as the basis for longer-term capacity improvement measures. Clearly, the level of base delay is an important factor in the setting of RP4 capacity targets.

ANSP	SOG delay minutes	2022 Total delay minutes	SOG ratio
DFS	3,269,616	5,634,773	58%
DSNA	1,137,622	4,342,492	26%
ENAIRE	410,527	598,463	69%
PANSA	341,227	799,668	43%
HungaroControl	271,377	480,956	56%
Croatia Control	267,769	407,715	66%
Skyguide	138,784	241,643	57%
ENAV	99,308	253,695	39%
HASP	85,390	138,090	62%
NAV Portugal	65,349	404,196	16%
Austro Control	33,699	78,166	43%
LFV	17,086	22,147	77%
MUAC	9,855	137,573	7%
ANS CR	8,039	798,202	1%
Avinor	1,492	3,266	46%
NAVIAIR	130	762	17%
Union-wide	6,157,270	14,454,970	43%

Table 13 – 2022 sector-opening gap (SOG) delays and ratio in total en route ATFM delays, ANSPs and Union-wide level. ANSPs without SOG delays are not shown (source: PRB elaboration).

[16] For example: If the maximum number of sectors on any day in the year was 10, than a day when the ACC only had 8 sectors open at the same time had a 20% sector-opening gap.

[17] Sector-opening data is based on the DDR AIRAC datasets. Daily en route ATFM delays are taken from the non-post-ops adjusted dataset of the AIU of Eurocontrol.

4.3 Evidence 2 – Delays related to non-ATC disruptions and adverse weather

105. Annex I point 3.1.(c) of Implementing Regulation (EC) 2019/317 stipulates that the capacity KPI of average en route ATFM delay per flight covers all IFR movements and all delay causes excluding exceptional events. This means that en route ATFM delays due to adverse weather and disruptions caused by non-ATC stakeholders (such as airports) are included in the calculation of the KPI.

106. As these delays have an impact on the functioning of the network, they are important aspects of Union-wide capacity performance but are not under the direct influence of ANSPs. For this reason, the PRB considers that an allowance for these delays should be included in the target ranges for capacity.

107. The PRB proposes to exclude from consideration the allowances related to events such as equipment failure or industrial actions at ANSPs. These factors fall within the remit of the management of the ANSP, and can be subject to management and improvement measures.

Allowance for delays due to non-ATC disruptions

108. The PRB calculates the allowance for non-ATC disruptions on the basis of the respective delay reason group. The non-ATC disruptions delay reason group includes five delay reason codes (Table 14).[18] These reasons are considered as exogenous factors from the perspective of the operation of the ANSPs and cannot be resolved through capacity improvement measures or specific investments.

Delay code	Main delay reason
A	Accident/incident
E	Non-ATC equipment failure
N	Non-ATC industrial action
O	Other reason
NA	Reason not specified/available

Table 14 - Delay codes included in the non-ATC disruptions delay reason group (source: AIU of Eurocontrol).

109. For the calculation of the allowance, the PRB considers the evolution of non-ATC disruptions from 2012 to 2022. The delays covered by this group can occur anywhere in the network and they are not attributable to any ANSP or Member State. Therefore, the analysis is only conducted at Union-wide level (Figure 7). While the level of such delays varies from one year to another, there appears to be an increasing level of volatility in the network due to non-ATC disruptions. The outlier value in 2022 is largely due to the impact of Russia's war of aggression on Ukraine (Figure 7).

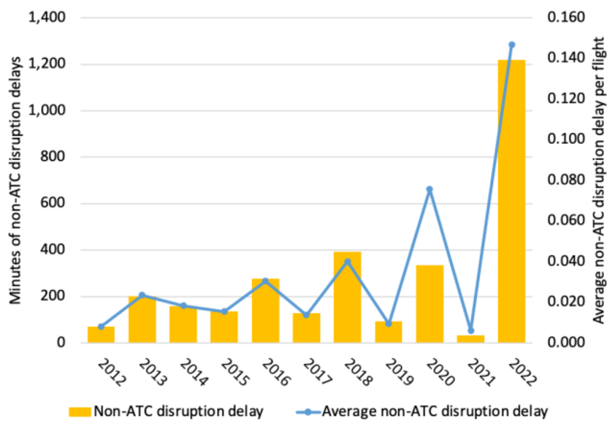

Figure 7 - Evolution of Union-wide non-ATC disruption en route ATFM delays between 2011 and 2022. The network was more volatile in later years (source: PRB elaboration on data from AIU of Eurocontrol).

110. The PRB considers that the delay allowance for non-ATC disruptions should reflect the expected value of such delays during the years of RP4. To this end, a range for the allowance is defined as follows:

- Non-ATC disruption allowance for the upper bound of target ranges is based on the overall average of non-ATC disruption delays per flight (i.e. average over entire period of 2012-2022). The value equals to 0.033 minutes per flight.
- Non-ATC disruption allowance for the lower bound of target ranges is based on the median value of the average non-ATC disruption delays per flight (i.e. median of the yearly averages). The value equals to 0.018 minutes per flight.

[18] The PRB uses the categorisation of the AIU of Eurocontrol as defined in the datasets published on http://ansperformance.eu/.

111. The PRB proposes to adjust downwards the allowance for the lower bound to 0.01 minutes per flight, as in six out of the ten years actual values were around 0.01 minutes per flight. In a similar way, the PRB proposes to adjust the allowance for the upper bound to 0.030 minutes per flight, noting that the average is highly affected by the outlier value of 2022 (without 2022, the overall average would be 0.022 minutes per flight). While it is not possible to predict the evolution of the conflict, this approach reflects the operational status considering the effects of Russia's war of aggression against Ukraine without inflating the allowance beyond a historically reasonable value. The allowance ranges are shown Table 15.

	Statistical value (min/flight)	Proposed value (min/flight)
Upper bound	0.033	0.030
Lower bound	0.018	0.010

Table 15 - Proposed allowance for non-ATC disruption delays (source: PRB elaboration).

Allowance for delays related to adverse weather

112. Weather phenomena such as thunderstorms, turbulence and icing may affect the level of capacity an ANSP is able to offer. When traffic demand is already high and ANSPs operate at or close to their maximum capacity, these weather phenomena can generate high en route ATFM delays. Similarly to non-ATC disruptions, weather phenomena are outside the remit of ANSPs, and while ANSPs might be able to increase their capacity to mitigate some of the impacts, delays due to adverse weather are inevitably part of the operation of the network.

113. In order to allow for such delays in the capacity target ranges, the PRB analysed the evolution of weather-related en route ATFM delays between 2012 and 2022. This analysis was performed at ANSP level, as weather phenomena tend to have a systematically different impact on the operations of ANSPs depending on their geographical locations.

114. Weather-related delays are captured under two delay codes: 'W' for weather and 'D' for de-icing.[19] The PRB analysed delays recorded under these codes for all ANSPs in the SES area during the past ten years.

115. The minimum/maximum values for each ANSP were calculated, as well as the average values over the entire period. DFS, Austro Control, DSNA, Croatia Control, and MUAC had the highest impact when looking at the average values of ten years. When considering only the past five years, the overall impact is much bigger and HungaroControl emerges as the ANSP with the fifth highest weather impact instead of MUAC.

116. The effects of climate change are apparent in the changes in frequency, duration, and location of severe weather phenomena, and this tendency is expected to worsen as global temperature rises. To reflect this scenario, the PRB proposes that allowance for weather-related delays for the upper bound of the target ranges is calculated on the basis of averages of the past five years, while for the lower bound on the basis of the entire period average.

117. In order to estimate the total minutes of en route ATFM delay due to adverse weather on the Union-wide level, the PRB projected both the ten-year and the five-year average values of each ANSP on the forecast IFR movements (STATFOR March base forecast) for the period of RP4. The values obtained were then divided by the forecast number of Union-wide IFR movements to calculate the Union-wide average weather delay allowance range.[20]

118. The result for the upper bound is 0.27 minutes per flight using the average of the past five years, while for the lower bound the result is 0.20 minutes per flight (based on the average of the ten years).The values estimated are in line with the calculations made by the Network Manager in the NOP for 2023 where the Network Manager estimated weather-related en route ATFM delays to be on average 0.22 minutes per flight. The summary of the analysis is shown in Table 16 (next page).

[19] The PRB uses the categorisation of the AIU of Eurocontrol as defined in the datasets published on http://ansperformance.eu/.
[20] Detailed calculations are not shown for the sake of brevity. They can be provided upon request to prb-office@prb.eusinglesky.eu.

119. The PRB proposes that 0.27 and 0.20 minutes per flight are used for the upper and lower bounds of the Union-wide target ranges.

ANSP	Minimum - Maximum	Average of last 10 years	Average of last 5 years
ANS CR	0 - 0.11	0.03	0.06
Austro Control	0 - 0.65	0.14	0.22
Avinor	0 - 0	0.00	0.00
BULATSA	0 - 0.01	0.00	0.00
Croatia Control	0 - 0.32	0.11	0.16
DCAC Cyprus	0 - 0.05	0.01	0.01
DFS	0 - 0.47	0.18	0.24
DSNA	0 - 0.33	0.12	0.16
EANS	0 - 0.02	0.00	0.00
ENAIRE	0 - 0.17	0.06	0.08
ENAV	0 - 0.14	0.02	0.04
Fintraffic ANS	0 - 0	0.00	0.00
HASP	0 - 0.06	0.01	0.02
HungaroControl	0 - 0.3	0.07	0.13
IAA	0 - 0	0.00	0.00
LFV	0 - 0.04	0.01	0.01
LGS	0 - 0.01	0.00	0.00
LPS	0 - 0.08	0.02	0.03
LVNL	0 - 0.03	0.02	0.02
MATS	0 - 0	0.00	0.00
MUAC	0 - 0.28	0.09	0.08
NAV Portugal	0 - 0.02	0.01	0.01
NAVIAIR	0 - 0	0.00	0.00
Oro Navigacija	0 - 0	0.00	0.00
PANSA	0 - 0.07	0.02	0.02
ROMATSA	0 - 0.08	0.01	0.02
skeyes	0 - 0.07	0.03	0.03
Skyguide	0.01 - 0.17	0.05	0.08
Slovenia Control	0 - 0	0.00	0.00

Table 16 - Analysis of weather-related en route ATFM delays for the period 2012-2022 (source: PRB elaboration on data from the AIU of Eurocontrol).

4.4 Evidence 3 – Capacity improvement plans

120. The third piece of Evidence considered by the PRB in the capacity KPA is collated from three different sources:

- The capacity improvement plans of ANSPs in the NOP;
- The calculation of the SESAR Deployment Manager regarding the capacity benefits of implementing the ATM functionalities included in the CP1 package; and
- The RP3 performance plans and monitoring reports submitted by the Member States.

Capacity improvement plans of ANSPs in the NOP

121. During the preparation of the NOP, the Network Manager and the ANSPs participate in an iterative Collaborative Decision-Making (CDM) process in order to plan and improve the future operation of the European ATM Network. In doing so, a set of capacity improvement measures for each ACC was defined, indicating the planned future sector-opening schemes. This serves as the basis for the Network Manager to calculate capacity profiles and delays forecasts.

122. The latest version of the NOP covers the period of 2023-2027 and only includes the first three years of RP4. Another limitation in the use of the NOP for target setting is that reference profiles (the capacity profiles required to meet the reference value for average en route ATFM delay for each ACC) are only calculated for 2023 and 2024, as these calculations are based on Union-wide targets for en route capacity and cannot be calculated prior to defining the targets. Nevertheless, the plans included in the NOP and the delay forecast are valuable information for establishing the target ranges for RP4.

123. For the definition of target ranges in the KPA of capacity for RP4, the PRB considered three key topics included in the NOP:

- The delay forecast for each ACC and for the network;
- The forecast growth of IFR movements for each ACC; and
- The capacity profile plans of each ACC and their relation to the reference profiles.

124. The NOP forecast of the network level delay is shown in Table 17. The forecast level of average delays is significantly higher than the RP3 Union-wide targets (for 2023, 2024, and 2025), but the figures show a 45% reduction in average delays per flight over the five years.

Average en route ATFM delay per flight				
2023	2024	2025	2026	2027
1.78	1.47	1.28	1.19	0.97

Table 17 - Delay forecast for the Eurocontrol NM area with estimations of industrial actions and technical failures inlcuded at the statistical level of 0.15 minutes per flight. 2023 value shown without NM measures (source: NOP 2023-2027 Edition April 2023).

125. The NOP also provides the forecast average en route ATFM delays per flight for each ACC for each year within the period of 2023-2027. In order to understand how each ACC would contribute to the Union-wide delay performance, these figures are projected on the ACC-level forecast of IFR movements for the same period. The NOP provides this forecast as a percentage growth compared to 2022. By combining the forecast average delay, the forecast traffic growth, and the actual number of IFR flights in 2022 for each ACC, the forecast number of en route ATFM delays can be calculated.

126. Figure 8 (next page) shows the resulting figures for the ACCs which have at least a 5% contribution to en route ATFM delays in one or more years between 2025 and 2027. The nine ACCs shown correspond to only six ANSPs, which is consistent with the analysis of Evidence 1 of the capacity KPA. The figure shows a significantly decreasing contribution from Karlsruhe UAC, and an emerging contribution from Brest and Bordeaux ACCs and Zürich ACC. The contributions of Bremen ACC, Budapest ACC, Vienna ACC, and Zagreb ACC show relatively small changes compared to the other top contributing ACCs. The calculation of the forecast delay minutes and the contributions to the Union-wide delay minutes is also in line with the analysis of delay concentration under Evidence 1 of the capacity KPA.

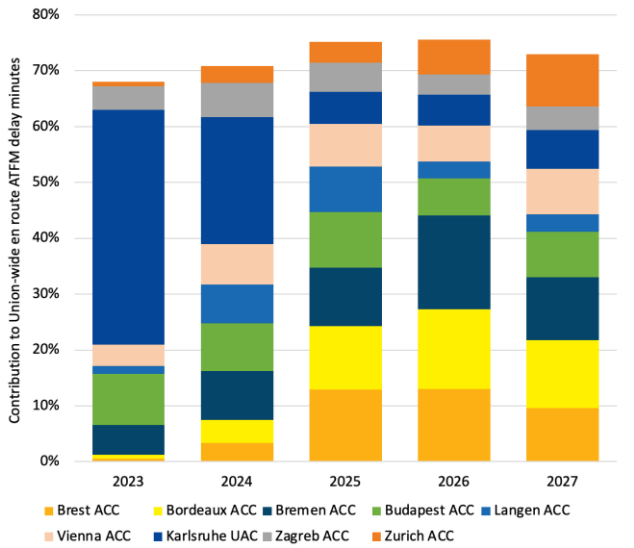

Figure 8 - Forecast contribution of ACCs to Union-wide en route ATFM delay minutes during 2023-2027. Source: PRB elaboration on NOP data. Only ACCs with a contribution greater than 5% in RP4 years are shown (source: PRB elaboration).

127. The PRB notes that these delay forecasts are based on measures which the ANSPs planned and committed to undertake during the preparation of the NOP. The example of Karlsruhe UAC shows that ANSPs are willing to commit to ambitious capacity improvement plans and to consider realistic a significant delay reduction over a relatively short period of time (i.e. two years). This is further emphasised by the example of Reims ACC, which was a top contributor of en route ATFM delays in previous years but is not included in Figure 8 following the transition to the new ATM system.

128. The forecast growth of traffic and the measures planned by the ANSPs to enhance capacity are combined in the NOP into capacity profiles. Capacity profiles are expressed as hourly movements in the airspace of the ACC, and are a metric for the theoretical maximum capacity an ACC is able to sustain over a longer period of time. Capacity profiles cannot be directly tied to delay figures or other indicators used for capacity measurements, as their calculation is based on a set of iterative simulations by the Network Manager. Despite this, capacity profiles are useful when analysing how ANSPs are planning to increase capacity, and how that increase compares to traffic growth.

129. The NOP contains the capacity profile plans of all ACCs in the SES area for the period of 2023-2027. During the last three years of RP4, ACCs are expected to increase their capacity on average by 2.4% to follow traffic growth and avoid capacity gaps. A detailed summary of the required capacity increase is shown in Table 18.

Required Y-o-Y increase	2025	2026	2027
Average	+3%	+2%	+2%
Minimum	0%	0%	0%
Maximum	+5%	+5%	+4%

Table 18 – Overview of the required year-on-year increase of capacity profiles of ACCs in the SES area between 2025-2027 (source: PRB elaboration on NOP data).

130. The highest required year-on-year increase of any ACC is +5% during 2025-2027, while the minimum requirement is 0% in all three years. For most of the ACCs, the required growth is between 2 and 3%, as shown in Figure 9.

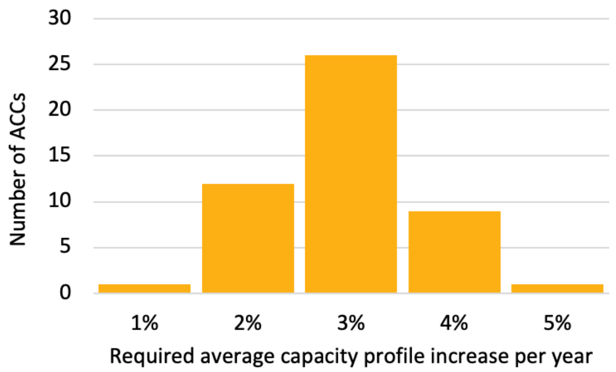

Figure 9 - The distribution of ACCs across their required average annual increase of capacity profiles. Most of the ACCs have a required average annual growth between 2-3% (source: PRB elaboration on NOP data).

131. The required average annual increase can be compared with the planned increase of the capacity profiles for each ACC. This comparison reveals that most ANSPs plan to improve their capacities to cope with traffic growth between 2025-2027. There are only nine ACCs out of the 49 in the SES area which consistently plan a lower increase than required by traffic growth. At the same time, these ACCs are forecast to have a significant capacity surplus in 2023 and 2024 which will cover the growth without resulting in a capacity gap. This indicates that if ANSPs can close existing capacity gaps by 2025, the forecast traffic growth should not require major step changes in capacity, but rather a steady improvement of performance.

132. The analysis of capacity profile plans and their comparison with the reference profiles (which are required to meet capacity targets) shows that there are 6 and 7 ACCs with a significant capacity gap in 2023 and 2024, respectively. All other ACCs have either a minor capacity gap (i.e. smaller than -5%), or have capacity profile plans which are aligned with or above the reference profiles. A more detailed view of capacity gaps and surpluses is shown in Table 19.

Capacity gap/surplus	2023	2024
<-10%	2	2
<-5%	4	5
<0	7	10
<5%	15	11
<10%	12	13
>=10%	9	8

Table 19 - Number of ACCs in each capacity gap/surplus category. A gap/surplus greater than 5% in absolute value is considered significant (source: PRB elaboration on NOP data).

133. These figures also confirm the analysis conducted under Evidence 1 of the capacity KPA, which found that significant capacity issues are concentrated in a small number of ACCs/ANSPs.

134. Reference profiles for RP4 are not calculated until the Union-wide capacity targets are set, therefore the NOP does not contain information on capacity gaps/surpluses for the years 2025-2027. Nevertheless, based on the gap/surplus information provided for 2024, the forecast traffic growth, and the increase planned by the ANSPs, it is possible to estimate if the planned capacity profiles will be sufficient to accommodate traffic growth. As shown in Table 20, the ACCs with the highest forecast contribution to en route ATFM delays between 2025 and 2027 are generally planning to significantly reduce their capacity gaps by 2027. Differently, out of the nine ACCs with a contribution greater than 5% in RP4, Brest and Bordeaux ACCs do not plan a significant reduction (although both ACCs plan to implement new systems at the end of the period), and Zürich ACC shows an increase in the capacity gap over the three years.

135. The PRB notes that these figures are based on the plans included in the current version of the NOP, and may be subject to revision by ANSPs in the coming years. However, the PRB considers it reasonable to assume that all the significant capacity gaps can be resolved at the latest by 2027, based on the current plans of the majority of the ACCs.

ACC	2025	2026	2027
Brest	-8%	-8%	-8%
Bordeaux	-9%	-9%	-8%
Bremen	-16%	-23%	-12%
Budapest	-9%	-6%	-4%
Langen	-7%	-3%	0%
Vienna	-6%	-4%	-4%
Karlsruhe	0%	3%	6%
Zagreb	-5%	-2%	-2%
Zurich	-4%	-6%	-8%

Table 20 – Estimated capacity gaps/surpluses of ACCs with the highest contribution to en route ATFM delays between 2025-2027 (source: PRB elaboration on NOP data).

Expected benefits of implementing CP1 functionality

136. The CP1 package includes a set of ATM functionalities that are expected to deliver significant benefits to the network in terms of capacity performance. The SESAR Deployment Manager (SDM) closely monitors the implementation of CP1 projects which have been funded by the European Union. As part of its planning and monitoring procedures, the SDM also calculates the expected benefits and monitors the actual benefits of each project in its portfolio. The results of these calculations are summarised in Annex IV of this report.

137. The SDM calculates the benefits of the projects as avoided minutes of ATFM delay or delay savings. The original estimation dating from 2015 has been updated to factor in the impact of the COVID-19 pandemic, which slowed the ramp-up of savings. The current calculation provided by the SDM estimates yearly delay savings in the range of 24-27 million minutes for RP4. These calculations are made against a theoretical 'do-nothing' scenario, and thus are not directly applicable to the delay forecast or other calculations performed within the target setting exercise. Nevertheless, the data provided by the SDM shows that the ATM functionalities included in the CP1 package should

deliver a significant improvement in capacity performance over the course of RP4.

138. Further to this, the PRB notes that the benefits estimated by the SDM are realised as network effects stemming from the synchronised implementation of the functionalities and as such are not factored into the capacity improvement plans of the ANSPs.

RP3 performance plans and monitoring reports of Member States

139. While the RP3 performance plans and monitoring reports are concerned with the period up to 2024, they provide information on the outlook for RP4 performance. The two most relevant aspects for the target ranges are the plans presented by the Member States in relation to the recruitment and training of air traffic controllers (ATCOs), and the ANSPs' capacity improvement measures.

140. The combination of all ATCO training plans included in performance plans shows that ANSPs are planning to have 8,402 ATCO FTEs working in operations by the end of 2024. This represents an annual average increase of +2% over RP3. If these plans are realised, this may serve as a solid basis for increasing capacity and reducing delays related to ATC capacity and staffing (i.e. SOG delays).

141. Further to recruiting and training ATCOs, ANSPs also plan to invest in new ATM functionalities and new ATM systems. Out of the 11 Member States that did not meet the 2022 local capacity targets, seven plan to upgrade/update their ATM systems in RP3. Moreover, in the NOP, almost all ACCs provided plans to further update their systems in RP4.

142. As shown by the recent system transition projects deployed at Reims ACC, Lisbon ACC, and Prague ACC, these measures can deliver a significant improvement in sector capacities, and thus enable a better capacity performance of the ANSPs. This indicates that ANSPs have a significant potential to improve their capacity performance and may be able to close the capacity gaps if the appropriate set of measures are defined and implemented in a timely manner.

143. With the implementation of new ATM systems and state-of-the-art data processing and data exchange functionalities, ANSPs should exploit the benefits of dynamic cross-border demand-capacity balancing solutions in order to alleviate the pressure on ATCO recruiting and training.

4.5 Combining the Evidence

144. The three pieces of Evidence in the capacity KPA are combined to obtain the proposed target ranges for the RP4 Union-wide target on average en route ATFM delay per flight. The overall priority for the target setting for RP4 in the capacity KPA is to ensure that capacity provision supports the delivery of the RP4 environmental targets, and that the European ATM Network can function efficiently without avoidable disruptions.

145. Evidence 1 demonstrates that the current capacity problems in the network can be associated with the local issues of a few ANSPs, and if these are resolved, network performance would improve significantly. Evidence 1 also shows that 45% of the delays experienced in 2022 were related to sector-opening gaps, and should be resolved without major, long-term measures. Finally, Evidence 1 also indicates that the current capacity targets are realistic and achievable despite the disappointing actual average Union-wide performance.

146. Evidence 2 defined the allowances to be included in the target ranges for the Union-wide capacity target with respect to delays which cannot be influenced by the ANSPs.

147. Evidence 3 defined the required and realistic levels of capacity improvement over the course of RP4.

148. Based on the above, the PRB proposes the target ranges for the Union-wide capacity target by combining the below three elements.

149. The proposed allowance for non-ATC disruption delays is 0.03 minutes per flight for the upper bound, and at 0.01 for the lower bound of the target ranges. The PRB proposes these allowances in each of year of RP4.

150. The proposed allowance for weather-related delays is at 0.27 minutes per flight for the upper bound of the targets, and at 0.20 minutes per

flight for the lower bound. The PRB proposes these allowances in each of year of RP4.

151. Based on Evidence 1 and 3, the PRB proposes to include a system resilience buffer defined as the amount of delay that may occur despite the best efforts of ANSPs due to unforeseen sudden local traffic growth or minor issues in the operations of ANSPs. The PRB expects ANSPs to resolve SOG delays by the end of RP3, and to address their remaining capacity issues by 2027 (i.e. within the timeframe of the current NOP). The proposal of the system resilience buffer is based on the assumption that these two expectations are met.

152. For the upper bounds of the target ranges, the PRB proposes a system resilience buffer constant and equal to 0.20 minutes per flight in for the first three years of RP4 (2025, 2026, 2027). The PRB proposes to reduce the system resilience buffer to 0.10 minutes per flight in 2028 and 2029, since ANSPs are expected to resolve their remaining capacity issues by 2027 and to deliver the benefits of the improvement measures in 2028 and 2029.

153. For the lower bound of the target ranges, the PRB proposes a gradual improvement in capacity performance. The PRB expects that the major capacity improvement measures planned by ANSPs will deliver more significant results in 2026 and 2027, and this will be followed by a more organic improvement. Therefore, the system resilience buffer starting at 0.20 minutes per flight in 2025 is proposed to decrease by -0.03 minutes per flight in 2026 and 2027 (i.e. 0.17 in 2026, 0.14 in 2027), and by -0.02 minutes per flight in 2028 and 2029 (i.e. 0.12 in 2028, 0.10 in 2029).

154. The PRB proposes not to include a delay allowance due to the impact of Russia's war of aggression on Ukraine. As presented in Evidence 1, the impact of the war subsided significantly after the first few months following the outbreak of the war, and Member States and ANSPs managed to adapt. While it is not possible to predict the evolution of the conflict, the PRB assumes that ANSPs will had sufficient time to implement any further measures that might be required to mitigate the impacts.

155. The resulting proposed target ranges for the Union-wide target on average en route ATFM delay per flight in RP4 is shown in Table 21.

En route ATFM delay minutes per flight	2025	2026	2027	2028	2029
Allowance for non-ATC disruption delay	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*
Allowance for weather-related delay	*0.27*	*0.27*	*0.27*	*0.27*	*0.27*
System resilience buffer	*0.20*	*0.20*	*0.20*	*0.10*	*0.10*
Targets upper bound	0.50	0.50	0.50	0.40	0.40

En route ATFM delay minutes per flight	2025	2026	2027	2028	2029
Allowance for non-ATC disruption delay	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*
Allowance for weather-related delay	*0.20*	*0.20*	*0.20*	*0.20*	*0.20*
System resilience buffer	*0.20*	*0.17*	*0.14*	*0.12*	*0.10*
Targets lower bound	0.41	0.38	0.35	0.33	0.31

Table 21 - Union-wide capacity target ranges.

5 COST-EFFICIENCY

5.1 *Introduction to the target setting*

156. To define the cost-efficiency target ranges, the PRB has relied on three pieces of Evidence:

- Member States costs forecast;
- PRB costs forecast; and
- Academic study on cost inefficiency (Annex II).

157. The pieces of Evidence are combined, and, after considering the PRB level of ambitions, are the basis for the definition of the baseline values, the Union-wide determined unit costs for RP4, and the related year-on-year targets range.

5.2 *Actual data analysis*

158. Between 2012 (the first year of RP1) and 2022 (the latest available data), total actual costs at Union-wide level remained relatively stable (i.e. -0.1% compound annual growth rate (CAGR)). In contrast, over the same ten-year period, total service units increased at an average of +1.3% CAGR. The combination of these two trends resulted, excluding 2020 and 2021, in a steady reduction in the actual unit cost at Union-wide level, which moved from an average of 70.12€$_{2022}$ in 2012, to an average of 61.38€$_{2022}$ in 2022 (-1.3% CAGR) (Table 22).

	2012	2022	CAGR
Actual costs (M€$_{2022}$)	6,699	6,652	-0.1%
Actual service units (M)	96	108	+1.3%
Actual unit cost (€$_{2022}$)	70.12	61.38	-1.3%

Table 22 - 2012-2022 actual costs, service units, and actual unit cost evolution (source: PRB elaboration).

159. In 2020 and 2021, as a result of the COVID-19 pandemic, the average actual unit costs increased well above the historical values. The unprecedented drop in traffic brought about by the pandemic resulted in a sharp increase in the average unit cost at Union-wide level in both 2020 (+127.26€$_{2022}$, or +128% compared to 2019) and in 2021 (+95.62€$_{2022}$, or +72% compared to 2019).

160. Across the 29 en route charging zones, actual costs evolved rather homogenously, ranging from a minimum of -2.5% CAGR reduction, recorded by Latvia, to a maximum of +3.2% CAGR increase for Bulgaria. All the largest charging zones, with the exceptions of France (+0.4% CAGR), experienced a moderate reduction in costs between 2012 and 2022.

161. The ten-year evolution in the number of service units presents a more varied picture, especially considering the impact brought by Russia's war of aggression against Ukraine, which hampered the post pandemic traffic recovery in certain areas. Specifically, while Member States such as Bulgaria (+6.7% CAGR), Hungary (+4.6% CAGR), and Greece (+3.9%) experienced, on average, a steady increase in service units over the last ten years, other Member States such as Estonia (-5.1% CAGR), Latvia (-4.1% CAGR), and Finland (-2.8% CAGR), recorded actual 2022 service units well below the 2012 levels.

162. ANSPs, which account for about 90% of the total cost-base, are the entities explaining the evolution of costs at Union-wide level. Over the 2012-2022 period, total ANSP costs remained stable (-0.01% CAGR). This is the result of two different trends: First a progressive increase in ANSPs' costs over the RP2 period, and then followed by a reduction in 2020 and in 2021. The reduction reflected the fact that many ANSPs implemented cost-cutting measures in response to the COVID-19 pandemic. In summary, the total 2022 ANSP costs fell to their initial 2012 level.

163. While both MET service providers and Eurocontrol reduced their costs consistently during the entire period (-1.9% CAGR, and -0.8% CAGR respectively), NSAs exhibited an increasing trend in costs continuing throughout RP2 and RP3 (+3.3% CAGR). However, the increase in NSA costs has had a negligible impact on the Union-wide trend, as they represent 1% of the total cost-base (Figure 10, next page).

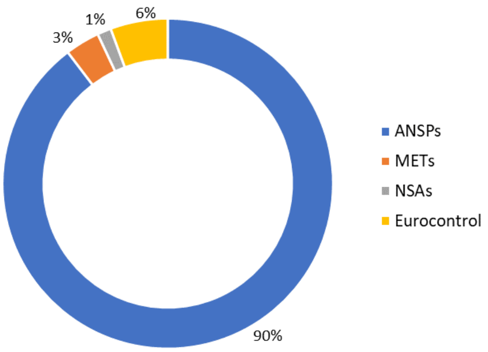

Figure 10 - 2012-2022 average proportion of costs across ANSPs, MET service providers, NSAs, and Eurocontrol (source: PRB elaboration).

164. In terms of cost categories, the analysis of actual 2012-2022 data shows the following (Figure 11):[21]

- Staff costs, which account on average for 64% of the total cost-base at Union-wide level, remained constant over the 2012-2022 period. The steady increase observed during RP2 (+4.2% between 2015 and 2019), was fully compensated by a strong reduction in both 2020 and 2021 (actual 2021 costs -8.4% below the 2019 actual costs).
- Other operating costs (on average, 22% of the total Union-wide costs) is the single cost category that consistently reduced over the last ten-year period. Actual 2022 other operating costs were -3.2% lower than in 2012 (-0.3% CAGR).
- Depreciation costs, which account for about 10% of the total costs, present a relatively stable trend over the 2012-2022 period (-0.1% CAGR). Towards the end of RP2 (2018-2019), depreciation costs recorded an increase over the 2012 value, which was subsequently compensated by a reduction in 2020 and 2021.
- Cost of capital is the category which presents the highest degree of variability (although the 2022 actual value remains close to the 2012 cost). The PRB notes that this is strongly influenced by the inconsistent reporting of cost of capital values by several ANSPs. This variability has a relatively minor impact on the overall trend, as the cost of capital represents some 4% of the total costs at Union-wide level.

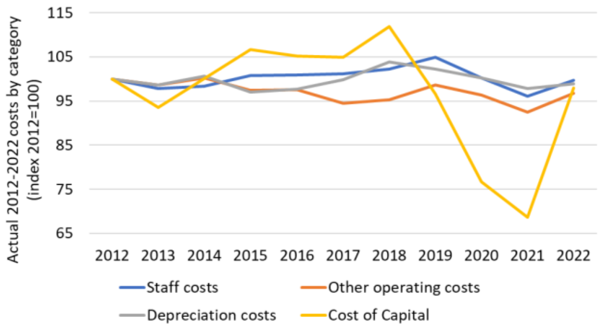

Figure 11 - 2012-2022 evolution of costs by category (index 100=2012) (source: PRB elaboration).

165. In addition to the cost evolution mentioned above, the PRB notes that, during both RP1 and RP2, actual costs were below their respective determined values, with ANSPs making the greatest contribution to this result. While during RP1 savings were mostly the result of lower staff costs, in RP2 the difference between actual and determined costs was largely due to lower other operating costs and depreciation costs.

166. Over RP2, ANSPs and METs achieved, at an aggregated level, a regulatory result (i.e. RR) of 2.9B€$_{2022}$ (on average, 0.6B€$_{2022}$ per year), which represents about 8.8% (ranging between a minimum of 7.4% in 2019 and a maximum of 10.1% in 2017) of the actual revenues generated over the same period.[22] In addition to the 1.5B€$_{2022}$ embedded in the actual return on equity (RoE), ANSPs and METs achieved a net gain from the en route activity of 1.4B€$_{2022}$ (0.7B€$_{2022}$ from the application of the cost sharing mechanism and 0.7B€$_{2022}$ related to the traffic risk sharing (TRS)). The impact of the financial incentives related to capacity is negligible (a total of 18M€$_{2022}$ of bonuses gained over the five years) (Figure 12, next page).

[21] The exceptional costs and the deduction of costs incurred for services provided to exempted VFR flights are excluded from the figure due to their negligible impact on the trend (less than 1%).

[22] The regulatory result corresponds to the revenues (or losses) generated by the activities of a specific year that exceed (or are lower than) the direct and indirect operating costs of an ANSP, and so provide for a reasonable return on assets to contribute towards necessary capital improvements. The regulatory results should be associated to a "margin" generated by the ANSPs with respect to the activity of the year but should not be considered or be compared to the financial profit/loss margin from financial statements as its calculation does not take account items such as taxes, capital expenditure, or dividend payments.

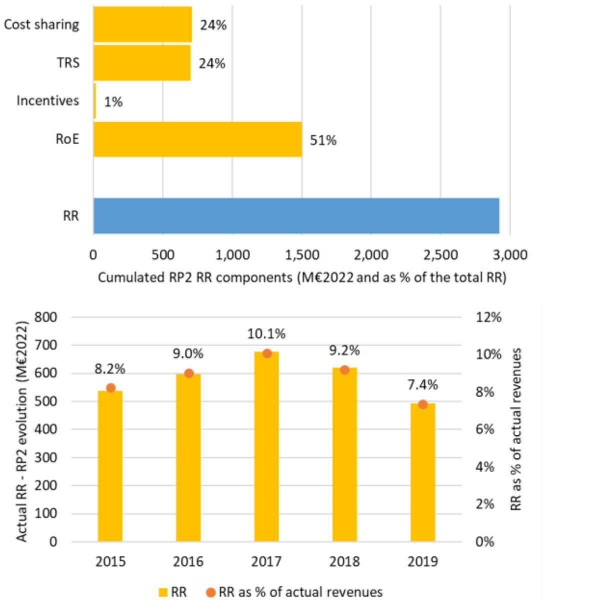

Figure 12 - Evolution of RP2 regulatory result and its components (M€$_{2022}$ and as % of actual revenues) (source: PRB elaboration).

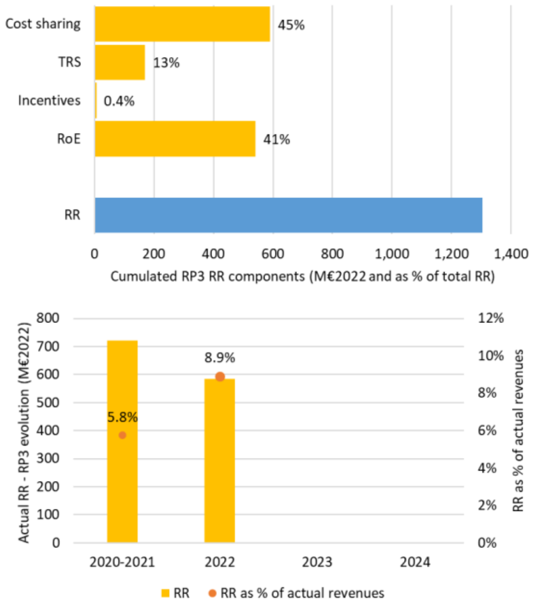

Figure 13 - Evolution of RP3 regulatory result and its components (M€$_{2022}$ and as % of actual revenues) (source: PRB elaboration).

167. The RP3 actual RR to date amounts to 1.3B€$_{2022}$ (i.e. 0.7B€$_{2022}$ for the combined year 2020-2021 and 0.6B€$_{2022}$ for 2022), which represent about 6.8% (5.8% for the combined year 2020-2021 and 8.9% in 2022) of the actual revenues collected over the three years. The most significant element contributing to the achieved RR is the net gains from the application of the cost sharing mechanism (0.6B€$_{2022}$), particularly influenced by the significant inflation adjustment recorded in 2022, followed by the embedded RoE in value (0.5B€$_{2022}$) (Figure 13).

5.3 Evidence 1 – Member States costs forecast

168. As defined by the Regulation, the NSAs are requested to provide the Commission, no later than 19 months before the start of a reference period, initial cost data and information about traffic related to the upcoming reference period, as inputs for the setting of Union-wide performance targets. This section presents the aggregation of the data submitted in June 2023 by the NSAs.

169. In some instances, data sets provided by the NSAs were missing key elements needed for proper aggregation at system level and the PRB had to make some assumptions to complete the data set. The summary of the PRB assumptions is provided in Table 23 (next page).

Charging zones	Missing data	PRB adjustment
Norway	Complementary information on the cost of capital for the ANSP	Assumptions: 10.8% RoE, 2.95% interest on debt, 40% share of financing through equity.
Ireland	Complementary information on the cost of capital for the ANSP	Assumptions: 100% share of financing through equity.
Netherlands	Complementary information on the cost of capital for the ANSP	Assumptions: 50% share of financing through equity.
Malta	Missing Eurocontrol costs	Eurocontrol costs forecast 2024-2029 dated May 2023.
	Inflation rates and index	IMF forecast dated April 2023.
	Complementary information on the cost of capital for the ANSP	Assumptions: 8% RoE, 2% interest on debt, 98% share of financing through equity.
Czech Republic	MET provider inflation index	IMF forecast dated April 2023.
Denmark	MET provider inflation index	IMF forecast dated April 2023.
Slovakia	Missing Eurocontrol costs	Eurocontrol costs forecast 2024-2029 dated May 2023.

Table 23 – Adjustments/corrections made to the revised initial data for RP4 received by the NSAs (source: PRB elaboration).

170. The unit costs derived from the initial data submitted (i.e. costs, inflation rates, traffic forecast) by the NSAs increase from 54.08€$_{2022}$ in 2024 (the last year of RP3) to 55.96€$_{2022}$ in 2029, the last year of RP4 (Table 24).[23]

171. Compared to the 2022 actuals, the unit costs as submitted by the Member States are lower for each year of RP4 (Figure 14).

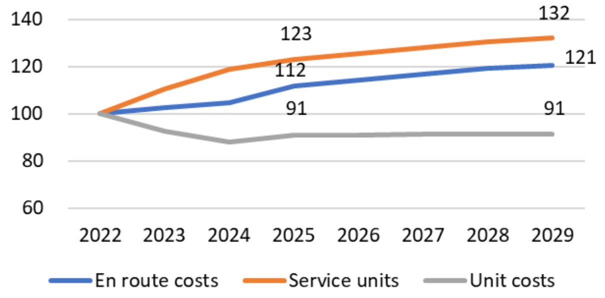

Figure 14 - Member States forecasts, index 100 in 2022. (source: PRB elaboration).

172. To evaluate the robustness of the initial RP4 data provided by the Member States, the PRB has analysed the difference between the initial RP3 data, as provided in December 2020 ahead of the draft revised performance plan process, and the determined data included in the RP3 draft revised performance plans:[24]

- In terms of costs, the initial data provided by the Member States present a trend consistently above the determined costs from the RP3 performance plans. This gap, which amounted to 250M€$_{2022}$ in 2020, widened to reach 565M€$_{2022}$ (+7.3%) in 2024 (Figure 15, next page).
- In terms of traffic forecast, the 2024 determined service units included in the adopted revised RP3 plans are expected to be +10.6% above the value originally forecast in the initial RP3 data submission for 2024.

	Union-wide en route costs – States submission (M€$_{2022}$)						CAGR 2024-2029
	2024	2025	2026	2027	2028	2029	
Costs (M€$_{2022}$)	6,959	7,433	7,603	7,774	7,932	8,023	+2.9%
Service units (M)	129	133	136	139	141	143	+2.2%
Unit costs (€$_{2022}$)	54.08	55.85	55.87	56.05	56.13	55.96	+0.7%

Table 24 – Aggregation of Member States forecasts (source: PRB elaboration).

[23] Values are including the PRB adjustments specified in Table 23.

[24] A similar analysis has been conducted also in respect of the initial data provided in the context of the original RP3 target setting process, which led to the submission of RP3 plans in autumn 2019. However, considering that the original RP3 assessment process was halted because of the COVID-19 outbreak at the beginning of 2020, this analysis is considered as not representative.

173. As a result of these two different trends in both costs and service units between the initial RP3 data and the RP3 performance plans, the initial forecast 2024 DUC at Union-wide level (65.82€$_{2022}$) was +16% higher than the RP3 performance plans (55.16€$_{2022}$). This indicates that the initial cost data was overestimated by Member States, while traffic expectations were still strongly affected by the uncertainty concerning the post-COVID recovery.

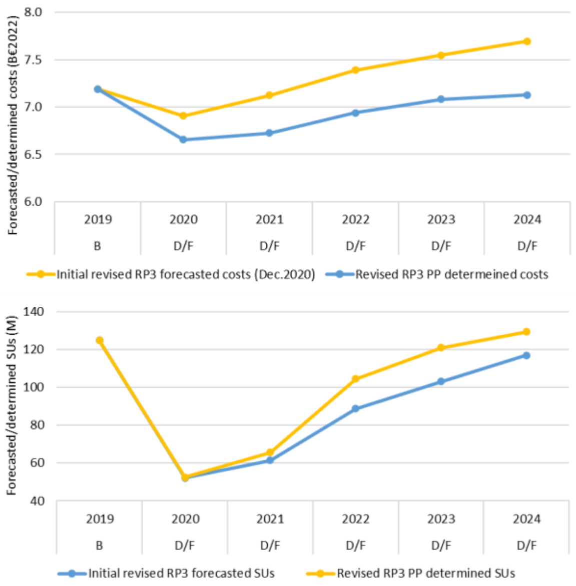

Figure 15 – Comparison between initial revised RP3 data and RP3 performance plans data for costs (figure above) and service units (figure below) (source: PRB elaboration).

Initial data for the remaining years of RP3 (2024 baseline)

174. The initial cost and traffic data reported for the two remaining years of RP3 (2023 and 2024) include a mix of determined and revised forecast data:

- In respect of the costs, Cyprus and Bulgaria have reported the determined costs from their RP3 performance plans at charging zone level in nominal terms but have associated them with a revised inflation forecast. It is also the case for the following entities: DFS (Germany), HASP (Greece) and LGS (Latvia) and some MET providers. This may have a impact on the level of the 2024 forecast costs, which could be artificially lower in real terms than they were in the performance plans. Belgium-Luxembourg have also reported the determined costs from their draft RP3 performance plans both in real and nominal terms, as reported with the inflation forecast associated with the determined costs.
- In respect of traffic, most Member States have reported service unit forecasts in line with the STATFOR March 2023 base forecast. In four charging zones, Member States have reported the determined service units from their RP3 performance plans (Belgium-Luxembourg, Cyprus, and Bulgaria for both 2023 and 2024, and Lithuania for 2023 only). For some, the initial data presents slightly higher services units than the STATFOR March 2023 base forecast, while in others it is the opposite. In three charging zones (Portugal, Finland, and Norway) the service units forecast has been revised for 2023 and 2024 compared to their performance plans but differs from the STATFOR March 2023 base forecast (while for the first two the initial data were slightly lower, for the latter the initial data was slightly higher). At Union-wide level, the difference between the Member States' initial data and the STATFOR March 2023 base forecast is negligible (-0.7% lower for each year).

175. Given the above, the PRB concludes that the 2024 aggregated unit cost as submitted by the Member States may be underestimated.

176. The 2024 forecast costs provided by the States are higher by +4.6% than the actual costs 2022 (+304M€$_{2022}$), while the forecast service units 2024 show an increase of +19% compared to 2022 actuals. This results in a forecast unit cost for 2024 which is significantly lower (-12%) than the actual unit cost 2022 (Table 25).

	2022	2024	Variation	CAGR
Costs (M€$_{2022}$)	6,652	6,959	+4.6%	+2.3%
Service units (M)	108	129	+19%	+9.0%
Unit costs (€$_{2022}$)	61.38	54.08	-12%	-6.1%

Table 25 – Aggregation of Member States cost forecasts 2024 vs 2022 actuals (source: PRB elaboration).

177. The main contributors to the increase in costs (+304M€$_{2022}$) are: Romania (+55M€$_{2022}$), the Netherlands (+33M€$_{2022}$), Italy (+31M€$_{2022}$), Greece

(+30M€$_{2022}$), and Portugal (+28M€$_{2022}$), all of which also have significant increases in forecast service units (more than +15%). The 2024 forecast costs are lower than the 2022 actuals in four charging zones: Germany (-34M€$_{2022}$), Spain Continental (-16M€$_{2022}$), Sweden (-11M€$_{2022}$), and Spain Canarias (-5M€$_{2022}$), all of which had higher actual 2020 costs than planned in their performance plans.

178. In terms of service units, strong increases are forecast in all charging zones, ranging from +7% to +32% for the two-year period.

Initial data for RP4

179. The Member States were required to use the latest inflation forecast from IMF (April 2023) to compute their cost forecasts. All bar three complied. Of the three, Bulgaria and Italy used a local forecast (higher than the IMF April forecast) and Croatia used different figures (lower than the IMF April forecast), although it reported to have used the IMF April 2023 forecast.[25]

180. In respect of the traffic forecast, the Member States were required to use the latest available base forecast from STATFOR (March 2023). All of them did, except for Bulgaria which used a local forecast (higher than the STATFOR March 2023 base forecast).[26] For Germany, the STATFOR figure includes service units for flight segments performed as Operational Air Traffic, which are then deducted for the setting of the cost-efficiency targets and unit rates.[27] At Union-wide level, the difference between the Member States initial traffic data and the STATFOR March 2023 base forecast is negligible (+0.4% in 2029).

181. Overall, over RP4, the forecast unit cost shows a slight increase by +3.5% (or by +0.7% per year on average), as costs are forecast to increase by +15% over the period (or +2.9% per year on average), while the number of service units is forecast to increase by +11% (or +2.2% per year on average) (Table 26).

	2024	2029	Variation	CAGR
Costs (M€$_{2022}$)	6,959	8,023	+15%	+2.9%
Service units (M)	129	143	+11%	+2.2%
Unit costs (€$_{2022}$)	54.08	55.96	+3.5%	+0.7%

Table 26 – Aggregation of Member States cost forecasts 2029 vs 2024 forecasts (source: PRB elaboration).

182. At local level, costs and service units are forecast to increase over RP4. In ten charging zones, the unit cost is forecast to decrease over RP4, as the estimated increase in service units outweighs the estimated increase in real en route costs. In the remaining 19 charging zones, the unit cost is forecast to increase over RP4, as the estimated increase in costs is greater than that for service units. The largest average annual increases in unit costs are observed in Romania (+8.3%), Latvia (+4.8%), Hungary (+4.1%), Germany (+3.5%), Estonia (+3.3%), and Poland (+2.5%).

183. The difference in costs between 2024 and 2029 forecasts amounts to +1,064M€$_{2022}$. The main contributors to this increase are: Germany (+267M€$_{2022}$), Romania (+175M€$_{2022}$), France (+84M€$_{2022}$), Poland (+54M€$_{2022}$), Bulgaria (+51M€$_{2022}$), the Netherlands (+39M€$_{2022}$), Italy (+39M€$_{2022}$), and Hungary (+37M€$_{2022}$). These eight charging zones account for 70% of the increase.

Analysis of the 2029 initial forecast data compared to the actual 2022 data (latest available actual data)

184. The aggregation of the initial cost data indicates an increase from 6,652M€$_{2022}$ in 2022 (the latest available actual data) to 8,023M€$_{2022}$ in the last year of RP4 (CAGR +2.7%), which is lower than the increase in service units forecast for the same period (CAGR +4.1%). This results in a decrease of -1.3% per year on average in the unit costs between 2022 and 2029 (Table 27, next page).

[25] For Bulgaria, higher by 5.1 pp by 2029. For Italy, higher by 1.4 pp by 2029. For Croatia, lower by -2.1 pp by 2029.
[26] For Bulgaria, higher by 12% by 2029.
[27] 152 thousand service units per year, representing around 1% of the total en route service units for Germany.

	2022	2029	Variation	CAGR
Costs (M€2022)	6,652	8,023	+21%	+2.7%
Service units (M)	108	143	+32%	+4.1%
Unit costs (€2022)	61.38	55.96	-9%	-1.3%

Table 27 – Aggregation of Member States cost forecasts 2029 vs 2022 actuals (source: PRB elaboration).

185. The increase in staff costs between 2022 actuals and 2029 forecasts (+733M€2022, or +17%) accounts for more than half of the total increase (Table 28). The increase in depreciation (+279M€2022, or +43%) and the cost of capital (+247M€2022, or +87%) account for nearly 40% of the total increase. Although some of the Member States' submissions provide some information on SESAR deployment costs and benefits expected for RP4, it is not clear to what extent these have been reflected in the overall Member States' forecasts at system level.

186. The aggregated RoE forecast for the main ANSPs in RP4, and included in the cost of capital, ranges from 5.1% in 2025 to 6.0% in 2029, a significant increase from the 3.0% applied for 2022 in the performance plans.

Costs (M€2022)	2022	2029	Variation	CAGR
Staff	4,271	5,005	+17%	+2.3%
Other operating	1,470	1,582	+8%	+1.1%
Depreciation	643	921	+43%	+5.3%
Cost of capital	283	530	+87%	+9.4%
Exceptional items	5	7	+44%	+5.3%
Exempted VFR	21	22	+7%	+1.0%
Total costs	**6,652**	**8,023**	**+21%**	**+2.7%**

Table 28– Aggregation of Member States cost forecasts by nature 2029 vs 2022 actuals (in M€2022) (source: PRB elaboration).

187. At local level, the unit costs show a decrease between 2022 actual and 2029 forecasts for 17 charging zones. The largest decrease is observed for Spain (Continental and Canarias), as costs are expected to be close to 2022 actual levels, despite an average annual increase in service units of +4-5%. (Figure 16, next page). For the other 12 charging zones, costs are forecast to increase more than the traffic in service units between 2022 and 2029. The most significant increase is reported by Romania, with a forecast average annual increase of +6%, due to an average increase in costs of +11% p.a., which exceeds the forecast traffic increase. This increase is principally due to a significant increase in staff costs by +121% over the 7-year period, or +12.0% p.a. on average, mainly due to the recruitment and training of ATCOs while the ageing ATCOs are only starting to retire. Romania indicates that "*there are no major operational or structural changes foreseen for RP4*".

188. At Union-wide level, the cost forecasts submitted by the Member States (+2.7% CAGR from 2022 actuals to 2029- forecasts) depart from the relatively stable costs observed between 2012 and 2022 despite significant traffic variations. The PRB analysis of the differences between the initial RP3 data and the current RP3 plans showed that the Member States overestimated the initial cost data by +7.3% by the end of RP3. The 2029 forecast costs from the Member States' submissions should be considered as the maximum cost envelope before considering any inefficiency gap reduction.

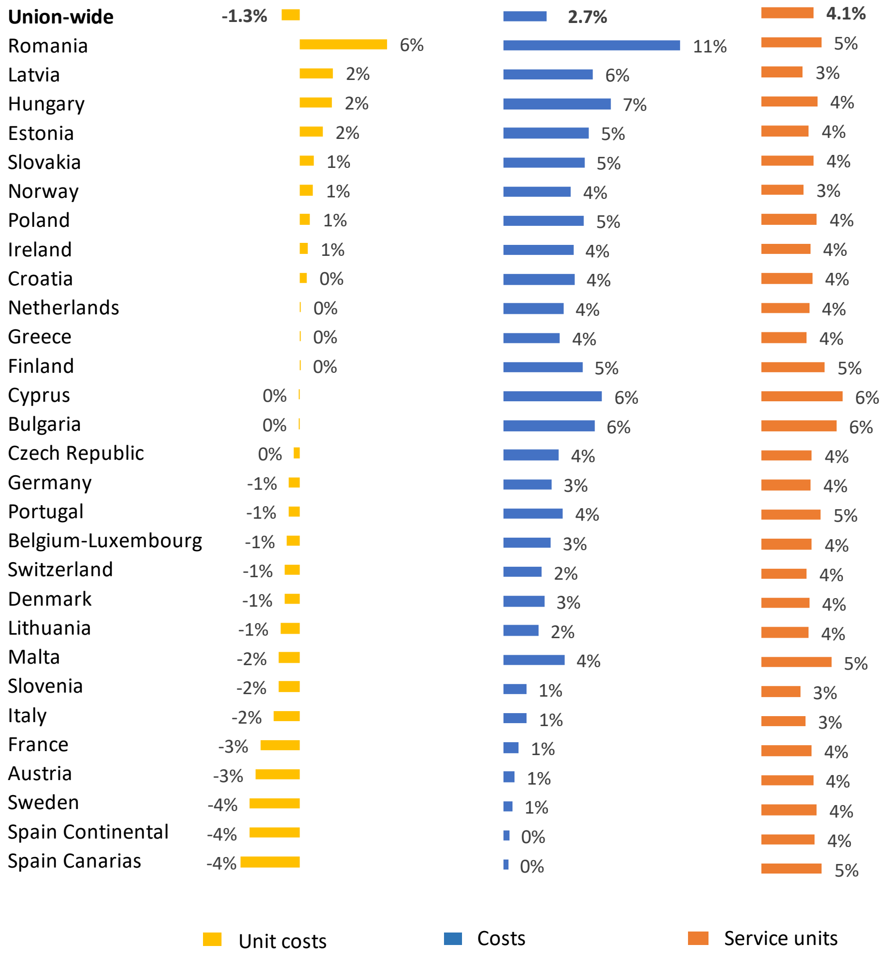

Figure 16- Member States forecasts, CAGR variations in unit costs, costs, and service units 2022-2029, per en route charging zone (source: PRB elaboration).

5.4 Evidence 2 – PRB costs forecast

Data and variables

189. The PRB cost forecasts are based on a statistical analysis of the historical actual costs. The level of observations are the charging zones considered for the period 2012 to 2019. The years from 2020 to 2022 have been excluded from the analysis; they are considered exceptional years, due to the impact of the pandemic. A total of 233 observations have been considered in the analysis.

190. The variables included and combined in different models are:

- Total real actual costs for each charging zone, excluding the exceptional items cost category, costs for exempted VFR flights, NSA and Eurocontrol costs;
- Real actual staff and other operating costs for each charging zone, excluding NSAs and Eurocontrol costs;
- Real actual depreciation and cost of capital for each charging zone, excluding NSAs and Eurocontrol costs;
- Actual IFR movements for each charging zone;
- Actual service units for each charging zone (in M3); and
- Actual sector opening hours for each charging zone.

191. All cost variables have been expressed in euros and converted in €$_{2022}$ real values following the Regulation rules. Inflation rate values are the annual average Consumer Price Index change (in percentage) published by the IMF in April 2023. The average 2022 exchange rates used for non-euro currencies are the average of the daily "Closing Rates" calculated by Reuters based on daily bid rates.

192. As the aim is to forecast Union-wide costs for the years 2024-2029, the models only include variables that can be forecast for this period. The PRB recognises that other variables (e.g. complexity, FTEs and flight hour controlled) may better explain the evolution of costs, however no reliable or complete forecasts for each year of RP4 are available.

Models

193. Two sets of models have been estimated:

- Set 1 includes as dependent variable the total costs in euros 2022 (without exceptional costs, cost for exempted VFR flights, NSA and Eurocontrol costs).
- Set 2 includes as dependent variable a decomposition of the actual costs, in euros 2022, in two sub-categories: Staff and other operating costs, and depreciation and cost of capital.

194. For each of the two sets, three models have been estimated considering as explanatory variables: (i) the service units, (ii) the IFR movements, (iii) the sector opening hours. The PRB has also estimated models including the squared value of the explanatory variables, a set of dummies to control for the size, time and locations. However, none of the approaches resulted in statistically significant results.

195. All the models have been estimated with fixed effects (i.e. the charging zone) applying a panel estimator (i.e. controlling for the time).[28] The fixed effect models explore the relationship between dependent and explanatory variables taking the individual characteristics of each entity into account (i.e. the charging zones). Characteristics not captured through specific variables are included in the estimation and quantified within the specific intercept value. All models consider the natural logarithm of the variables and have been tested for the standard statistical assumptions.

[28] Fixed effects vs Random effects have been tested with Hausman test.

196. The results of the models are shown in Table 29. The Set 1 models (based on service units and IFR movements) show a low but not negligible R^2 value. This means that despite the low predictive power of the variables, the models are retained for the forecast. Both service units and IFR movements show a positive and significant coefficient. An increase of 1% in service units is, on average, increasing the total costs by 0.33%, while an increase of 1% in IFR movements is, on average, increasing the total costs by 0.39%.[29] The Set 1 model (based on the sector opening hours) shows a negligible predictive power, and the coefficients estimated are not significant. Therefore, the model using sector opening hours as explanatory variable is discarded.

197. When analysing the Set 2 models, the results show that none of the variables are significant in the models with the dependent variable as depreciation and cost of capital (models with time lags have been estimated to consider the investment planning, but none of those show statistically significant results). Therefore, the Set 2 models have been discarded.

Forecast

198. The results obtained from the Set 1 models are applied to forecast the costs for the years 2024 to 2029. As the models considered data up to and including 2019, the underlying assumption is that the manner of operations for ANSPs during RP3 has not changed when compared to the previous years. Despite the significant decrease of traffic due to COVID-19 pandemic, it appears that ANSPs did not fully adapt and did not implement innovative or radical change within their operation. The results of the estimated models can be used for forecasting.

199. To forecast costs from 2024 to 2029, the forecasts for IFR movements and service units for each charging zone (STATFOR March 2023 base) have been applied to the coefficients resulting from the Set 1 models.[30] As the models are considering actual data up to and including 2019, any change in the costs resulting from a change of scope between RP2 and RP3 is not included in the results of the model. To correct for this, the adjustments of the cost base in the approved RP3 performance plans have been added to the costs for each year forecast.

		Set 1	Set 2	
	Variables	Total costs	Staff+other operating costs	Depreciation+cost of capital
Service Units	Ln(SUs)	0.33***	0.38***	0.07
	R^2	*0.19*	*0.23*	*0.00*
IFR movements	Ln(IFR_mov)	0.39***	0.45***	0.00
	R^2	*0.19*	*0.25*	*0.00*
Sector opening hours	Ln(Soh)	0.18***	0.20	0.09
	R^2	*0.04*	*0.05*	*0.00*

*Table 29 – Estimation of the two set of models. The models that are retained for the analysis are underlined. Significant levels: 1% ***, 5% **, 10% *.*

[29] The intercept values are not shown for the sake of brevity. They can be provided upon request to prb-office@prb.eusinglesky.eu.
[30] The STATFOR base forecast for Germany has been modified by deducting the OAT flights, 152,000 service unit for each year.

200. The actual total cost data used to estimate the Set 1 models does not include exceptional costs and costs for exempted VFR flights, NSA, and Eurocontrol. To account for these costs, the values as provided by the Member States in the initial data submission have been added to the forecast costs for each year.

201. The forecast Union-wide costs, applying the Set 1 models for service units and IFR movements and all the adjustments, are shown in Table 30. The two series of forecast costs are quite similar in each year; differing on average by 0.5% (i.e. 36M€$_{2022}$). The forecast Union-wide costs for 2024 are between 7,173M€$_{2022}$, and 7,206M€$_{2022}$, increasing to 7,471M€$_{2022}$ and 7,513M€$_{2022}$ in 2029, respectively (CAGR +0.8% for both the forecast).

202. The two forecasts at Union-wide level are relatively similar to the aggregation of the submissions of the Member States (Evidence 1). Both forecasts are 3% above the submissions of the Member States in 2024, and 7% below in 2029. The main differences, especially for 2029 are stemming from a small number of Member States, notably Belgium-Luxembourg, Bulgaria, Cyprus. Hungary, and Romania. These countries submitted the highest increase against the actual costs 2022 (Evidence 1).

	2024	2025	2026	2027	2028	2029
	Set 1 – Forecast based on service units (M€$_{2022}$)					
Model forecast	6,620	6,681	6,728	6,767	6,807	6,835
	Set 1 – Forecast based on IFR movements (M€$_{2022}$)					
Model forecast	6,588	6,649	6,694	6,732	6,770	6,793
	Costs as provided by Member States (M€$_{2022}$)					
Exceptional cost	-16	2	4	5	7	7
Exempted VFR cost	-22	-22	-22	-22	-22	-22
NSA ECTL costs	514	548	565	575	578	581
	RP3 baseline values adjustments (M€$_{2022}$)					
Baseline RP3	110	110	110	110	110	110
	Union-wide total cost RP4 forecasts (M€$_{2022}$)					
Forecast (SU based)	7,206	7,319	7,385	7,436	7,481	7,513
Forecast (IFR based)	7,173	7,287	7,351	7,400	7,444	7,471

Table 30 – Union-wide cost forecast based on Set 1 models results (Service units and IFR movement models). The forecast costs are expressed in real term and include the baseline adjustments of each of the Member States as for RP3 performance plans, and considers exceptional costs, exempted VFR costs, and NSA and Eurocontrol costs as submitted by the Member States.

5.5 Evidence 3 – Academic study on cost inefficiency

203. To identify the cost base inefficiency, the PRB commissioned a benchmarking study from a group of Academics (Annex II). The study developed and combined two benchmarking models which are well recognised in the scientific domain and are applied to regulated industries. One model is based on data envelopment analysis (DEA) and the other is based on stochastic frontier analysis (SFA). The models define the percentage of costs that an entity (i.e. the ANSPs) can reduce compared to the best performers.

204. The results show that the weighted average of inefficiency of the cost base is between the range of 11% to 21%, depending on the model applied. The study recommends applying a middle point of intervals to balance advantages and disadvantages of two modeling approaches, defining a 16% average Union-wide inefficiency.

205. The results are based on historical data (up to and including 2019). Despite the significant decrease of traffic due to the COVID-19 pandemic, ANSPs did not fully adapt their cost base and did not implement innovative or radical changes within their operation. On this basis, the PRB assumes that the estimated inefficiency in the cost base remained unchanged during RP3 (as highlighted in the historical data analysis), and that the results can be applied to the RP4 cost base.

206. Given that the RP4 priority for cost-efficiency is to facilitate the delivery of the capacity targets to achieve the environmental targets, the PRB proposes to recover a proportionate share of the inefficiency in the ANSPs cost base by the end of RP4. The PRB proposes to consider the average of 16% of inefficiency, and to recover 1/3 (5%) of it for the upper bound of the targets, while 2/3 (10%) of it for the lower bound of the targets. The inefficiency not recovered in RP4 should be considered as extra means to improve operational performances.

5.6 Combining the Evidence

207. The three cost-efficiency pieces of Evidence are combined to calculate the ranges of the year-on-year change of the Union-wide average determined unit cost. The RP4 priority for cost-efficiency is to facilitate the delivery of the capacity targets to achieve the environmental targets. The PRB proposes that this should be implemented while gradually improving the efficiency of the cost base. Accordingly, the yearly target ranges for cost-efficiency should be constant over the period. This allows for a gradual improvement as defined most adequate by the PRB.

208. To calculate the year-on-year change of the Union-wide determined unit cost, the PRB applies the CAGR (i.e. the average change) between the baseline values for 2024 (i.e. the starting point) and the determined unit costs for 2029 (i.e. the end point).[31]

209. All the calculations have been carried out to include all the digits and decimals. Values displayed in the tables (e.g. costs, service units) are rounded for the sake of readability.

2024 baseline values

210. As defined by the Regulation, both a Union-wide baseline value for the determined costs and a Union-wide baseline value for the determined unit costs should be defined in respect to the year preceding the start of the reference period (i.e. 2024). The PRB considered four baseline values, calculated by dividing the 2024 costs estimated in the evidences by the 2024 STATFOR base forecast.[32] The Member States' submissions for 2024 may have been underestimated for some, while for others the forecast costs are more accurate and reflect the latest available data.[33] In order to eliminate the bias of the underestimated data and capture at the same time the latest available costs

[31] The compounded annual growth rate (CAGR) is calculated following this formula $CAGR = \left(\frac{end\ point}{start\ point}\right)^{\left(\frac{1}{end\ year - start\ year}\right)} - 1.$

[32] As defined by Article 9 of the Regulation, to calculate the cost-efficiency targets the latest available STATFOR base forecast should be used.

[33] In particular for those Member States not having updated the 2024 nominal costs from the RP3 plans, while having updated upwards both the service units forecast and the inflation index.

forecasts, the PRB calculated a baseline based on the sum of the maximum costs per Member State (i.e. the maximum costs between Evidence 1 and 2 for each Member State separately). The summary of the baseline considered is presented in Table 31.

	2024 Costs (M€$_{2022}$)	2024 Service units (M)	2024 Unit cost (€$_{2022}$)
Evidence 1 – Member States submission	6,959	129	53.77
Evidence 2 – SU based forecast	7,206	129	55.68
Evidence 2 – IFR based forecast	7,173	129	55.42
Max of evidence 1 and 2	7,452	129	57.58

Table 31 – 2024 baseline values as estimated from the cost-efficiency evidence.

211. Considering the potential bias of each evidence, the PRB recommends, as 2024 baseline, the average between the four values estimated. The resulting 2024 unit cost baseline equals **55.61€$_{2022}$**.[34]

212. In advising the Commission on the cost-efficiency targets for RP4, the PRB proposes to revise the baseline values in light of the new traffic forecast, the new inflation forecast, the latest available information, and the outcomes of the stakeholder consultation.

2029 determined unit cost

213. The determined costs for 2029 have been estimated in Evidence 1 and 2 as follows:

- Evidence 1 - 2029 Union-wide costs: 8,023M€$_{2022}$;
- Evidence 2 SU based forecast – 2029 Union-wide costs: 7,512M€$_{2022}$; and
- Evidence 2 IFR based forecast - 2029 Union-wide costs: 7,471M€$_{2022}$.

For the calculation of the upper bound of the target ranges, the highest of the estimated values has been selected (i.e. 8,023M€$_{2022}$ from Evidence 1 – Member States submission). Using the highest end point allows for the calculation of the lowest, less ambitious year-on-year change. Conversely, for the calculation of the lower bound of the target ranges, the lowest of the estimated values has been selected (i.e. 7,471M€$_{2022}$ from Evidence 2 – IFR based forecast). Using the lowest end point allows for the calculation of more ambitious year-on-year change.

214. Evidence 3 provides information on the level of inefficiency in the ANSPs' cost bases (16% of the Union-wide cost base). In line with the priorities defined in the main report, the PRB proposes a gradual improvement in the cost-efficiency KPA, which in the less ambitious scenario should recover 5% of the inefficiency in the cost base by the end of RP4 (i.e. 1/3 of the estimated inefficiency), and the more ambitious scenario should recover 10% by the end of RP4 (i.e. 2/3 of the estimated inefficiency). Given that the cost inefficiency from Evidence 3 is estimated on the ANSPs costs, the percentage is applied only to a part of the cost base (i.e. NSAs and ECTL costs are not reduced). Dividing the resulting cost bases by the 2029 Union-wide service units as forecast by STATFOR base scenario, the 2029 unit costs for the upper and lower bounds of the targets are as in Table 32 (next page).[35]

215. As described in the main report, for both the upper and the lower bounds, the PRB proposal allows for the retention of certain inefficiencies in the ANSPs' cost bases. These amount to 746M€$_{2022}$ for the upper bound of the target ranges, and 345M€$_{2022}$ for the lower bound of the target ranges, in 2029. The PRB fully expects that Member States transform these cost inefficiencies into measures to demonstrably improve the

[34] The 2024 costs corresponding the unit cost baseline equals 7,198M€$_{2022}$.

[35] As defined by Article 9 of the Regulation, the latest available STATFOR base forecast should be used in order to calculate cost-efficiency targets.

operational performances leading to improved capacity and environmental outcomes.

Upper bound 2029	
Evidence 1 – 2029 Member States submission costs	8,023M€$_{2022}$
5% efficiency gain	-373M€$_{2022}$
2029 Union-wide costs	7,650M€$_{2022}$
2029 Service units (M)	143
2029 upper bound unit cost	**53.58€$_{2022}$**

Lower bound 2029	
Evidence 2 – 2029 IFR based forecast costs	7,471M€$_{2022}$
10% efficiency gain	-691M€$_{2022}$
2029 Union-wide costs	6,780M€$_{2022}$
2029 Service units (M)	143
2029 lower bound unit cost	**47.49€$_{2022}$**

Table 32 - Upper and lower bound 2029 unit cost.

Target ranges

216. To determine the target ranges, the 2024 baseline for the unit costs and the unit costs for 2029, for both the upper and lower bounds were included in the CAGR formula.

217. The target proposed as upper bound is a year-on-year decrease of the unit cost by -0.7%, while the target proposed as lower bound is a -3.1% year-on-year decrease (Table 33). The targets should be applied equally for each year of RP4.

Union-wide cost-efficiency target ranges					
2024 baseline	55.61€$_{2022}$ / 7,198M€$_{2022}$				
y-o-y change of Union-wide determined unit costs	2025	2026	2027	2028	2029
Targets upper bound	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%
Targets lower bound	-3.1%	-3.1%	-3.1%	-3.1%	-3.1%

Table 33 - Union-wide cost-efficiency target ranges.

Performance Review Body
Advice on the Union-wide target ranges for RP4

Annex II - Academic study on cost-efficiency

September 2023

Performance Review Body of the Single European Sky | Rue de la Fusée 96, Office 50.659, 1130 Brussels
Office Telephone: +32 (0)2 234 7824 | cathy.mannion@prb.eusinglesky.eu | prb-office@prb.eusinglesky.eu | wikis.ec.europa.eu/display/eusinglesky

Academic Group
Nicole Adler and Gianmaria Martini

Nicole Adler, Hebrew University of Jerusalem
Gianmaria Martini, University degli Studi di Bergamo

31 July 2023

Executive Summary

a. The cost efficiency of Air Navigation Service Providers (ANSPs) is an important element in the development of an efficient Single European Sky. Each ANSP serves an individual airspace and in so doing is a natural monopoly. Since there is little direct competition in the market, efficiency is not encouraged by sound competitive pressure.

b. Benchmarking can provide a useful substitute for such settings. Benchmarking allows to identify best practices, and if ANSPs are asked over time to adjust to best-practice levels, their cost efficiency will converge as if they are working in a competitive setting. Hence, instead of competing in the market, it is possible to create pseudo competition via benchmarking-based regulation, whereby the ANSPs compete via a model.

c. Two such benchmarking models are implemented and the results are subsequently combined. One is based on data envelopment analysis (DEA) and another on stochastic frontier analysis (SFA). They may be combined in different ways (minimum or maximum estimated scores or an average between the measures) and across different time periods in order to determine cost-efficiency targets.

d. The report analyzes en-route activities only rather than gate-to-gate provision. En-route provision has remained a monopolistic service provided by a single ANSP in each Member State (with the only exception being MUAC).

e. We present the Union-wide estimated efficiency scores after accounting for negative externalities (i.e., delays) and the operational environment (i.e., variability (seasonality), and complexity).

f. Union-wide, the DEA model presents estimated efficiency levels of approximately 79%, while the SFA model estimates efficiency levels of 89%. The weighted average therefore suggests potential efficiency levels of 84%.

g. We find that the ANSPs could save just under one billion euros annually by adjusting to best practices (based on the 2019 PPP-adjusted costs). However, there are substantial differences in potential cost saving levels across the individual ANSPs. It is therefore natural to work not only with a general cost reduction requirement that captures technological progress, but also to work with additional individual requirements encouraging the less efficient ANSPs to catch-up to best practices.

h. It is noteworthy that there seems to be a significant reduction in efficiency between RP1 (covering 2012 to 2014 inclusive) and RP2 (covering 2015 to 2019). Concerns are also raised over the reporting of capital expenditures, suggesting the possibility of some data manipulation or gaming, which presents a challenge for the regulatory authorities. In setting the x% savings target for the RP4 period, it is important to guarantee that the 1% annual cost efficiency improvements realized over the eight years analyzed is not negated in the process.

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1. Introduction

1.1. The task of the academic group (AG) is to provide advice to the Performance Review Body (PRB) on target setting for cost efficiency for Reference Period 4 (RP4, years 2025-2029).

1.2. The object of this document is to provide a report and a model to the PRB with meaningful and scientifically robust Union-wide targets on cost efficiency on a benchmarking of ANSPs from the efficient cost frontier based on proven models. These targets take into account the estimates of inefficiency provided by the AG.

1.3. The document reports the data analysis by the AG, the steps implemented to construct the variables for the empirical analyses, the models estimated to study the Union-wide efficiency of ANSPs, the descriptive statistics regarding the variables included in the empirical analyses, and the set of results assessing ANSP efficiency during the period of observation. Finally, we suggest a possible range of improvements relevant for RP4.

1.4. The Academic Group has been tasked with delivering a report and modeling methodologies to the PRB, offering scientifically robust benchmarking of ANSPs' cost efficiency.

2. Cost efficiency

2.1. The principle of cost efficiency is broadly employed in business management and regulatory agencies. Intuitively, the concept revolves around the capability of producing a specified volume of product or service at the lowest possible cost. This practice ensures that a company optimizes its resources and avoids wastage. In effect, any increase in costs implies expenses exceeding what is deemed necessary. For this reason, in the realm of business management, the objective of cost minimization is continuously monitored and assessed, utilizing a variety of tools.

2.2. The costs of a business are tied to the acquisition of factors necessary for the production of a good or service. Consequently, management strategies aim to monitor the costs by checking the utilization of production factors, also referred to as inputs, according to economic theory.

2.3. Inputs utilized by a company encompass a wide range of elements, including personnel, facilities, buildings, computers, energy, raw materials, etc. For purposes of simplification, economic theory generally groups them into two broad categories: labor and capital. Inputs that are exhausted after usage fall under the labor classification, for example an hour of work once performed is irrecoverable. The consumption of 10 kWh of electricity cannot be reused. Conversely, the capital category includes all inputs that are not immediately depleted upon usage. Examples of capital inputs include computers, buildings, plants, radars, etc. However, the capital goods will gradually become obsolete over time, necessitating maintenance or upgrades, and eventually replacement, for example with newer generation models over time.

2.4. In business management, monitoring is typically conducted using simple, easily calculable indices that are quickly updated. These are the key performance indicators (KPIs), which are usually calculated and monitored according to the two broad input categories described above.

2.5. In the context of the labor production factor, KPIs are typically calculated based on the product per employee, or the product per hour worked, etc. A similar process is undertaken, albeit less frequently, for the capital factor of production. A common KPI in this case is the volume of product produced per hour of use of the facility, or by the value of the fixed assets indicated in the financial statements. In terms of cost efficiency, a typical KPI is the labor cost per full-time equivalent employee.

2.6. While these KPIs are extensively utilized by managers, they do present an issue: they represent partial measures of efficiency. They concentrate on a single input and neglect the contribution of the other input to production. For example, one firm may have lower unit labor costs than another, thereby appearing more efficient. However, this may be attributable to a larger endowment of capital, which increases the volume of output, rather than higher worker productivity. If one also considers the capital endowment, it could reveal that the second firm is more efficient than the first.

2.7. For this reason, the correct measure for calculating cost efficiency is based on methods that take into account all production factors. In order to estimate whether an ANSP is carrying out the activity cost-effectively, a computational method is therefore needed that takes into account both categories of inputs, i.e., labor and capital, the volume of output that is produced, and whether this is achieved at minimum cost.

2.8. This method incorporates two dimensions: the costs of the company are determined by the expenditure on production factors, namely the cost of labor and the cost of capital. The first dimension therefore concerns whether the firm's labor and capital endowment are the minimum necessary to achieve a specific volume of output. In economic theory, this dimension is called technical efficiency, and is represented in Figure 1. The second dimension involves the optimal mix of labor and capital, according to their individual prices. This is referred to as cost efficiency, and is represented in Figure 2.

Technical efficiency

2.9. The initial step in determining technical efficiency is to establish the level of output. This is represented by the isoquant, which illustrates the combinations of labor (L) and capital (K) that could potentially be sufficient to produce the target level of production, such as the number of flight hours controlled in a year. The second step involves identifying the ANSPs position with respect to the isoquant. In Figure 1, two ANSPs are depicted, one with a black dot and the other with a red dot. The black dot lies on the isoquant, suggesting that the ANSP operates relatively efficient. Conversely, the red dot is located above the isoquant, indicating that the ANSP is producing the same number of controlled flight hours as the black dot ANSP but utilizes more labor and capital. This is indicative of technically inefficiency. The level of technical inefficiency may be estimated by the vertical segment projecting the red dot onto the isoquant.

Cost efficiency

2.10. The second step consists of estimating cost efficiency, as shown in Figure 1. In this figure, we depict three ANSPs as black, red and blue dots. The target level of production is identified by the isoquant (as in Figure 1), and an isocost function is also depicted. The isocost is depicted as a straight line, which represents all possible input combinations that yield the same cost. The gradient of the isocost function is determined by the cost of labor and the cost of capital, where the former is given by the price of labor times the amount of labor used by the ANSP, and the latter by the price of capital times the amount of capital available. Hence, cost efficiency takes into account the costs of the inputs.

2.11. In Figure 2, three isocost lines are illustrated, one in bold and two in dashed lines. The bold line, extending from the origin of the graph towards the top right, indicates the lowest cost, while the two dashed lines signify higher costs. Hence, the ANSP represented by the blue dot incurs the highest cost because the isocost line passing through it is the highest. The ANSP denoted by the black dot is cost-efficient for two reasons. First, it is technically efficient i.e., it lies ON the isoquant. Second, it operates at minimum cost because, given the price levels of the inputs (denoted by the slope of the isocost line), it employs the optimal combination of inputs to produce the target output, i.e., it is located on the isocost line tangent to the isoquant. The blue-dot ANSP is technically efficient, as it lies on the isoquant, meaning it is not using more inputs than necessary to meet the output target. However, it is not utilizing the best combination of inputs relative to their prices. The isocost line passing through the blue dot intersects the isoquant, indicating that this dashed-line isocost is higher than the bold one. Thus, the blue-dot ANSP is technically efficient but cost-inefficient, i.e., it is not operating at minimum costs. The measure of its cost inefficiency is indicated by the vertical segment in Figure 2. The red-dot ANSP is both technically and cost inefficient because it lies above the isoquant, and the isocost line passing through it is highest.

2.12. The definition of cost efficiency provided by economic theory implies that the ANSP selects the input mix (i.e., the combination of labor and capital) that yields the minimum expenditure for the required level of operations, given the current level of input prices.

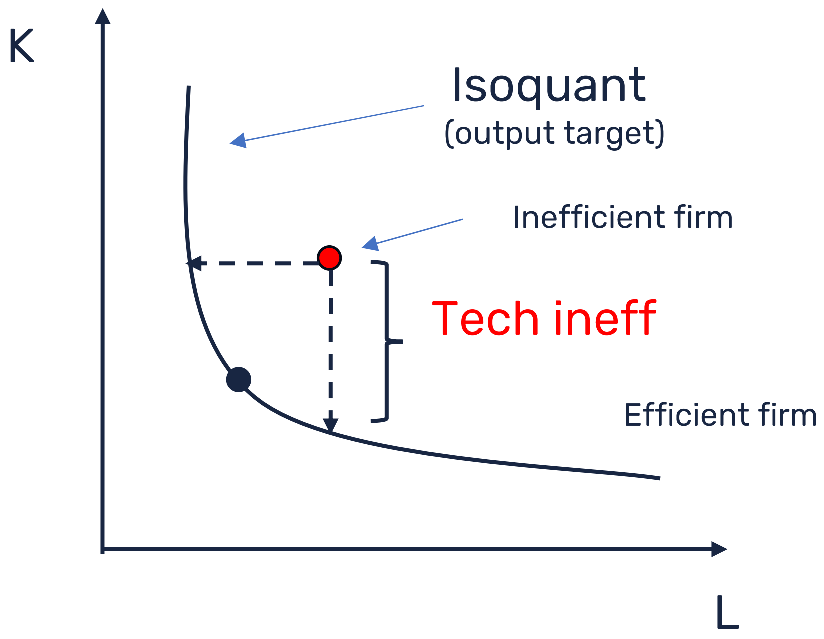

Figure 1 - Technical efficiency

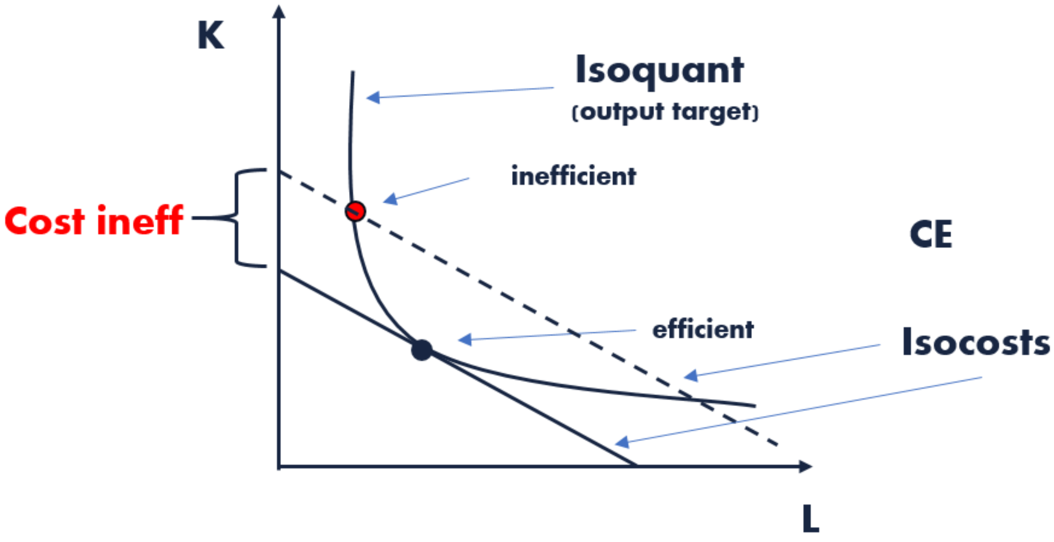

Figure 2 - Cost efficiency

From data to cost functions

2.13. Estimates of ANSP cost efficiency are obtained from the observed data, including input quantities, output, input prices and other factors that may influence the ability of the ANSPs to operate at the minimum level of costs, as depicted in Figure 3.

2.14. Operations may be influenced by exogenous factors that are beyond the control of management. Such factors include the possible presence of random shocks, such as striking air traffic controllers in another country or a volcanic eruption. Furthermore, non-random factors may impact the ability of management to minimize costs, such as seasonality which necessitates adequate staff and capital levels to handle peak traffic during specific periods of the year. Finally, the quality of management also influences costs, as it impacts the level of effort required to attain the minimum cost level. It is important to note that only this last component signifies true cost inefficiency.

2.15. The methodology outlined in Figure 3 is applied to the observed variables describing the ANSPs operations. Since these data points pertain to costs, they require standardization. This is necessary as costs are measured in different currencies and span various time periods that may be affected by inflation. Moreover, the purchasing power of different ANSPs must be considered due to variations in input prices across different countries.

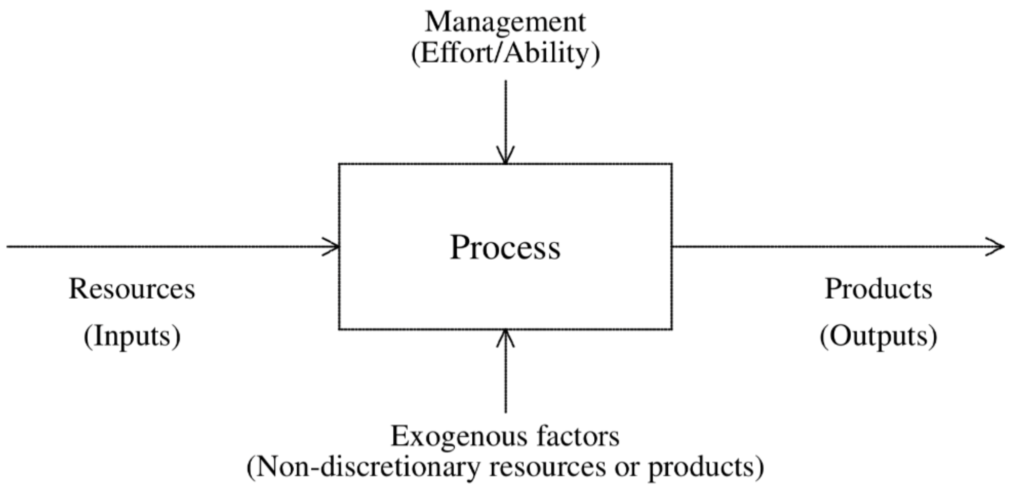

Figure 3 - Cost efficiency model

Regulatory benchmarking

2.16. The evaluation of cost-efficiency is a common objective in regulated sectors. In these sectors, public agencies regulate the market due to the potentially significant market power of a company. Regulated sectors are characterized by the presence of natural monopolies, i.e., single companies that control the entire market. ANSPs, in fact, are local natural monopolies. They are the sole organizations that control air traffic in a specific country or territory. In other sectors, such as electricity transmission, gas, water, telecommunications and transport networks, activities are typically concentrated in the hands of a small number of companies due to economies of scale. In these sectors, costs are characterized by a high proportion of fixed costs, leading to decreasing unit costs. By centralizing all activity within a single firm, the provision of various products or services are achieved at the lowest unit costs.

2.17. To prevent monopolies from reducing production and/or inflating prices due to the lack of competition, regulatory agencies oversee the costs of the company by defining supply prices, also known as tariffs. These regulatory bodies ensure that the tariffs cover production costs while also providing a reasonable return on invested capital. For the purposes of tariff setting, regulatory agencies need estimates of the levels of cost-efficiency of such natural monopolies. This is necessary for achieving two objectives. First, to establish tariffs that ensure a reasonable level of quality. Second, to incentivize cost-inefficient monopolies to exert effort towards achieving efficiency.

2.18. There are multiple regulatory methods, including cost-plus regulation, price cap regulation, yardstick competition and concessions through auctioning.

2.19. Cost-plus regulation is based on the idea that the regulated monopoly should only reach the break-even point where the regulated price (the tariff) is equal to the average costs (Alexander and Irwin, 1996). In this case the regulatory agency must know the economic costs of the monopolist, including the opportunity cost of capital invested. The regulation model is such that the tariff is computed by aggregating two elements: (1) the average monetary costs, observed from operations, and (2) a fair rate of return on the capital invested. The cost-plus method does not provide strong incentives toward cost efficiency. The management knows that any cost level will be covered by the tariff and has no strong incentive to reduce costs by cutting inefficiencies. Furthermore, increasing investments will also be covered by the tariff through the granted return on the capital. Hence, the cost-plus regulation model leads to over-investment.

2.20. Price cap regulation is a different approach in which the regulatory agency sets the price levels that the monopolist can charge over the next four to five years (Alexander and Irwin, 1996). The pattern of prices decreases over the subsequent years, providing the monopolist with an incentive to reduce its costs. Moreover, if the monopolist reduces costs beyond that defined by the regulatory body, it will gain profits. For example, if the price in a given year is 3% lower than the previous year, and the costs are decreasing by 5%, the 2% difference translates into an increased surplus for the monopolist. This perspective fosters efficiency and innovation incentives. However, there is a downside because the monopolist has an incentive to cut costs, which may lead to under-investment.

2.21. Yardstick competition is a price regulation scheme in which the regulated price established for a given firm is derived from the cost structure of similar firms operating in different niches (Shleifer, 1985). The approach requires extensive data and can be challenging to implement because identifying comparable benchmarks may prove difficult.

2.22. The final model of regulation is based on auctions. The regulatory agency grants the right to manage a sector for a specified period of time to the company that wins the auction based on the best bid. The auction can be designed in different ways, such as the English style (where the winner is the one who places the highest bid in an ascending order auction), the Dutch style (which is similar to the English auction, but with bids in descending order), the first-price sealed-bid (where the winner is the one who places the highest bid in a scenario where each firm places a single bid confidentially), and the second-price sealed-bid auction (Vickrey, 1961), in which the winner is the one with the highest bid but pays the second highest price offered. Concessions through auctions are typically implemented for long-term periods, such as 20 or 30 years. It is noteworthy that auctions are now being used at various airports across Europe for the selection of a terminal ANSP provider.

2.23. The regulatory model promoting cost efficiency in the Union-wide ANSP sector presently utilizes a price cap approach. This approach dictates an annual percentage of inefficiency that must be addressed. The incentive aspect of the ANSPs' regulatory framework sets a target for an annual percentage reduction in costs over the five year review period.

3. Empirical methods

3.1. Benchmarking methods, and in particular Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA), have become well-established and informative tools for economic regulation. DEA and SFA are now routinely used by European regulators to set reasonable revenue and price caps for energy transmission and distribution system operators for example. The application of benchmarking in regulation, however, requires specific steps in terms of data validation, model specification and outlier detection that are not systematically documented in open publications.

3.2. We note that the Performance Review Unit (PRU) of Eurocontrol has been collecting data systematically on ANSP services since 2002. Furthermore, since year 2012, Member States submit cost data to the European Commission as defined by the Single European Sky (SES) framework. Substantial work on data verification is undertaken, leading to the likelihood that the information for the timeframe analyzed (2012 to 2019 inclusive) should be reasonably reliable.

3.3. In this chapter, we explain the modern foundations for frontier-based regulation, and we discuss its use in the present project aimed at regulating en-route ANSP charges.

Benchmarking

3.4. In the business world, benchmarking is traditionally thought of as a managerial tool that helps improve performance by identifying and quantifying the impact of applying best documented practice. Managers compare the performance of their respective organizations, products and processes externally with competitors and best-in-class companies and internally with other operations within their own organizations that perform similar activities.

3.5. The idea of best practice is important. In benchmarking the idea is not to compare existing organizations to some theoretical ideal or green-field solution. Rather, the idea is to use best realized practice as the benchmark. This naturally implies that the benchmarking targets are achievable, relative to the comparators and evolving from the action of the firms. Consequently benchmarking in both models applied here are reasonably conservative since they estimate only relative efficiency.

Key Performance Indicators

3.6. Traditionally benchmarking focuses on key performance indicators (KPIs). KPIs are ratio numbers that are assumed to reflect the purpose of the ANSP in some essential way. KPIs are widely used by operators, shareholders, regulatory agencies, researchers and others with an interest in performance evaluation. Well-known KPIs are related to the analysis of financial accounts. They include indicators like Return on Investments (=net income/total assets), gross margin, etc.

3.7. Unfortunately, the use of KPIs has its limits. First, when we compare a small ANSP to a large ANSP on a ratio (say support staff cost per flight hour controlled), we implicitly assume that we can scale input and output proportionally. That is, we assume constant returns to scale. A second limitation of the KPI approach is that it typically involves only partial evaluations. One KPI seldom reflects the purpose of the ANSP. We may have multiple inputs and outputs and therefore form several output-input ratios each of which provides an incomplete representation of the ANSP. KPIs in this case do not account for substitution between inputs and between outputs.

3.8. A third limitation is that KPIs seldom capture the allocation properly. One ANSP may be better in all conceivable sub-processes and still be inferior by relying more on the relatively less efficient processes.

Model based

3.9. For these reasons, advanced benchmarking is model based. We try to account for multiple effects that may interact in complicated ways. To handle this, we use a systematic approach to the ANSP. An ANSP is seen as a transformation of multiple resources into multiple products and services. The transformation is affected by non-controllable factors as well as by non-observable skills deployed and efforts made within the organization. The idea is to measure the inputs, outputs and non-controllable factors and hereby to evaluate the managerial characteristics, like skills and effort. Note that in benchmarking, we usually think in economic production terms, and we refer to different performance dimensions as inputs and outputs. Non-controllable factors are also often thought of as special non-controllable inputs and outputs depending on whether they facilitate or complicate the production process.

Frontier methods

3.10. In the scientific literature, different state-of-the-art estimation techniques have been presented. The best-practice methods go under the name of frontier analysis methods, as they combine the best-practice observations to form a continuous frontier towards which any observation can be gauged. A taxonomy of these methods is illustrated in Table 1 below.

	Deterministic	Stochastic
Parametric	Corrected Ordinary Least Squares (COLS) Aigner and Chu (1968), Lovell (1993), Greene (1990, 2008)	Stochastic Frontier Analysis (SFA) Aigner et al. (1977), Battese and Coelli (1992), Coelli et al. (1998a)
Non-Parametric	Data Envelopment Analysis (DEA) Charnes et al.(1978), Deprins et al. (1984)	Stochastic Data Envelopment Analysis (SDEA) Land et al. (1993), Olesen and Petersen (1995), Fethi et al. (2001)

Table 1 - State of the art frontier methods

3.11. The different estimation methods used for benchmarking are basically suggestions for how to compare individual observations, as illustrated by the dots (ANSPs) in Figure 4 below, given the relationships between input costs and outputs.

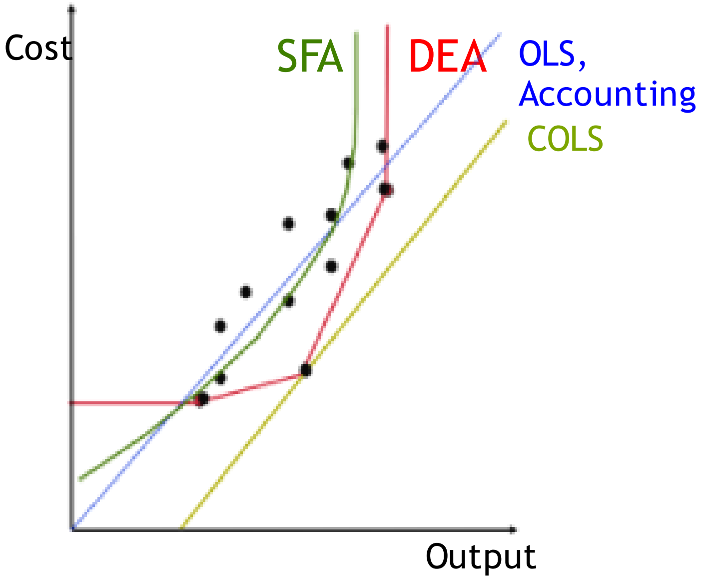

Figure 4 – Multiple estimation methods

3.12. The most frequently applied methods are Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) methods (see Bogetoft and Otto (2011) for a full review). Both approaches have their advantages and disadvantages. In this project, we therefore apply both.

Efficiency measures

3.13. The most frequently applied methods are Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) methods (see Bogetoft and Otto (2011) for a full review). Both approaches have their advantages and disadvantages. In this project, we therefore apply both.

$$Efficiency = \frac{Minimal\ cost}{Actual\ costs}$$

3.14. A cost efficiency measure of, for example, 90% suggests that the ANSP could have produced the same services spending only 90% of its real costs. In other words, there is a savings potential of 10% of the benchmarked cost.

3.15. The relationship to potential savings is illustrated in Figure 5.

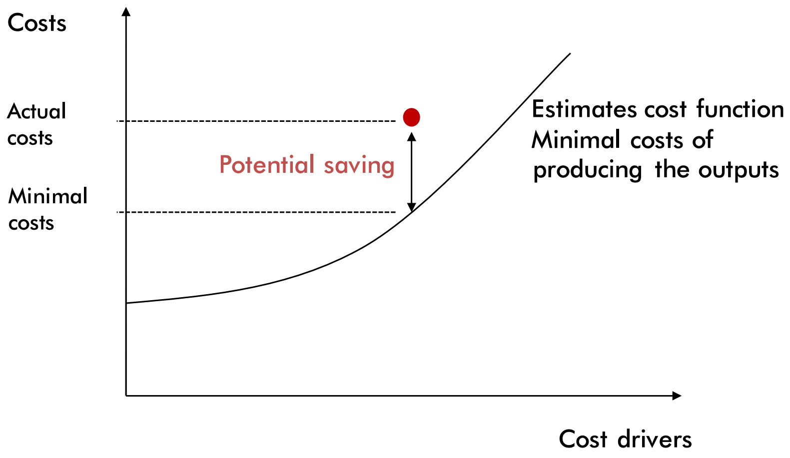

Figure 5 - Efficiency measurement

The benchmarking process

3.16. The development of a regulatory benchmarking model based on international comparisons is a considerable task due to the diversity of the ANSPs involved and the procedural constraints. In this section, we shall highlight some of the typical steps of a regulatory benchmarking analysis and we shall discuss what creates a good benchmarking model. Some of the important steps in a careful benchmarking exercise include the following.

3.17. Choice of variable standardizations: opting for appropriate accounting standards, cost allocation guidelines, inclusion/exclusion criteria, asset definitions, and operating standards is crucial to obtain a consistent data set from ANSPs with varied internal practices.

Choosing a good model

3.18. *Choice of variable aggregation*: Selection of aggregation parameters, such as interest and inflation rates, is necessary for determining standardized capital costs. Additionally, identifying relevant combined cost drivers, possibly through engineering information, helps streamline and reduce the complexity of pertinent data.

3.19. *Initial data cleaning*: Data collection is an iterative process where definitions are likely to be adjusted and refined and where data collected are constantly monitored by comparing simple KPIs across ANSPs and using more advanced econometric outlier detection methods.

3.20. *Average-cost model specification*: To complement expert and engineering model results, econometric model specification methods can be used to investigate which cost drivers / ANSP services best explain average cost. This can be useful to estimate the variability of the data, to validate the fit on the model specification to data and to determine how many cost drivers are necessary.

3.21. *Frontier model estimations*: To determine the relevant best practice model using DEA and SFA models, they must be estimated, evaluated and tested on full-scale data sets. The starting point is the cost drivers derived from the model specification stage, but the role and significance of these cost drivers is further examined in the frontier models, and alternative specifications derived from using alternative substitutes for the cost drivers should be investigated, taking into account the outlier detection mechanisms. In frontier models, special outlier criteria are typically used. The aim is to protect the evaluated ANSPs against a small number of special ANSPs, potentially deploying an incomparable technology or serving an incomparable context, that have an excessive influence on best practices. Two frontier criteria are often used in regulatory benchmarking. One is based on the idea of super-efficiency and says that a single ANSP that is doing very much better than all other ANSPs is most likely an outlier. The other is based on the idea of the average impact on the efficiency of the other ANSPs. An ANSP that has a sizable impact on the efficiency of a large share of the other ANSPs might also be considered an outlier.

3.22. The choice of a benchmarking model in a regulatory context is a multiple criteria problem. There are several objectives, which may conflict with one another.

3.23. *Conceptual*: It is important that the model makes conceptual sense both from a theoretical and a practical point of view. The interpretation must be easy and the properties of the model must be natural. This contributes to the acceptance of the model in the industry and provides a safeguard against spurious models developed through data mining and without much understanding of the industry. More precisely, this has to do with the choice of outputs that are natural cost drivers and with functional forms that, for example, have reasonable returns to scale and curvature properties.

3.24. *Statistical*: It is, of course, also important to discipline the search of a good model with classical statistical tests. We typically seek models that have significant parameters of the right signs and that do not leave large unexplained variation. At the same time, there must be a balance between the complexity of the model used and the sample size. In statistical approaches, this is the question of degrees of freedom. In a DEA context, there are less guidance although some rules of rules-of-thumb has been proposed. One is to require a sample of size of at the very least 3*(number of inputs + number of outputs) and (number of inputs)*(number of outputs). With 30 observations, we should therefore have no more than 9 output parameters. Experience suggests however that this number of output parameters is exaggerated and may lead to models that cannot separate between the efficient and the inefficient firms. Another informal heuristic is to say that DEA models, since they are non-parametric, are extremely flexible and that we therefore need at least enough observations to estimate a translog cost function (Coelli, 2004). With two cost drivers, a translog has 1+2+3 = 6 unknown parameters and with 3 cost drivers it has 1+3+6 = 10 unknown parameters.

3.25. *Regulatory and pragmatic*: The regulatory and pragmatic criteria calls for conceptually sound, generally acceptable models as discussed above. Also, the model will ideally be stable in the sense that it does not generate too much fluctuation in the parameters or efficiency evaluations from one year to the next.

The regulatory perspective also comes into the application of the model. In other words, let us not forget the trivial but very important requirement to comply with the specific conditions laid out in the regulatory directives of the individual jurisdictions.

3.26. The multiple criteria nature of model choice is a challenge. When we have multiple criteria, they may conflict, and this means that there is no optimal model that dominates all other models. We have to make trade-offs between different concerns to find a compromise model, to use the language of multiple criteria decision making, and such trade-offs can be challenged by the regulated parties.

Output based cost functions

3.27. The focus of this project is on the estimation of best practice cost functions and the use of these to estimate potential savings across multiple ANSPs.

3.28. We can distinguish two types of cost functions. Output based costs function explain cost directly as a function of the services provided and the contexts in which they are provided:

$$Cost = f(Outputs, Context)$$

3.29. Price based cost functions explain costs by the outputs provided, the prices of input factors, and the context:

$$Cost = f(Outputs, Input\ prices, Context)$$

3.30. Both approaches have their advantages and disadvantages in a practical, regulatory context. The output based approach requires less data since it does not require data on factor prices. Factors prices are often not observed directly but constructed from allocated costs and measures of the physical inputs. An advantage of this approach is therefore that it is also less dependent on the cost allocation of different ANSPs and the use of these costs together with the number of full time equivalents to construct the prices. On the other hand, the output case approach does not allow us to take into account that the relative factor prices may be different across ANSPs and that this may explain some of the cost differences. Note that it is the relative price difference, not the general price levels (which we corrected by inflation and PPP as described below) that matters. If, for example, the cost of capital and the cost of labor are very different across the ANSPs, we would expect them to use different factor combinations, with one relying more on labor and the other more on capital inputs. The consequence of ignoring such differences in price relations might be that some ANSPs are held responsible for aspects of the environment that they cannot entirely control, namely the relative prices of factor input. For these reasons, the output based cost function may potentially lead to harsher evaluations.

3.31. We have chosen to estimate the output based cost function using DEA and the price based cost function using SFA. In this way, we obtain intervals of efficiency scores for each ANSP which may capture some of the methodological uncertainty of any benchmarking study.

Combining DEA and SFA results

3.32. The results from DEA and SFA could be merged in various different ways, with examples of every type of aggregation found in regulatory practices throughout Europe.

3.33. Interval estimates could be created from the efficiency score estimated by each of the two methods (DEA, SFA). It would create a hopefully small band from which the regulator could choose an appropriate level or bound on the individual ANSP price.

3.34. The minimum efficiency score, min(DEA,SFA), would be the toughest estimate of potential cost reduction identified by at least one of the models results.

3.35. The maximum efficiency score between the results of the two models, max(DEA,SFA), could be referred to as the 'benefit of the doubt' regulatory approach. This would lead to the lowest possible cost reductions.

3.36. Calculating the average score of the results of the two models, median(DEA,SFA), would balance the advantages and disadvantages of each model equally. This would lead to results similar to that of the interval estimates and is the approach that we have chosen as described in Section 6.

4. Data and descriptive statistics

4.1. The data regarding the performance of the ANSPs have been provided and validated by the Performance Review Body (PRB). The AG received the data covering the period 2012-2021. The data includes 28 Member States plus MUAC. The costs considered here include the actual costs reported in the charging zones except for National Supervisory Authorities (NSA) and Eurocontrol costs. Therefore, the cost efficiency models only focus on the ANSPs cost base.

4.2. The countries included are (the ANSP is indicated in parenthesis): Austria (Austro Control), Belgium-Luxembourg (Belgocontrol), Bulgaria (BULATSA), Croatia (Croatia Control), Cyprus (DCAC Cyprus), Czech Republic (ANS CR), Denmark (NAVIAIR), Estonia (EANS), Finland (Finavia), France (DSNA), Germany (DFS), Greece (HCAA), Hungary (HungaroControl), International (MUAC),Ireland (IAA), Italy (ENAV), Latvia (LGS), Lithuania (Oro Navigacija), Malta (MATS), Netherlands (LVNL), Norway (Avinor Continental), Poland (PANSA), Portugal (NAV Portugal Continental), Romania (ROMATSA), Slovakia (LPS), Slovenia (Slovenia Control), Spain (ENAIRE), Sweden (LFV), Switzerland (Skyguide).

4.3. The years 2020 and 2021 have been excluded from the empirical analyses due to the severe impact of the COVID-19 pandemic on the air transportation sector. For example, in March-April 2020, 100% of available seats were grounded in Europe (Andreana et al., 2021), showcasing the dramatic effect of COVID-19 on the industry. Additionally, current global capacity is still lower than that of 2019.[1] Data from the Official Airline Guide (OAG) indicate that worldwide capacity reached 111.4 million seats in May 2023, which is still 3.6% lower than the same month in 20192. Relating the ANSP costs to their operations and traffic volumes in the years 2020 and 2021 would likely lead to skewed results. Therefore, the benchmarking analysis uses a dataset that includes only the period from 2012 to 2019 to evaluate ANSP performance.

4.4. Most of the data are in monetary values and have been converted to euros. The costs of an ANSP are primarily composed of two main elements: operating costs (OPEX) and capital costs (CAPEX). OPEX encompasses the variable staff costs and other operating expenses. CAPEX, on the other hand, comprises the cost of capital and depreciation. The cost of capital represents the opportunity cost associated with investing money in air traffic control, which is economically linked to the return on the capital invested. Depreciation accounts for the necessary funds to maintain the quality of assets at a consistent level. Capital is estimated by the ANSP net book value.

4.5. Much of the data draws from accounting records and therefore requires standardization to be comparable across ANSPs. First, data in currencies other than the euro must be converted to euros (the values have been calculated by the PRB supporting team using the average exchange rate for the year 2017

[1] See reports on the website oag.com.

as a reference). Second, since purchasing power varies among the countries included in the analysis, all monetary values must be adjusted using a Purchasing Power Parity (PPP) index to account for these differences.

4.6. Purchasing Power Parity (PPP) denotes the number of currency units required to buy a specific quantity of goods and services in different countries. PPPs can be used as currency conversion rates to convert expenditures expressed in national currencies into an artificial common currency, thereby eliminating the effect of price level differences across countries. The index has been estimated by Eurostat, using the average purchasing power of the EU across 29 member states in 2020 as a reference.

4.7. All monetary values are transformed into constant terms using a Producer Price Index (PPI) for each country (source: Eurostat). In general, producer price indices measure the average change in prices paid by domestic producers for goods and services sold in domestic and/or export markets between different time periods. The Producer Price Index is used to represent the cost of purchasing materials and supplies from local producers. The PPI is set at 100 for the base year, which is 2012.

4.8. In summary, if a variable X is defined in monetary terms and in a currency different from the euro, it is first converted to euro, and then standardized according to the following formula: $\frac{X/PPP}{PPI} \times 100$.

Physical production factors

4.9. We include measures of the physical amounts of multiple production factors utilized by the ANSPs. We consider the working hours of air traffic controllers (ATCO) for this purpose (i.e., area control center air traffic control (ACC ATCO)-hours on duty, taken from the Eurocontrol ATM Cost-Effectiveness (ACE) benchmarking reports).

4.10. Output is measured by the total instrument flight rules (IFR) flight hours controlled by each ANSP on an annual basis, information provided in the Eurocontrol ACE benchmarking reports.

Pricing factors

4.11. The labor cost is determined by dividing staff expenses by ATCO hours, offering an approximation of the hourly labor rate.

4.12. The price of capital is derived from the ratio of CAPEX to the annual sector opening hours of the corresponding ANSP. Economic theory posits that the price of capital represents the cost a firm incurs for utilizing capital, closely aligning with the rent paid for asset usage, including buildings. Therefore, the economic price of capital intrinsically links to the operational hours of an asset, a perspective adopted in this report.

4.13. We also tested alternative estimations using different definitions for the price of capital, based on an evaluation of each ANSP's total assets provided by the PRB support. For example, CAPEX divided by the regulated asset base (RAB), or alternatively, CAPEX divided by the net book value of the fixed assets (NBV). However, as depicted in

4.14. Figure 6, the RAB trend throughout the observation period showcases pronounced fluctuations, particularly in France, Germany, Greece, Italy, Spain, and Switzerland. These variations were particularly evident towards the end of the timeline, coinciding with the onset of Regulatory Period 2 (RP2, 2015-19).

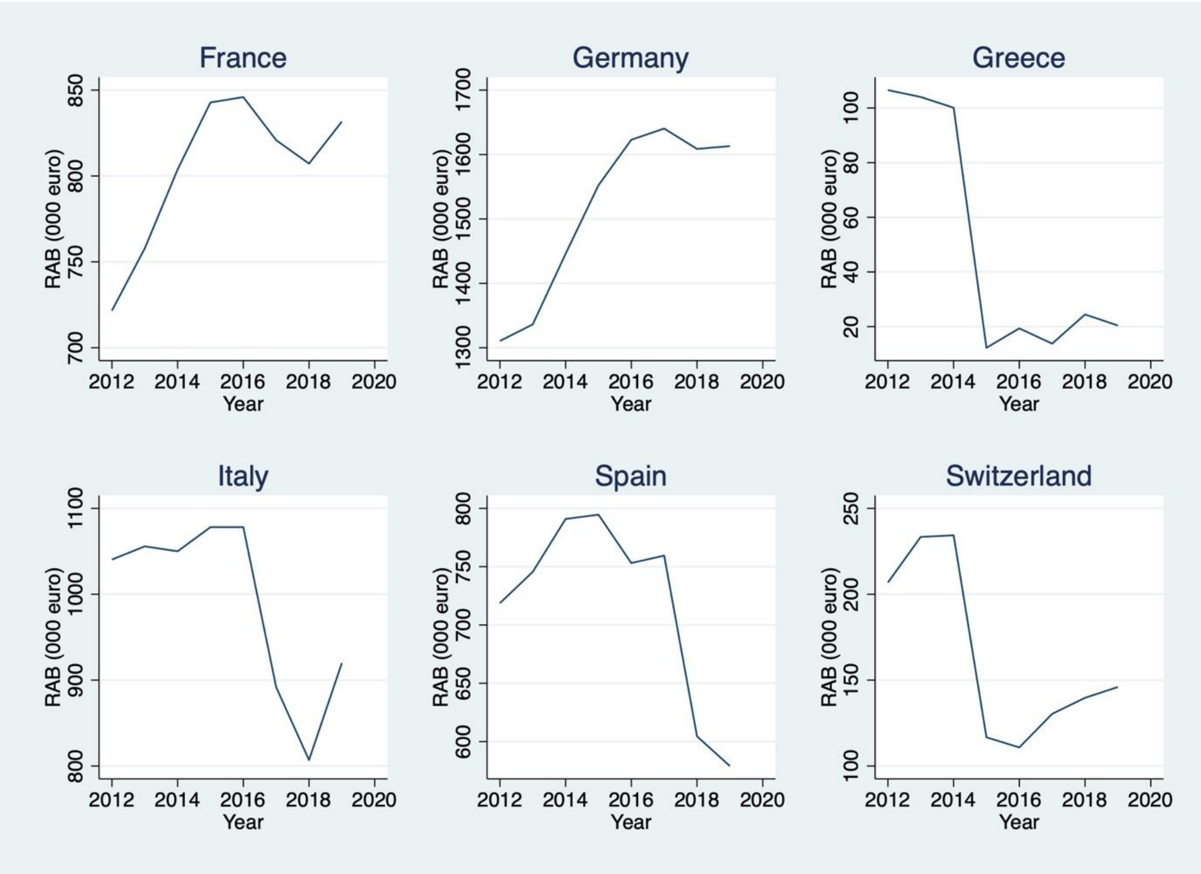

Figure 6 – Variability in RAB of six ANSPs, 2012-19

4.15. Similarly, as demonstrated in

4.16. Figure 7, we analyzed the data using the NBV. In this scenario, even more ANSPs show dramatic fluctuations. The effect of these trends becomes significant when we consider CAPEX, which experiences a marked decrease towards the end of the observed period. These features render the price of capital, if calculated as the ratio between CAPEX and either RAB or NBV, statistically insignificant when we apply stochastic frontier analysis to estimate cost efficiency. Consequently, we chose to employ the definition of the price of capital given by the ratio of CAPEX over the sector opening hours, which performs satisfactorily in the estimation procedure.

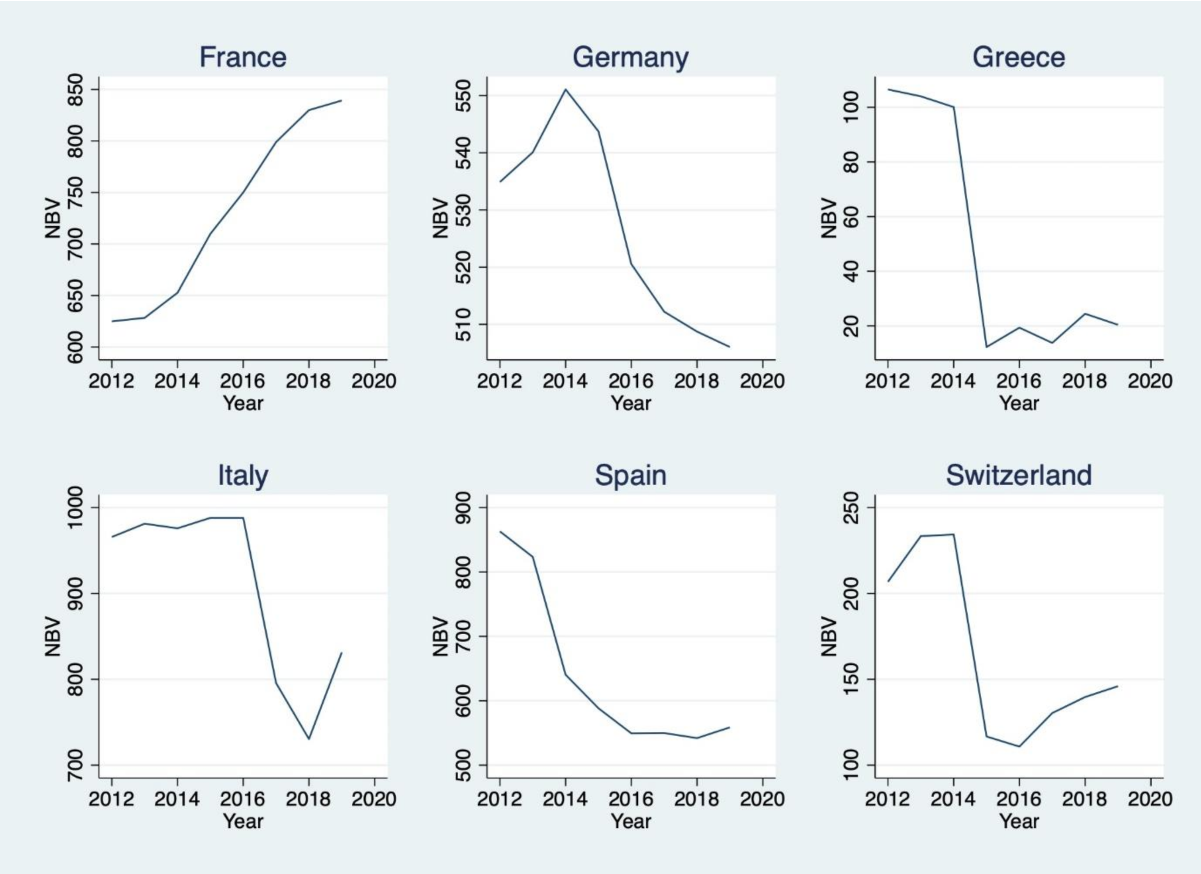

Figure 7 – Variability in NBV of six ANSPs, 2012-19

Negative Externalities

4.17. ANSP operations may inadvertently result in negative externalities, often referred to as 'bad outputs', which lead to undesired outcomes that detract from the overall experience of travelers due to unforeseen extended travel times. Therefore, the AG also included delays in the benchmarking analysis. In an ideal scenario, increased delays should correlate with lower total costs because the ANSP does not utilize all necessary inputs to ensure punctuality. However, the actual impact of delays on total costs is a subject left to the empirical analysis.

4.18. Since delays are considered a negative output, they are treated in such a way that an ANSP is penalized for higher levels of delay. The reasoning behind this is that an ANSP's performance is considered particularly good in terms of delays when this negative output is minimized. Therefore, the time lost due to delays is inverted in the cost efficiency estimation. This implies that the greater the delays attributed to an ANSP, the lower the output. Furthermore, since we have several instances with zero delays, this negative output variable is computed as follows: $\frac{1}{1+delays}$. This approach ensures that the ratio is always defined and that the ANSP's performance in this dimension ranges between 0 and 1.

4.19. To accurately assess the workload of each ANSP, we must take into account the complexity of the flight paths managed by them. To assist in this, Eurocontrol generates an index reflecting the complexity of each ANSP's flight paths on an annual basis.

4.20. The fluctuation of traffic load over a year can also influence the relative cost base of an ANSP. This variability is calculated by dividing the traffic levels in the peak month by the average monthly traffic. Since it is not feasible to employ ATCOs seasonally, high variability could result in increased annual costs compared to an ANSP with a similar output distributed evenly throughout the year. Variability is computed as an index by Eurocontrol.

4.21. Complexity and variability are characteristics of the air traffic controlled by the ANSPs and can be incorporated in the benchmarking analysis in different ways. Most commonly, they are included as explanatory variables in the inefficiency model or they are used to construct additional volume-based output measures that can be considered as outputs. In the first case, they are added to the estimated regression as explanatory variables. In the second case, we have constructed the following additional variables for the data envelopment analysis model:

$$Complexityhours = Complexity \times Total\_IFR\_hours$$

$$Variabilityhours = Variability \times Total\_IFR\_hours$$

Data transformation

4.22. Table 2 presents all the variables included in the cost efficiency estimation, their unit of measure and description. The data draws on different sources: Reporting tables (costs, capital), EUROCONTROL (traffic, staff) and Eurostat (inflation, purchasing power parity).

	Variable	Unit of Measure	Description/Computation
Output	Flight Hours	hours	Total IFR flight-hours controlled by ACC (aggregated at ANSP level)
Costs	Staff costs Other operating costs Depreciation Cost of capital	000€	Normalized by average euro exchange rate 2017
Staff	ACC ATCO-hours on duty	hours	Staff
Explanatory Variables	Sector opening hours	hours	Sum of sector hours
	ATFM delay	minutes	Minutes of en route ATFM delay
	Variability score	index	Traffic levels in the peak month divided by average monthly traffic
	Complexity score	index	Potential number of interactions between aircraft per flight-hour controlled, considering traffic density and structural index
Indices	PPI	%	Producer Price Index (annual growth rate)
	PPP		Purchasing Power Parity (EU27_2020=1)

Table 2 - Variables definition, unit of measure and description

Descriptive statistics

4.23. Exploratory data analysis are presented in Figure 8 and Figure 9, having been normalized at the base year 2012. Figure 8 depicts a consistent increase in flight hours-controlled by upwards of 20% compared to 2012, and similar patterns are observed for IFR flights per ANSP.

4.24. Sector opening hours remain relatively constant from 2012 to 2015, increase between 2015 and 2017 and then decrease slightly, leading to an overall 7% percentage increase between 2012 and 2019.

4.25. Complexity in managing flight traffic control gradually increases over the timeframe by about 15%, whilst variability remains relatively constant over the same timeframe.

4.26. Delays increase over three-fold by 2018 and decrease slightly in 2019. In order to visualize the bad output, it is necessary to use a two-scale plot. The scale of the delays index is shown on the right of the graph in Figure 8. At the end of the period the increase is approximately 300%.

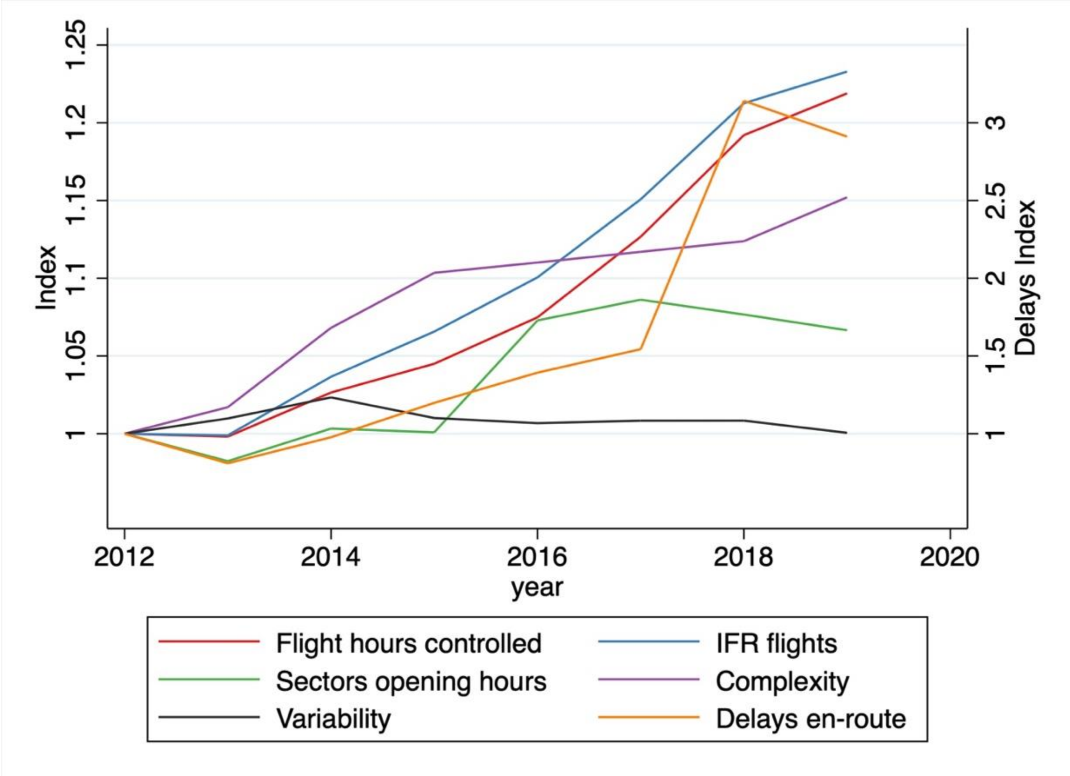

Figure 8 - Output indices, 2012-19

4.27. Figure 9 illustrates a +9% increase in total costs. Labor is quantified using the full-time equivalent (FTE) metric. Staff costs have increased by about 12%, despite a decline of about 2% in the total number of employees, which indicates a significant rise in wages.

4.28. The operating costs (OPEX) index has increased by 11%. CAPEX at the end of the period (2019) is at the same level as the beginning year (2012), due to a 7% decrease between 2018 and 2019.

4.29. Hence, the observed trend at the descriptive level is that output increased more than costs, and that the lower increase in costs is due to constant capital costs whereas labor costs have risen.

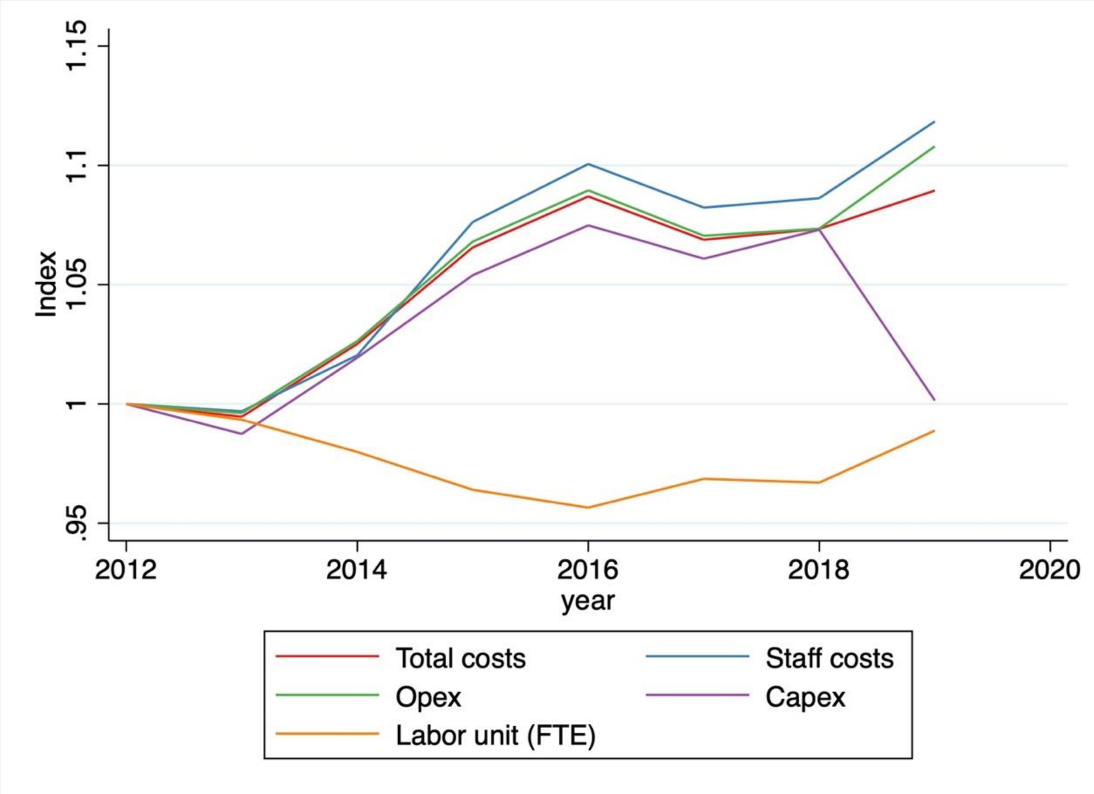

Figure 9 - Cost indices, 2012-19

4.30. Table 3 presents a summary of the data over the timeframe analyzed. Depreciation costs and the economic cost of capital are relatively invariant over time. In year 2012, about 21,700 full-time-equivalent employees worked for the ANSPs, which decreased until 2015 and then increased in the last years, leading to 21,500 by year 2019.

Years	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
All currency in 000€ PPPd	**Costs**							
Staff costs	3,527,512	3,486,527	3,509,171	3,598,576	3,607,221	3,673,799	3,774,476	3,932,105
Other operating costs	886,229	880,305	900,210	875,124	867,922	885,350	912,554	961,861
Depreciation	634,453	626,779	637,873	617,410	622,640	636,870	661,689	652,581
Cost of capital	285,645	268,529	287,882	308,576	304,477	304,240	323,724	277,848
Opex	4,413,741	4,366,832	4,409,381	4,473,700	4,475,143	4,559,149	4,687,030	4,893,966
Capex	920,098	895,309	925,755	925,985	927,117	941,110	985,413	930,429
Total costs	5,333,839	5,262,140	5,335,136	5,399,685	5,402,260	5,500,259	5,672,442	5,824,394
	Inputs							
ATCO hours on duty	9,529,471	9,412,612	9,487,217	9,331,701	9,454,511	9,530,020	9,514,383	9,728,853
Labor unit (FTE)	21,719	21,575	21,282	20,937	20,775	21,037	21,003	21,476

Table 3 - Annual trends in ANSPs costs and labor inputs

5. Models applied

Data Envelopment Analysis (DEA)

5.1. The non-parametric DEA approach uses linear programming to evaluate the performance of the firms or organizations. In the DEA literature is common to refer to the evaluated as Decision Making Units (DMUs). A DMU can be an observation of inputs and outputs for a firm at a given time (cross section) or across time periods (panel data).

5.2. DEA does not use maximum likelihood estimation, which is common in more statistical approaches, to determine the underlying model. Instead, DEA is based on the idea of minimal extrapolation.

5.3. In DEA, the estimate of the technology T, which is the empirical reference technology, is constructed as the smallest set of input-output combinations that contains data from the different DMUs, (xk,yk), k = 1,...,K and satisfies certain technological assumptions specific to the given approach.

5.4. By constructing the smallest set that contains the actual observations, the method extrapolates the least. As long as the true technology T satisfies the regularity properties, the approximation T* that we develop will be a subset of the true technology. We refer to this as an inner approximation of the technology. By choosing the smallest set, we are making a cautious or conservative estimate of the technology set and therefore, also a cautious or conservative estimate of the loss due to inefficiency. We can say also that the approximation is based on best practices rather than on speculation as to what may be technologically feasible. A popular understanding of the property is also that we estimate the technology so as to present the evaluated units in the best possible light.

5.5. We note that DEA is based on the implicit assumption that there is no noise in the data. If the data are somewhat random, due to exogenous shocks, bad reporting practices or ambiguity in accounting practices, the result may not be an inner approximation of the true possibilities.

Assumptions of DEA models

5.6. The basic DEA models mainly differ in the assumptions that they make about the technology T. The most important assumptions include free disposability (we can produce less with more), convexity (a weighted average of feasible production plans is feasible), scaling (production may be scaled) and additivity (the sum of two feasible production plans is feasible).

5.7. Given the size of the data set, and our aim to discriminate among efficient and inefficient firms, it is useful to assume convexity. Convexity is an assumption that complies with standard cost and production theory and that is also invoked in most parametric approaches.

5.8. With respect to returns-to-scale, we choose between the following:

a) Constant Returns to Scale (CRS) means that we do not believe there to be significant disadvantage of being small or large.

b) Non-Increasing Returns to Scale (NIRS), sometimes referred to as Decreasing Returns to Scale (DRS), means that there may be disadvantages of being large but no disadvantages from being small.

c) Non-Decreasing Returns to Scale (NDRS), sometimes referred to Increasing Returns to Scale (IRS), means that there may be disadvantages of being small but no disadvantages of being large.

d) Variable Return to Scale (VRS) means that there are likely disadvantages of being too small and too large.

5.9. Both conceptual reasoning and statistical tests aid in determining the appropriate scale assumption. The CRS assumption is the most stringent and results in the lowest efficiency scores. To align with the SFA translog model, we have chosen the VRS convex DEA model.

5.10. Finally, we analyze the ANSPs on an annual basis in order to minimize the impact of noise in the data.

Outliers

5.11. Outlier analysis consists of screening extreme observations. Depending on the approach chosen (DEA or SFA), outliers may have a different impact. In DEA, particular emphasis is put on the quality of observations that define best practice. In SFA, outliers may distort the estimation of the curvature and affect the magnitude of the idiosyncratic error term.

5.12. There are several possible outlier detection techniques that are relevant for DEA models, c.f. Bogetoft and Otto (2011) and Wilson (1993). One approach is to identify the number of times a DMU serves as a peer unit for other DMUs, peer counting. If a DMU is the peer for an extreme number of units, it is either a very efficient unit or there may be mistakes in the reported numbers. An alternative approach is the super efficiency criterion (Andersen and Petersen, 1993; Banker and Chang, 2006). The idea is to eliminate ANSPs that are far outside the technology spanned by the other ANSPs.

5.13. Applying multiple approaches, we identified MUAC as an outlier and have removed the ANSP from the analyses across all years, simply assuming that it is consistently relatively efficient.

DEA Variables

5.14. In the en-route model, we define five cost drivers as shown in Table 4. The total IFR flight hours controlled is a direct measure of workload (Flight Hours), the total hours that the sectors are open is the measure of the size of the operation and the actual and potential workload (Sector Opening Hours), the complexity index multiplied by IFR flights controlled is a workload measure that is corrected by complexity, the variability index multiplied by IFR flights controlled is a measure of the capacity for handling a large workload at least temporarily, and delays include the total minutes of delay specifically attributed to the ANSP.

Model	Variables
Inputs	
Total Costs	Total expenses PPP corrected
Outputs	
Flight hours	Total IFR flight hours controlled en-route
Sector opening hours	Total hours that sum of sectors open
Complexity*Flight hours	Complexity Index * flight hours controlled
Variability*Flight hours	Variability Index * flight hours controlled
Delays	Total minutes of delay annually ascribed to ANSP
Estimation Approach	
	Variable returns-to-scale
	Outlier MUAC eliminated

Table 4 - Variables in DEA model

Stochastic Frontier Analysis

5.15. The econometric approach to efficiency estimation is concerned with measuring the performance of firms and institutions in converting inputs to outputs. SFA may be applied to either cross-sectional or panel data at the firm level in order to estimate the relationship between inputs and outputs whilst accounting for exogenous factors. The latter may impact the production relationship however the management of the firm in general may have little to no control.

5.16. A firm is deemed cost efficient if it minimizes the total production cost of a given output, which requires technical efficiency but also a mix of inputs that makes more intensive use of the relatively cheaper variables. After testing both Cobb-Douglas and the more flexible translog cost function approaches, we chose the latter due to the higher log likelihood function values.

5.17. Due to the existence of panel data and potential externalities, we apply the Battese and Coelli (1995) model, which accounts for potential heteroscedasticity in the decomposed error terms and the estimation of the impact of externalities on the inefficiency distribution. Consequently, the Battese and Coelli model considers environmental variables twice if necessary, namely within the cost function and as an explanation for the average level of inefficiencies (Hattori, 2002).

5.18. From the dataset, we apply the model to the set of variables described in Table 5, where the cost of operation index equals the producer price index (PPI). Total costs and prices are normalised by one of the prices in order to meet the homogeneity condition and we have chosen the purchase price parity (PPP) index accordingly.

Dependent Variable	
Total Cost	$\dfrac{\text{total cost } / \text{ PPP}}{\text{producer price index}}$
Independent Inputs	
Output	total IFR flight hours controlled en-route
Labour price	$\dfrac{(\text{total staff cost}/\text{ATCO hours })/\text{PPP}}{\text{producer price index}}$
Capital price	$\dfrac{(\text{depreciation cost } + \text{ cost of capital }) \ / \ (\text{sector openings}/ \text{ PPP})}{\text{producer price index}}$
Environmental Variables	
Airspace characteristics	variability (seasonality), complexity, sector opening hours, time trend, delays

Table 5 - Variables in Stochastic Frontier Cost Function

5.19. Given the translog nature of the analysis, which ensures a reasonably flexible cost function, all of the independent inputs are also multiplied by themselves and between each other.

5.20. We implement the estimations in STATA, using the tailor-made SFPANEL package (Belotti et al., 2012). We tested a number of alternative specifications including SFA with time decay in the inefficiency term (Battese and Coelli, 1992) and SFA with exogenous drivers affecting the distribution of the inefficiency term (Battese and Coelli, 1995) and chose the latter based on the log likelihood values. We also note that all variables were subsequently standardized by dividing them by their geometric mean prior to logging the data.

5.21. The SFA model applied to en-route air traffic control provision is presented below:

$$
\begin{aligned}
\ln\left(\frac{Total\ Cost_{it}}{PPI_{it}}\right) \\
&= \beta_0 + \beta_1 \ln(IFR\ flight\ hours_{it}) + \beta_2 \ln\left(\frac{Labor\ Price_{it}}{PPI_{it}}\right) \\
&+ \beta_3 \ln\left(\frac{Capital\ Price_{it}}{PPI_{it}}\right) \\
&+ \beta_4 \frac{1}{2} \ln(IFR\ flight\ hours_{it}) \ln(IFR\ flight\ hours_{it}) \\
&+ \beta_5 \frac{1}{2} \ln\left(\frac{Labor\ Price_{it}}{PPI_{it}}\right) \ln\left(\frac{Labor\ Price_{it}}{PPI_{it}}\right) \\
&+ \beta_6 \frac{1}{2} \ln\left(\frac{Capital\ Price_{it}}{PPI_{it}}\right) \ln\left(\frac{Capital\ Price_{it}}{PPI_{it}}\right) \\
&+ \beta_7 \ln(IFR\ flight\ hours_{it}) \ln\left(\frac{Labor\ Price_{it}}{PPI_{it}}\right) \\
&+ \beta_8 \ln(IFR\ flight\ hours_{it}) \ln\left(\frac{Capital\ Price_{it}}{PPI_{it}}\right) \\
&+ \beta_9 \ln\left(\frac{Labor\ Price_{it}}{PPI_{it}}\right) \ln\left(\frac{Capital\ Price_{it}}{PPI_{it}}\right) \\
&+ \beta_{z1} \ln(Complexity_{it}) + \beta_{z2} \ln(Variability_{it}) \\
&+ \beta_{z3} \ln(Sectors_{it}) + \beta_{z3} \ln(time_t)\, \beta_{z3} + v_{it} + u_{it}
\end{aligned}
$$

where $v_{it} \sim N(0, \sigma_v^2)$ and $u_{\text{it}} \sim N(\delta_1 ln(complexity)_{it} + \tau_{it}, \sigma_u^2)$

5.22. The results of the stochastic cost function models with respect to en-route services are presented in Section 6. Two models are analysed, namely without and with a time trend variable that estimates market level changes. All cost elements are PPP to allow for international comparisons. All variables are logarithm transformed and normalized by the geometric mean.

6. Results

6.1. In this section of the report, we present the estimates of the Union-wide ANSPs cost efficiency. Two models were applied in order to estimate the efficiency of the 29 ANSPs, namely radial, variable returns-to-scale DEA and translog SFA models.

DEA cost efficiency

6.2. The DEA model includes the variables specified in Table 4. The DEA cost frontier model includes a single input, total costs and four outputs: flight hours controlled, sector opening hours, complexityhours, and variabilityhours. We also estimate a second model that includes delays.

6.3. The AG performed a systematic outlier analysis prior to applying the DEA models, following the method in Bogetoft and Otto (2011). The evidence is that in most of the annual analyses, MUAC has been identified as outlier, therefore it has been classified accordingly. MUAC has been assigned an efficiency score equal to 1, and the remaining ANSPs have been investigated and assigned an efficiency score based on a DEA analysis limited to 28 annual observations.

6.4. The results of the DEA-VRS model without and with delays are presented in Table 6. The scores are cost efficiency measures, ranging from 0 to 1. For example, the estimated median score is equal to 0.85 in year 2019, which means that the estimated inefficiency score is 15%. The scores presented in this table are Union-wide annual median scores. Without considering delays, the efficiency increased in the system, moving from 61% in year 2012 to 85% in year 2019. During RP1, the efficiency levels remained relatively constant over the observed period. After a drop between the two regulatory periods, the relative improvement consistently increases over the five years of RP2.

Year	Without delays	With delays
2012	0.61	0.73
2013	0.59	0.77
2014	0.62	0.84
2015	0.59	0.59
2016	0.66	0.71
2017	0.71	0.81
2018	0.79	0.85
2019	0.85	0.90

Table 6 - DEA cost efficiency estimates without and with delays

6.5. The scores without delays in Table 6, are lower than those with delays by definition. This is simply due to the additional output dimension, which enables ANSPs with low delay levels to improve their relative performance. If delays are included, the ANSPs Union-wide DEA-VRS efficiency scores increased during the time interval 2012-2019, rising from 73% in year 2012 to 90% in year 2019. As in the previous case, there is a large drop in year 2015, at the beginning of RP2. The efficiency rose during RP1 (2012-14), then dropped by 25% in 2015. Subsequently, performance improves consistently until the end of RP2 (year 2019).

6.6. Figure 10 presents the distribution of the estimated efficiency scores for the 29 ANSPs per year of observation using the DEA-VRS model with delays. The graph in each year is a box plot, and the bottom line of the rectangular box is the efficiency score located at the 25th percentile of the distribution: for example, in year 2012 the efficiency of the first quartile of the distribution of efficiency scores is equal to 40%. The line in the middle of the box is the median and is the efficiency score exactly in the middle of the distribution. In year 2012, it lies at 73%. The upper line of the rectangular box is the efficiency score of the upper quartile of the distribution. In year 2012, it is 100% (and it is the same in all following years).

6.7. We note that the interquartile range, i.e., the vertical distance between the bottom and the upper line of the rectangular box has reduced across the timeframe. The inter-quartile range is about 60% in year 2012, and just above 50% in year 2019. Hence, the Union-wide ANSP system has reduced the dispersion in the efficiency scores by the end of RP2.

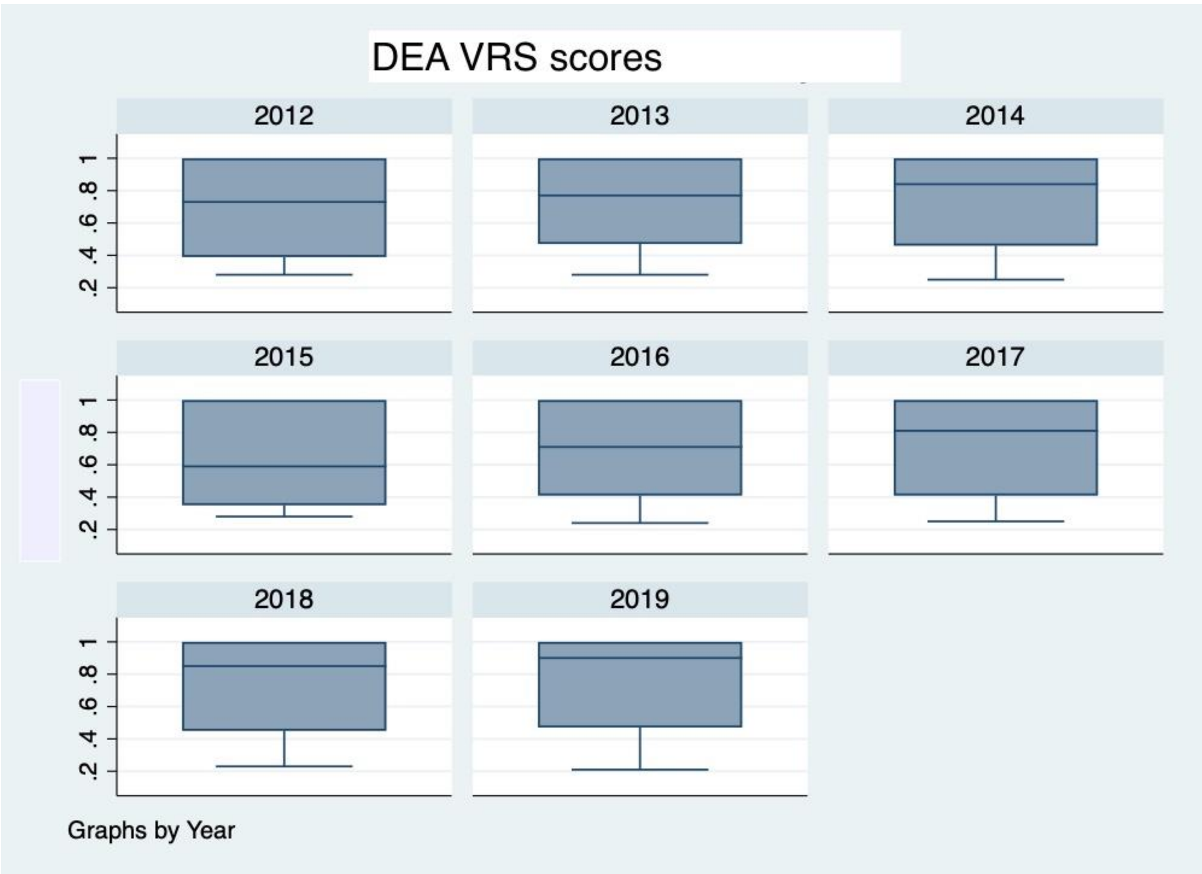

Figure 10 - Box plot distribution of DEA efficiency scores with delays

SFA cost efficiency

6.8. Cost efficiency with SFA is estimated with the translog, Battese and Coelli (1995) model. Total costs are explained by flight hours controlled, price of labor, price of capital, sector opening hours, complexity and variability together with a time trend in Model (1). Models (2) and (3) include delays. Model (3) treats complexity as a determinant of inefficiency rather than an explanatory variable. The estimates are presented in Table 7.

6.9. Models (1) to (3) show that flight hours controlled, and the prices of capital and labor, all explain total costs. Regarding input prices, the most significant values are labor, followed by capital in explaining overall costs.

6.10. We note that Model (3) appears to be preferable from a statistical perspective because the log-likelihood value is higher. Furthermore, it has a statistically significant (at the 5% level) estimated coefficient for the standard deviation of the inefficiency error component, σ_u, as well as the coefficient related to the standard deviation of the shock error component, σ_v. Hence, inefficiency is an important component of the cost function error term, as required for the adoption of SFA. We therefore refer to Model (3) for the rest of this section.

Dependent variable: *Total Costs*						
	Model 1		Model 2		Model 3	
Output and input prices	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Flight hours	0.40***	(0.11)	0.35***	(0.05)	0.33***	(0.11)
Capital price	0.35***	(0.06)	0.32***	(0.03)	0.29***	(0.04)
Staff price	0.53***	(0.06)	0.54***	(0.04)	0.56***	(0.06)
(Flight hours) ^{2}	-0.002	(0.07)	0.02	(0.04)	-0.003	(0.05)
(Capital price) ^{2}	0.02	(0.12)	0.02	(0.03)	0.01	(0.03)
(Staff price) ^{2}	0.47	(0.64)	0.66***	(0.18)	0.60***	-0.17
(Flight hours)(Capital price)*	-0.02	(0.05)	-0.003	(0.04)	-0.05	(0.03)
(Flight hours)(Staff price)*	-0.20***	(0.01)	0.21***	(0.04)	-0.13	(0.08)
(Capital price)(Staff price)*	-0.18	(0.26)	-0.23***	(0.08)	-0.23***	(0.08)
Shifters of total costs						
Sector opening hours	0.59***	(0.09)	0.60***	(0.06)	0.65***	(0.09)
Delays			0.002	(0.004)	0.001	(0.01)
Complexity			0.07**	(0.03)		
Variability (seasonality)					0.87***	(0.35)
Time trend	-0.006	(0.01)	-0.01**	(0.004)	-0.01**	(0.004)
Constant	12.3	(22.41)	16.67**	(7.17)	15.21**	(7.76)
Inefficiency (m)						
Complexity					0.09	(0.95)
Constant	-0.02	(0.36)	-4.41	(1.02)	-1.25	(1.67)
$\boldsymbol{\sigma_u}$ *(Inefficiency error component)*	0.26***	(0.95)	0.32	(0.21)	0.45**	(0.25)
$\boldsymbol{\sigma_v}$ *(shock error component)*	0.001	(2.97)	0.05***	(0.02)	0.05*	(0.03)
$\boldsymbol{\lambda}$	262.79***	(0.13)	6.97***	(0.21)	9.82***	(0.26)
Log-likelihood	149.61		151.18		168.3100	
Observations	232				232	
Legend: Battese and Coelli (1995) SFA models. *** = 1% significance level;						
** = 5% significance level; * = 10% significance level						

Table 7 - ANSPs cost function estimated with SFA translog model

SFA cost elasticities

6.11. Since the variables are in logs and standardized by their geometric means, the estimated coefficients of the first degree variables, namely flight hours, capital price and labor price, represent elasticities. Hence, the cost elasticity of flight hours is equal to about 0.33%, which suggests that were the volume of hours of traffic controlled by an ANSP to increase by 1%, the total costs will rise by 0.33%.

6.12. The cost elasticity of the price of capital is 0.29%, while the cost elasticity of the price of labor is higher and equal to 0.56%. An increase by 1% in the price of capital gives rise to an increase in total ANSP costs equal to 0.29%, whereas a 1% increase in the cost of labor will increase total costs by 0.56%.

6.13. Longer sector opening hours also contribute significantly to the overall costs. The estimated coefficient is equal to 0.65 and it is statistically significant.

6.14. Delays do not significantly impact cost efficiency for the ANSPs. The two estimated coefficients in Models (2) and (3) are not statistically significant. However, the estimated coefficient is positive. This implies that the lower the en-route delays, the higher is the cost to the ANSPs. In order to minimize delays, ANSPs may need to incur higher costs.

6.15. Higher complexity in ASNP operations implies higher total costs. The estimated coefficient of complexity in Model (2) is positive and significant, equal to 0.07. However, Model (2) suffers from a not statistically significant, coefficient for the standard deviation of the inefficiency error component, σ_u. Hence, after showing that complexity is a positive shifter in the cost frontier, in Model (3) we move complexity to be a determinant of the inefficiency error component and add variability as a cost function explanatory variable. The estimated coefficient of σ_u becomes positive and statistically significant, as required by SFA.

6.16. Variability (i.e. seasonality) contributes to higher costs and is statistically significant at the 1% level. In Model (3), the estimated coefficient is equal to 0.87.

6.17. The negative time trend, whilst not significant in Model (1), is significant at the 5% level in Models (2) and (3). This suggests that costs have decreased over the two reference periods by on average 1% annually.

SFA efficiency distributions

6.18. Figure 11 presents the distribution of cost efficiency scores over the period 2012 to 2019 using the SFA Model (3) estimates. Across all years, the inter-quartile range is smaller than that of the results of the DEA model. Consequently, SFA generates less dispersion in the efficiency scores, although the 75th percentile is always lower than 100%.

6.19. The SFA estimates yield Union-wide cost efficiency estimates of 83% if we do not consider delays (Model 1) and 88% if we include delays (Model 3).

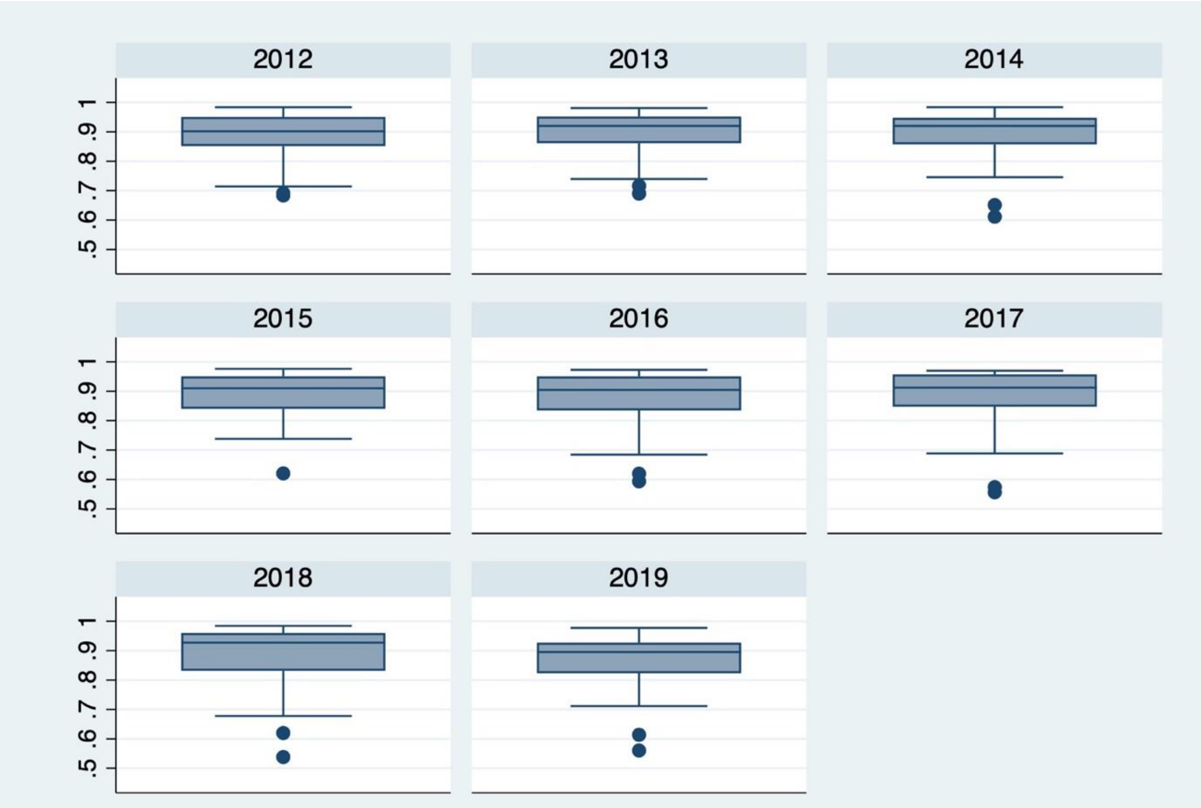

Figure 11 - Box plot distribution of SFA efficiency scores including delays

6.20. The SFA findings indicate that, on average over the observation period, the Union-wide cost efficiency is 83% without accounting for delays (Model 1), which rises to 88% when delays are incorporated (Model 3).

Combining the results

6.21. The suggested savings are based on the average cost efficiencies for the entire period, 2012 to 2019, and are computed as follows:

Potential cost saving = 1 – average efficiency score.

6.22. We combine the potential savings obtained by the DEA and the SFA models following three approaches:

- Potential savings as the maximum value resulting from the DEA and SFA models
- Potential savings as the minimum value resulting from the DEA and SFA estimates

Potential savings as the average of the two sets of results

6.23. Table 8 reports the DEA and the SFA Union-wide average estimated cost efficiency scores. We report two average measures: the simple average and the weighted average. In this case, the weight is set by the share of each ANSP's total costs on the Union-wide total costs, thus taking account of relative size. The results of the two models are reported across the two reference periods (RP) included in the observations: RP1 covering 2012 to 2014, i.e., 3 years, and RP2 covering 2015 to 2019, i.e., 5 years.

6.24. Table 9 presents the average potential savings for the overall period, i.e., 2012-19. The weighted average Union-wide ANSP inefficiency score offers a more accurate measure for this indicator in contrast to the arithmetic mean. The weighted average considers the varying sizes of the 29 ANSPs, ensuring a balanced representation. Conversely, the arithmetic mean distorts the measure by equally weighing all ANSPs, a misleading estimate if the target is a comprehensive Union-wide inefficiency score.

6.25. By considering the weighted average and the middle point between DEA and SFA, we obtain a potential savings equal to 1 – 0.84 = 0.16, i.e., a 16% cost reduction. For the last year only, i.e., 2019, taking into account the total costs for each ANSP in 2019, the average potential savings suggest that approximately one billion euros in costs could have been saved, of the 5.7 billion spent by the ANSPs in the dataset based on the 2019 PPP/PPI-adjusted costs.

	DEA-VRS			SFA-TL		
	overall period	RP1	RP2	overall period	RP1	RP2
Average	0.71	0.71	0.71	0.88	0.88	0.88
Weighted average	0.79	0.80	0.78	0.89	0.89	0.90

Table 8 - Estimated average ANSP cost efficiency

	Maximum	Minimum	Median
Average	29%	12%	21%
Weighted average	21%	11%	16%

Table 9 - Potential cost savings Union-wide

7. Conclusions and recommendations

Regulatory Benchmarking

7.1. Benchmarking methods, and in particular Data Envelopment Analysis (DEA), and Stochastic Frontier Analysis (SFA), have become well-established and informative tools for purposes of economic regulation. DEA and SFA are now routinely used by European regulators to set reasonable revenue / price caps for energy transmission and distribution system operators for example.

7.2. The cost efficiency of Air Navigation Service Providers (ANSPs) is an important element in the creation of an efficient Single European Sky. Each ANSP serves an individual airspace and in so doing is a natural monopoly. Since there is little direct competition in the market, efficiency is not encouraged by sound competitive pressure.

7.3. Benchmarking allows us to identify best practices, and if ANSPs are asked over time to adjust to best-practice cost, their cost efficiency will converge towards the cost levels of a competitive setting. Hence, instead of competing in the market, we create pseudo competition via benchmarking based regulation, where the ANSPs compete via a model. We note that this issue is particularly relevant in en-route provision given the clear monopolistic status of the ANSPs.

7.4. In this report, we develop two such benchmarking models, and we discuss how to combine them. One is based on data envelopment analysis (DEA) and another on stochastic frontier analysis (SFA). They can be combined in different ways (min, max, average) to determine more or less ambitious cost targets for each individual ANSP.

Methodological differences across models

7.5. Part of the variation of our results can be explained by the nature of the two approaches we have used. In the DEA models, all deviations from the model are classified as inefficiency whilst SFA uses a combination of noise and inefficiency to explain the deviations.

7.6. Furthermore, the SFA model makes more assumptions ex ante, including the structure of the cost function and the existence of competitive prices, which may also be driving some of the differences in the results.

7.7. Finally, we note that DEA, based on an envelopment frontier, has been estimated on an annual basis whereas the SFA model has used panel data and includes an estimate of changes over time. In this context, we have applied an average efficiency approach in the final results.

Results

7.8. We estimate the cost efficiency of 29 Air Navigation Service Providers (ANSPs), using two benchmarking models; the radial, variable returns-to-scale (VRS), Data Envelopment Analysis (DEA) model and the translog, Battese and Coelli (1995) Stochastic Frontier Analysis (SFA) model.

7.9. *DEA Cost Efficiency*: The estimated median efficiency score rose from 61% in 2012 to 85% in 2019, indicating an improvement in cost efficiency over time. When accounting for delays, the efficiency score increased from 73% in 2012 to 90% in 2019. We note that an artefact of all these models is that augmenting the number of variables (dimensions), will result in either a consistent or higher score for the individual ANSP. The results also reveal reduced dispersion in the efficiency scores by the end of RP2, reflecting a decrease in variability among ANSPs' performance.

7.10. *SFA Cost Efficiency*: Total costs were largely explained by flight hours controlled, and the prices of capital and labor. The model indicates that a 1% increase in flight hours, capital prices, and labor prices would lead to a rise in total costs of 0.33%, 0.29%, and 0.56% respectively. Delays did not significantly impact cost efficiency, but indicated that minimizing delays might incur higher costs for ANSPs. Additionally, higher complexity and variability (seasonality) contributed to increased costs.

7.11. *Cost Savings*: The AG finds that ANSPs could save approximately 16% of total costs on average by adjusting to best practices. Based on the 2019 PPP-adjusted costs, this amounts to potential savings of just under one billion euros on an annual basis. Additionally, the report highlights a wide distribution in the efficiency scores, indicating substantial variation in the performance of different ANSPs.

Recommendations

7.12. The large variation in the performance of the multiple ANSPs suggests that a one-size-fits-all approach, such as implementing a universal tariff reduction for all ANSPs, is insufficient. Tailored strategies are necessary to address the specific inefficiencies of each ANSP and maximize potential cost savings. It is therefore natural to work not only with a general cost reduction requirement to capture technological progress (which is around 1% annually over the eight years analyzed in this report) but also to work with additional individual requirements encouraging less efficient ANSPs to catch-up to best practices.

7.13. We suggest that the results could be strengthened over time. There are many ways to do so, including a further investigation of the cost standardization and the inclusion of additional cost drivers such as quality of services provided, including route directness.

7.14. Ideally, all ANSPs should use the same rules for allocating shared costs between en-route and terminal activities (where relevant) and across cost categories. Moreover, the ANSPs should also use standardized depreciation rules which would reduce some of the noise in the data.

7.15. Our analysis presumes that the number of ANSPs are fixed and that the deviation of air space between them remains unaltered. We hereby do not measure the possible gains or cost savings from consolidation of the Single European Sky. Including the United Kingdom, Canada and the United States may change the cost frontier and help to identify potential additional cost savings.

7.16. It is important to note that we only calculate potential savings of the less efficient European ANSPs adjusting to the practices of the more efficient European ANSPs. We do not make comparisons with air navigation services on other continents.

7.17. Reports, such as those produced by the FAA and Eurocontrol[3], seem to indicate that the US system is at least one third more efficient than Europe. In effect, an analysis looking for possible comparators outside of the EU could lead to a much higher savings potential.

7.18. Of course, it might also be that the variation in European efficiencies is larger than that of the US. If this is the case, the bias from using a European perspective only is less important. However, the real impact of economies of scale would only be possible with such a comparison.

Future Directions

7.19. It might be of interest to investigate the possibilities of introducing competition for the market rather than price regulation. In terminal provision, this exists in Sweden, the UK, Germany and Spain. It is likely that such an application to en-route services may lead to a more consolidated set of airspaces that achieve higher economies of scale.

7.20. It is clear that the environmental issues caused by the aviation industry are of growing concern. According to the European Commission, each aircraft flies 49 km longer than necessary on average[4], and this data considers only horizontal flight paths, not the vertical descent paths. The directness of a route is likely to contribute to a reduction in greenhouse gas emissions in the shorter term. Consequently, air traffic control provision could contribute to a reduction in emissions by minimizing the length of flight paths through improved pre-planning and reducing congestion and delays by better balancing demand and supply. Incentivizing such behavior through a hybrid price cap would likely reduce fuel burn in a relatively simple manner.

[3] U.S. - Europe continental comparison of ANS cost-efficiency trends (2006-2014) (eurocontrol.int) accessed online on the 31st July 2023

[4] Single European Sky (europa.eu) accessed online on the 31st July 2023.

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Performance Review Body
Advice on the Union-wide target ranges for RP4

Annex III - Impact of Russia's war of aggression on horizontal flight efficiency

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Performance Review Body of the Single European Sky | Rue de la Fusée 96, Office 50.659, 1130 Brussels
Office Telephone: +32 (0)2 234 7824 | cathy.mannion@prb.eusinglesky.eu | prb-office@prb.eusinglesky.eu | wikis.ec.europa.eu/display/eusinglesky

EUROCONTROL

TECHNICAL NOTE ON THE IMPACT OF THE WAR IN UKRAINE ON HORIZONTAL FLIGHT EFFICIENCY (HFE) INDICATORS

A QUANTIFICATION OF THE EFFECTS OF CONFLICT ZONE AIRSPACE RESTRICTIONS ON HORIZONTAL FLIGHT EFFICIENCY VALUES

Technical note prepared by the EUROCONTROL Aviation Intelligence Unit (AIU)

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1 INTRODUCTION

The invasion of Ukraine which began on February the 24th 2022 has led to extensive airspace closure and the need for airlines to reorganise the affected traffic, either cancelling flights or operating longer flights.

As the Horizontal Flight Efficiency (HFE) indicators utilise flight length as the main proxy for efficiency, those increased lengths have led to higher values for the indicators, which in the case of States close to the restricted airspace (in the northern and eastern part of Europe) have been notably higher. Due to the difference of the traffic flows involved, the effects have not been uniform.

Availability of alternative values of the indicator in which the impact of the exceptional circumstances has been considered is useful when there is a need to have comparisons. Such is the case for example when considering time series, which would otherwise be broken in two periods with different baselines. Similarly, those corrected values enable the comparison with targets which were established under assumptions which were valid at the time the targets were established but could not have envisaged such exceptional circumstances.

The purpose of this Technical Note is to define a methodology which can be used to generate those values, provide the details of the approach and the outcome of applying it to the data currently available.

Some HFE indicators are used in the Single European Sky (SES) performance scheme and targets have been set on the Key Environment indicator based on Actual trajectories (KEA). The technical note therefore provides some detail on the specificities of the indicator adopted for performance purposes and the proposed correction.

The final section of the technical note provides the values of the HFE based on the radar trajectories for the period January 2022 – May 2023, monthly and per SES Member State. Values for the entire SES area are also provided.

KEA is based on the HFE indicator calculated on radar data, with an additional provision to limit the impact of unusual, but temporary, circumstances: it is an annual rolling average in which the ten best and ten worst days are excluded from consideration. The evolving values of the KEA indicator (on the last day of each month) are also provided in the final section.

2 BACKGROUND

2.1 Horizontal Flight Efficiency Indicator

The Horizontal Flight Efficiency Indicator (HFE) uses the length of the trajectory as a proxy for the flight efficiency, so that longer flights are considered more inefficient flights.

For performance purposes it is the entire flight, gate-to-gate, from origin to destination, which is the main interest. For the additional distance, it is also the granularity at which the measurement is unequivocally defined[1].

At the core of the indicator is the consideration that while it is true that the most appropriate unit for performance analysis is the entire flight, there is also interest in splitting the flight in separate phases, or according to the different geographical areas which are traversed by the flight. In those cases, there is also a general expectation that the values of the additional distances are internally consistent. Thus, the goal in defining the indicator was to have a measurement such that the sum of the additional

[1] The distance between the airports being the minimal length possible for a flight and therefore the reference against which the “additional” can be calculated (the “zero” to ensure that all additional distances are positive).

distances, no matter how the entire flight is split into parts, is equal to the additional distance from the airport of departure to the airport of arrival.

As distances are not additive[2], the indicator requires the use of something else than the (great circle) distance to obtain the additivity property described above. "Achieved distance" provides such values.

In the rest of the document distance between two locations refers to the great circle distance between them[3]. The terms origin and destination refer to the first and last point of the trajectory considered for the flight, which in general should correspond to the airport of departure and the airport of arrival[4].

Achieved distances take into explicit consideration:

- For a flight between the airport of departure and the airport of arrival there are two fixed points, corresponding to the location of the two airports; different flights might follow different paths, but all flights between the airport pair will share the two airports as end points[5].
- There is a direction of travel, and the points are in a sequence[6]. Time[7] is a natural way to keep the sequence.

The achieved distance assigns an estimate to the amount of distance between the origin and the destination that has been covered between any two points. The estimate is based on the location of four points: origin, first point, second point, destination. The additional distance is the difference between the amount flown and the amount achieved[8].
The achieved distance is the average of[9]:

- how closer the flight gets to the destination[10]:
    - distance between the first point and the destination minus
    - distance between the second point and the destination, and
- how farther the flight gets from the origin[11]:
    - distance between the origin and the second point minus
    - distance between the origin and the first point.

[2] The defining characteristic of distances is that they satisfy the triangular inequality. Defining the distance as the length of the shortest path joining two points, it means that when considering a third point, the sum of the distances between the two original points and the third one will be the same only when the third point is already on the shortest path, otherwise it will be higher. In Euclidean geometry the shortest distance corresponds to the length of the straight line between the two points, on a sphere it is along the great circle because of the curvature. Hence the use of great circle distance (GCD) for the indicator.

[3] The location of the points is identified by the latitude and longitude instead of x, y, z coordinates in a three-dimensional space, and the distance refers to a path on the surface instead of the straight line, which would be internal to the surface. The GCD takes into consideration the relative location of the points and the curvature.

[4] For the indicator adopted in the performance scheme, this is not always the case.

[5] The distance between them is the length of the shortest path between them.

[6] From the airport of departure to the airport of arrival.

[7] Real, estimated or forecasted.

[8] The flown is the length of the trajectory, which could be the one that results from radar points or the one implied by a flight plan or any other trajectory (e.g., because of a simulation). The achieved is the result of the calculation based on the four points (origin, first point, second point, destination).

[9] It is the difference of values between the two times which counts (closer and farther), not the value of the distance at either points. The direction of travel counts: decreasing distance to destination and increasing distance from origin are indication that the overall goal of the flight is being achieved (hence the name).

[10] Both distances are taken with respect to the destination. It is GCD(origin, destination) at departure and 0 at arrival. Both values are non-negative, while the difference between the two might be negative.

[11] Both distances are taken with respect to the origin. It is 0 at departure and GCD(origin, destination) at destination. Both values are non-negative, while the difference between the two might be negative.

The calculation ensures that the achieved distance:

- Is the total distance to be covered by the flight when the two points are the origin and destination of the flight[12].
- Does not depend on what happens before and after the two points[13], so that the values are not influenced from additional distances in other areas.
- Provides[14] an estimate of the additional distance due to the misalignment of those points with respect to the origin and destination.
- The sum of the achieved distances over all airspaces traversed is equal to the great circle distance between the origin and destination[15].

All the above is not true for regular distances (so called "direct" between the two points), because of the mathematical properties of distances[16]. Regular distances would also ignore the additional information provided by the location of the origin and destination and direction of the flight[17].

For the performance scheme the phase of interest is the en route phase of the flight, which has been defined to begin and end when the flight crosses a cylinder of radius 40 nautical miles centered at the airport(s).

In the version of the indicator which has been adopted for the performance scheme there are two main differences with respect to the plain indicator:

- The origin and destination of the flight have been moved from the airports to the border of the reference area for flights arriving or departing (or both) outside the area[18].
- The inefficiency is calculated in percentage terms with respect to the achieved distance (the comparison between flown and achieved reflects the percentage increase rather than the absolute difference).

[12] The achieved distance is equal to the great circle distance between them. In the description above, the first point is the origin, and the second point is the destination. Closer to destination: GCD(origin, destination) – GCD(destination, destination) = GCD(origin, destination) – 0, farther from origin: GCD(origin, destination) – GCD(origin, origin) = GCD(origin, destination) – 0. Average: (GCD(origin, destination) + GCD(origin, destination)) / 2 = GCD(origin, destination).

[13] Except for the locations of the origin and destination of the flight, which are essential in defining whether there is additional distance implied by the location of the two points with respect to the origin and destination.

[14] The additional distance, which is the difference between the GCD and the achieved distance between the two points, is always positive (or zero). This is because the maximum value possible for the achieved distance is the GCD between the two points, which happens when the two points are on the great circle between origin and the destination, and the two points are also between the origin and the destination. In other words, when the two points are part of the shortest path between origin and destination there is no additional distance.

[15] Every intermediate point will be considered once with a positive sign and once with a negative sign (for each of the two values – towards destination and from the origin), while the origin and destination are taken into consideration once with the value of the overall great circle distance, and once as zero.

[16] To have an analogy with geometry in two dimensions, we can consider straight lines (as shortest, indicating a distance) and curves (not shortest). The more points considered the better the approximation to the length of the curve, and the worse the approximation to the length of the straight line joining the end points. The distance flown is a given, and what is needed for the indicator is the approximation of the portion of the straight line joining the end points.

[17] As an example, flying in the opposite direction with respect to the one from the origin to the destination might be efficient locally but is clearly inefficient for the whole flight.

[18] Consequently, the location of origin and destination might be different from the location of the airport of departure and the airport of arrival. The calculation of the achieved distances is with respect to the locations of origin and destination.

The KEA indicator is built upon the HFE indicator and is based on an annual moving window from which the ten best and worst days are removed.

More details on the calculation of horizontal flight efficiency and on the indicators can be found in the dedicated section of the Aviation Intelligence Unit's website (https://www.eurocontrol.int/portal/pan-european-air-navigation-services-performance-data-portal).

2.2 Airspace closures

Immediately after the invasion of Ukraine, EASA issued a Conflict Zone Information Bulletin (CZIB) detailing restrictions on the operations of flights in Ukraine, Russia and Belarus (the restrictions on Belarus' airspace were active since February 2021), whose validity has been extended several times.

The CZIB is available at the page https://www.easa.europa.eu/en/domains/air-operations/czibs/czib-2022-01r08.

It lists the following as regions in which operators should not operate:

- All altitudes / flight levels of the following Flight Information Regions: FIR LVIV (UKLV), FIR KYIV (UKBV), UIR KYIV (UKBU), FIR DNIPROPETROVSK (UKDV), FIR SIMFEROPOL (UKFV), FIR ODESA (UKOV).
- All altitudes / flight levels of the airspace within 200NM surrounding the borders with Ukraine in the FIR MOSCOW (UUWV).
- All altitudes / flight levels of the FIR ROSTOV-NA-DONU (URRV).

In addition, operators are urged to exercise caution for the entire FIR MOSCOW (UUWW) and reminded that operations are prohibited in the FIR MINSK (UMMV), due to previous safety directives.

A map of the affected airspace is provided as part of the description of methodology in the following section.

3 DESCRIPTION OF THE METHODOLOGY APPLIED

As it is common in the case in counterfactual analysis, the data available cannot directly show what would have been the value of the measurements under different conditions which would have directly or indirectly led to alternative decisions. The analysis must rely therefore on assumptions or simulations. In this case the direct simulation of the trajectories is not available, and the analysis relies on information from the past about flights between airport pairs to identify the flights potentially impacted.

Faced with airspace closures an airline must consider the trade-off between the increased costs due to the need to fly longer trajectories (which might not even be feasible with the type of aircraft originally planned) and the loss of revenue and costs related to the cancellation of the flight.

In the former case the data includes a (possibly very) inefficient flight, while in the latter case the absence of the flight means that the recorded inefficiency is better than the one which would include the flight.

For what concerns the former aspect, the analysis does not exclude completely the affected flights but applies instead for them a correction to the value of the indicator. The latter aspect is not considered in this analysis, as there is no replacement of the missing traffic.

The main rationale behind the counterfactual reasoning is the following:

- Airlines base their decisions on the entire flight, whose end points are the airport of departure and arrival. The location of the two airports is considered a strong predictor of the airspaces which will be traversed.
- For the period before February the 24th 2022, flight plans reveal airlines preferences about the areas to be traversed. These preferences are unaffected by the restrictions, which were not active at that time.
- If airlines did not file to use an airspace in the period preceding the invasion, then its subsequent closure should make no difference to them.

The bulk of the analysis consists of the identification of the flights impacted by the restrictions, based on the information about past behaviour. As it will be shown the information about the airport pairs is not always sufficient to have high coverage of the entire set of flights. This is because some of the flights are operating on markets and destinations which were not served before (or at least not in the period considered, which goes back to the beginning of 2019). Those flights are treated differently, and the identification of impacted flights is based on a categorisation based on area pairs instead of airport pairs.

3.1 Definition of impacted area

While the restrictions are related to airspace closures in Ukraine, Russia and Belarus, their impact might be wider due to the redefinition of the traffic flows.

The analysis considers a slighter wider area than the one directly mentioned in the EASA's CZIB by taking in consideration all FIRs with ICAO code beginning with the following letters: UK, UL, UM, UR, UU[19].

[19] Generally, the first letter of the ICAO codes refers to the geographical region, and the second to an area within the region. The last two letters in the ICAO code for an airport identifie the specific airport within the area.

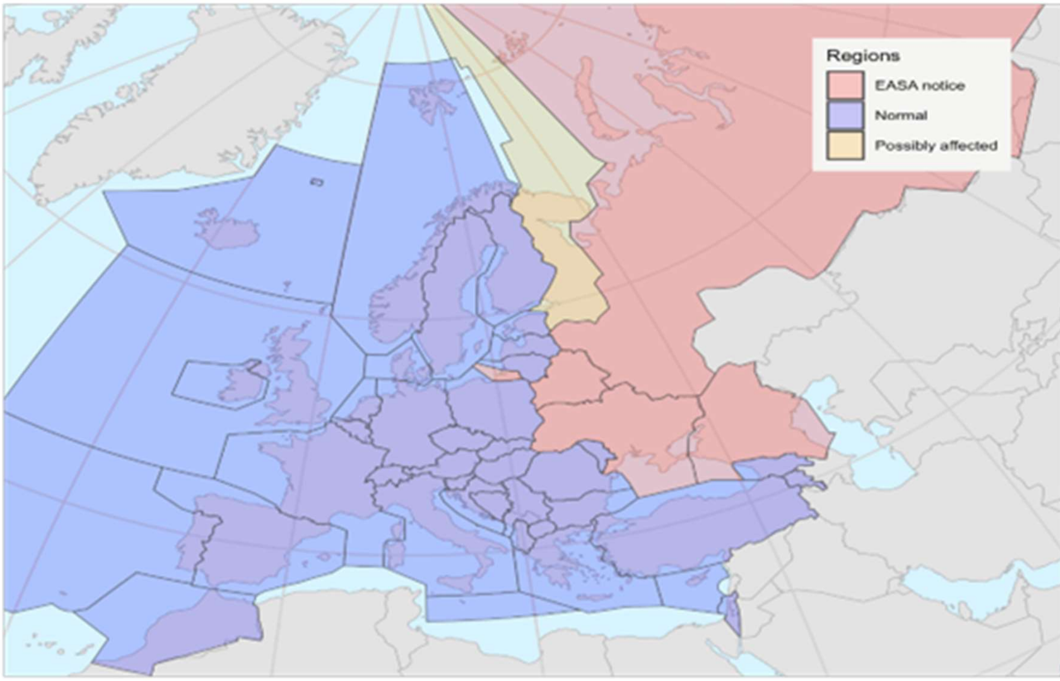


Figure 1: Map of impacted airspace

Figure 1 shows in red the areas directly affected by the notice and in yellow the area considered as very probably affected, UL. It is considered as very probably affected as it is an area which is part of the Russian federation and is wedged between the restricted area and the area of interest for the analysis.
As a preliminary step of the analysis, all flight plans have been categorised based on whether the plan included traversing one or more affected FIR regions (any of the yellow and red areas in the map).

3.2 Dataset available

The dataset considered for the identification of the affected flights consists of all flight plans in the pre-invasion period from January the 1st 2019 to February the 23rd 2022, whose main statistics are summarised in Figure 2.

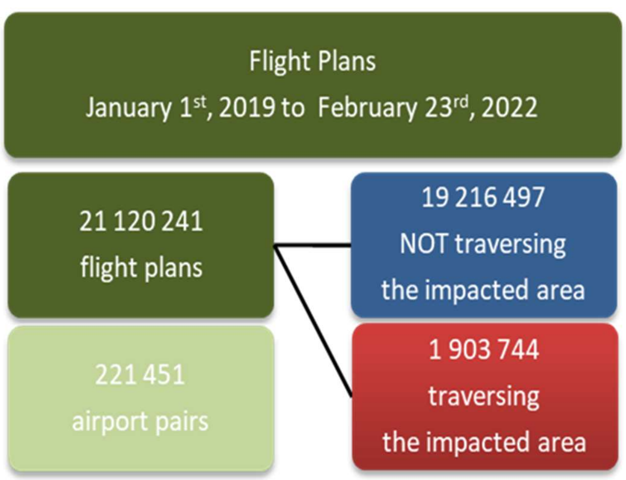


Figure 2: Information on dataset available

It consists of around 21,1 million flight plans, of which around 1,9 million include the traversal of the impacted area[20].

The number of airport pairs included is around 221 thousand. An airport pair is one-directional, distinguishing airport of departure and airport of arrival; AAAA-BBBB and BBBB-AAAA therefore are considered to be two different airport pairs, even if they involve the same two airports: AAAA and BBBB.

[20] Flying into, flying out, flying inside or flying over.

There is not a one-to-one correspondence between airport pairs and traversal of the impacted area, as for the same airport pair some flight plans might include the traversal of the impacted area, while others might not include it (flight plans are specific to the flight and there is no predefined route between airport pairs).

For the purpose of categorising flights in the post-invasion period, though, the goal is to assign them ideally based on airport pairs, so that the information about the airport pair indicates whether or not the flight has been affected by the airspace closures.

3.3 Identification of the impacted flights via airport pairs

For the categorisation to be based on airport pairs, there is the need to assign airport pairs for those cases in which some of the flights have requested to traverse the impacted area while others have not.

A simple approach would be to categorise the airport pair according to the majority rule (whether more than 50% have flown through the impacted area), but in the exploratory phase of the analysis the goal is to have a better idea of how many of the airport pairs would fall in an undecided category, in which the percentages might be close to each other.

For each airport pair the analysis calculates the number of flights for which the flight plan includes the crossing of the impacted area (traversing flights) and what percentage they make of the total for that airport pair. The percentage gives therefore an estimate of the strength of the preference to go through those airspaces when flying between the two airports.

The period considered is the one before February the 24th 2022 in which the area was not restricted and so aircraft operators could decide where to fly. Belarus is an exception as it is an area which has been restricted since 2021. However, the dataset includes the years 2019 and 2020 of higher pre-pandemic traffic, while in 2021 the level of traffic was still low because of the pandemic.

The application of a threshold either side of the bounds on the percentage of traversing flights allows to define three categories: unaffected, unassigned, affected.

The bounds on percentages are 0% and 100%, so a threshold of 1% implies the use of 1% and 99% as cutoff values, while 5% implies the use of 5% and 95% as cutoff values[21].

Table 1 provides some examples showing the categorization based on the total number of flights in the city pair and the number of traversing flights.

Number of flights in the pair	Threshold	Number of traversing flights		
		Unaffected	Undecided	Affected
10	1%	0	1 – 9	10
10	5%	0	1 – 9	10
20	1%	0	1 – 19	20
20	5%	0 – 1	2 – 18	19 – 20
50	1%	0	1 – 49	50
50	5%	0 – 2	3 – 47	48 – 50

Table 1: Categorisation of the pair according to the number of traversing flights

The lower the threshold, the fewer airport pairs (and all flights related) will be unequivocally assigned to the affected or unaffected category.

[21] 1% and 5% are the traditional values used in statistical approaches.

- When the percentage of traversing flights is below the threshold, the airport pair is considered as **unaffected** (all flights between the airport pair would be considered unimpacted post-closure).
- Conversely, when the percentage of traversing flights is above the complementary threshold the airport pair is considered as **affected** (all flights between the airport pair would be considered impacted post-closure).
- When the percentage is between the two values, the airport pair is considered to be "**unassigned**", as it might be considered to be in either category.

Table 3 and Table 2 show the outcome of applying the categorisation based on the value of 1% or 5% as threshold.

A comparison of the two tables shows that by changing the threshold to 5% a small percentage of airport pairs, and a higher one of flights, move out of the unassigned category and into the other two categories, but without major changes. To a change of categorisation of a relatively fewer number of airport pairs corresponds a higher coverage of flights. It also shows that the airport pairs involved have a relatively high number of flights, for which the choice of the 5% is relatively safe (the assignment is based on a bigger sample size).

The stability in the overall percentages is consistent with the fact that the great majority of airport pairs (which includes airport pairs within Europe and arriving from the South or from the West) is not affected by the airspace restrictions and is unequivocally assigned to a category.

Category (Threshold 1%)	Airport Pairs	Flights	Airport Pairs %	Flights %
Unaffected	194 229	18 553 318	87.7%	87.8%
Unassigned	5 283	1 001 668	2.4%	4.7%
Affected	21 939	1 565 255	9.9%	7.4%
Total	221 451	21 120 241	100.0%	100.0%

Table 3: 3-ways categorisation based on airport pairs with 1% threshold.

Category (Threshold 5%)	Airport Pairs	Flights	Airport Pairs %	Flights %
Unaffected	194 975	18 819 669	88.0%	89.1%
Unassigned	4 351	668 015	2.0%	3.2%
Affected	22 125	1 632 557	10.0%	7.7%
Total	221 451	21 120 241	100.0%	100.0%

Table 2: 3-ways categorisation based on airport pairs with 5% threshold.

To reach an either-or decision concerning the categorisation of the airport pair, the conservative decision which errs towards considering an airport pair as impacted is taken. Thus, the unassigned and affected are grouped together in the impacted category.

Category (Threshold 5%)	Airport Pairs	Flights	Airport Pairs %	Flights %
Unimpacted	194 975	18 819 669	88.0%	89.1%
Impacted	26 476	2 300 572	12.0%	10.9%
Total	221 451	21 120 241	100.0%	100.0%

Table 4: 2-ways categorisation based on airport pairs with 5% threshold.

In terms of Table 1 above, it means that the range for the pair to be categorized as impacted is the union of the two ranges in the last two columns (with twenty flights, the airport pair will be considered unimpacted only if zero or one flights were traversing the impacted area, and impacted if two or more flights were traversing the impacted area). Table 4 shows the results after the regrouping.

3.4 Identification of the impacted flights via area pairs

Moving to the analysis of data related to the post-invasion period, it can be verified how successful the methodology would in categorising all the flights.

For the period between February the 24th 2022 and May the 31st 2023, there are 159 632 airport pairs and 11 036 002 flight plans.
Of those, 41 145 are new airport pairs (they were not present in the previous dataset), for a total of 101 831 flight plans.

While it is only 1% of the flights, it is around a quarter of the city pairs, and it would be preferable to have an additional criterion to assign the category of flights between those city pairs. This would necessarily be based on a coarser grouping, as the detailed grouping given by the airport pairs cannot be used (the airport pair is not there, so there is no "look up" value).

The categorisation can be made coarse thus:

- Consideration of the airport's ICAO area (based on the first two letter of the ICAO code) instead of the airport itself.
- Consideration of the unordered pair instead of the ordered pair. This means that the AA-BB is grouped with BB-AA, as the two both describe more generic traffic flows between area AA and area BB.

Category (Threshold 5%)	Area Pairs	Flights	Area Pairs %	Flights %
Unaffected	4565	18 651 624	66.7%	88.3%
Unassigned	695	896 050	10.2%	4.2%
Affected	1581	1 572 567	23.1%	7.4%
Total	6841	21 120 241	100.0%	100.0%

Table 5: 3-ways categorisation based on area pairs with 5% threshold.

Category (Threshold 5%)	Area Pairs	Flights	Area Pairs %	Flights %
Unimpacted	4 565	18 651 624	6.7%	88.3%
Impacted	2 276	2 468 617	33.3%	11.9%
Total	6 841	21 120 241	100.0%	100.0%

Table 6: 2-ways categorisation based on area pairs with 5% threshold.

The results of applying the modified categorisation on the previous dataset are shown in Table 5 and Table 6, and can be compared with the results in Table 2 and Table 4 of the previous section. The conservative categorisation in this case leans slightly more towards the assignment to impacted than when considering the airport pairs.

This is to be expected as the areas defined via the two letter codes could be quite broad and the threshold used is still quite high.

It should be noted that for some airport pairs, the categorisation might be different between the two approaches, as the traffic between the airport pair would be part of the entire traffic flow between areas.

In those cases, we give priority to the categorisation based on the airport pair by following a sequential order, as explained in the next section.

3.5 Summary of steps for assignment of unimpacted status to a flight

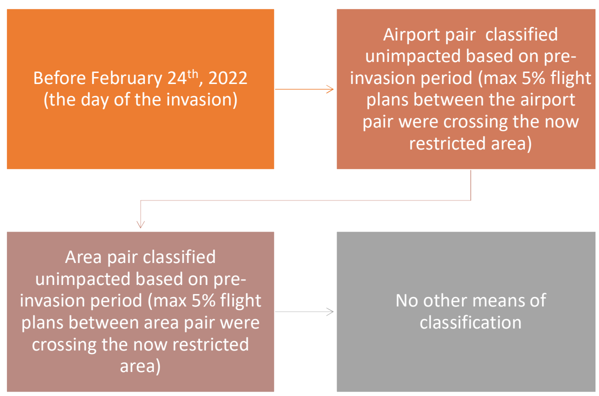


Figure 3: Steps for assignment of unimpacted status to flight

The process of assigning the unimpacted status to flights follows a sequential order illustrated in Figure 3, therefore establishing a priority between the different ways in which a flight can be considered impacted or not.

Flights before February the 24th 2022 are considered all unimpacted because the restrictions were not active.

For flights after that date the assignment is made first on the more detailed information, i.e., the airport pair. The airport pair has been classified as unimpacted if, in the period pre-invasion, maximum 5% of the flights between the airport pair filed to cross the now restricted area.

If that information is not available because there were no flight plans between the airport pair in the pre-invasion period[22], then the assignment is made on the basis of the area pair. The area pair has been classified as unimpacted if, in the period pre-invasion, maximum 5% of the flights filed to cross the now restricted area.

If the category of the area pair is also unknown, lacking any other information it is assumed that the flight would not be operated if particularly inefficient. The flight is therefore assigned to the unimpacted category[23].

3.6 Correction applied to the indicator

As mentioned in the background section, the role of the achieved distances in the HFE indicator is to account for the additional distance which is implied by the location of two local points, such as for example the points of entry into and exit out of an airspace, with respect to the overall flight, in turn characterised by the location of the origin and destination.

The achieved distance is essentially a projection on the shortest path, so that to every possible location corresponds an achieved value between 0 and the great circle distance between the origin and destination.

[22] If the airport pair is known, it has been classified as impacted if, in the period pre-invasion, more than 5% of the flights between the airport pair filed to cross the now restricted area. Thus, at this stage it must be an airport pair which was not present in the period pre-invasion.

[23] The assumption compensates somewhat the small bias towards assuming that the flight has been impacted of the previous two steps.

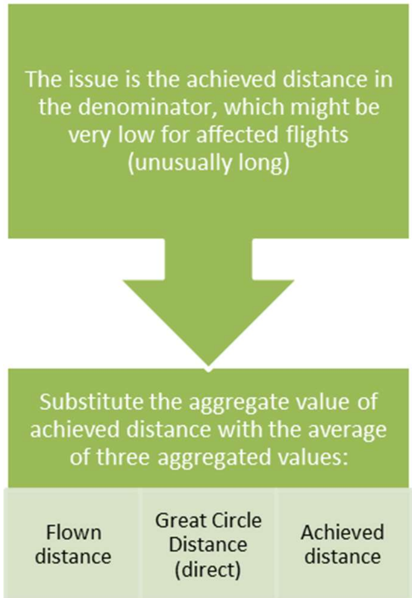


Figure 4: Correction applied to the indicator.

The implicit redistribution of the additional distances is over the whole length of the flight and is slightly more pronounced near the origin and destination of the flight[24], and when the trajectory is far from the shortest path[25].

The more central is the portion of the flight[26], the closer the value of distance and achieved distance between the two points (i.e., the additional distance is closer to zero).

One effect of moving the origin/destination to the border of the area instead of the airports is therefore to have in general lower achieved values with respect to those corresponding to the airports. On the other hand, the points might be better aligned.

As the adopted indicator makes the comparison between flown and achieved based on the ratio, the decrease in the value of the achieved distance is amplified by the use of the achieved distance also in the denominator.

The impacted flights will all be flights for which the origin or destination has been moved on the border, for which the achieved distance is probably reduced.

The correction therefore must be a heuristic one to be applied on the aggregate values. The one proposed is to keep the achieved distance (whose difference from the flown distance would still provide the correct value of the additional distance between origin and destination), but to limit the influence in the denominator by using an average of the flown, direct, and achieved distances in the denominator (the value of the average will necessarily be higher, and the correction will lead to a lower value of the indicator). This correction is applied only for the impacted flights.

4 RESULTS

The first results presented are the KEA values for the year 2022 before and after the proposed correction, and the value of the correction itself.

Table 7 and Figure 5 give a summary per State of those values (plus the value for the entire SES area). In Figure 5, which presents the areas in descending order of the impact of the war on the indicator (year 2022), the value in the white font and the length of the red bar correspond to the correction applied, the blue bar length corresponds to the KEA value after correction and the value in the black font correspond to the value of the KEA indicator (i.e., the sum of the two other values).

[24] They are the two reference points for the calculation of the achieved distances, and the same weight of ½ is given to the distance from origin and distance from destination.

[25] Being far from the shortest path implies more additional distance because it means more effort to join origin and destination.

[26] That is, the farther it is from both origin and destination.

Area	Impact of war	Corr. KEA	KEA 2022
Austria	0.16%	1.93%	2.09%
Belgium	0.07%	3.46%	3.53%
Bulgaria	1.19%	2.09%	3.28%
Croatia	0.06%	1.43%	1.49%
Cyprus	0.57%	3.64%	4.21%
Czech Republic	0.32%	2.23%	2.55%
Denmark	0.10%	1.13%	1.23%
Estonia	3.26%	2.20%	5.46%
Finland	1.73%	1.55%	3.28%
France	0.03%	3.25%	3.28%
Germany	0.14%	2.62%	2.76%
Greece	0.13%	2.20%	2.33%
Hungary	0.76%	1.41%	2.17%
Ireland	0.03%	1.09%	1.12%
Italy	0.04%	2.94%	2.98%
Latvia	3.73%	2.53%	6.26%
Lithuania	7.56%	4.65%	12.21%
Malta	0.05%	1.85%	1.90%
Netherlands	0.10%	2.94%	3.04%
Norway	0.08%	1.24%	1.32%
Poland	2.30%	2.49%	4.79%
Portugal	0.00%	1.52%	1.52%
Romania	1.63%	1.73%	3.36%
Slovakia	1.78%	2.26%	4.04%
Slovenia	0.09%	1.63%	1.72%
Spain	0.02%	3.30%	3.32%
Sweden	0.52%	1.18%	1.70%
Switzerland	0.05%	4.46%	4.51%
SES Area	**0.24%**	**2.72%**	**2.96%**

Table 7: Quantification of impact of war on indicator value for SES States

The following subsections provide the detail at the monthly level for the entire year 2022 and up until the end of May for year 2023, presented in two graphs.

The first graph shows the total number of flights considered (blue bar) and the number of flights which have been considered impacted (orange bar), together with the share of this value over the total number of flights (grey line, right vertical axis). The second graph shows the value of the monthly HFE, both with the current indicator (orange dots) and the corrected one (blue dots). It also shows the value of KEA on the last day of the month (grey bar).

The numerical values are provided in the tables at the bottom of the graphs.

In the future these values will be generated and made available as part of the regular update of the AIU portal, so that stakeholders' activities (e.g., monitoring and target setting for regulatory purposes) can be supported by up-to-date information.

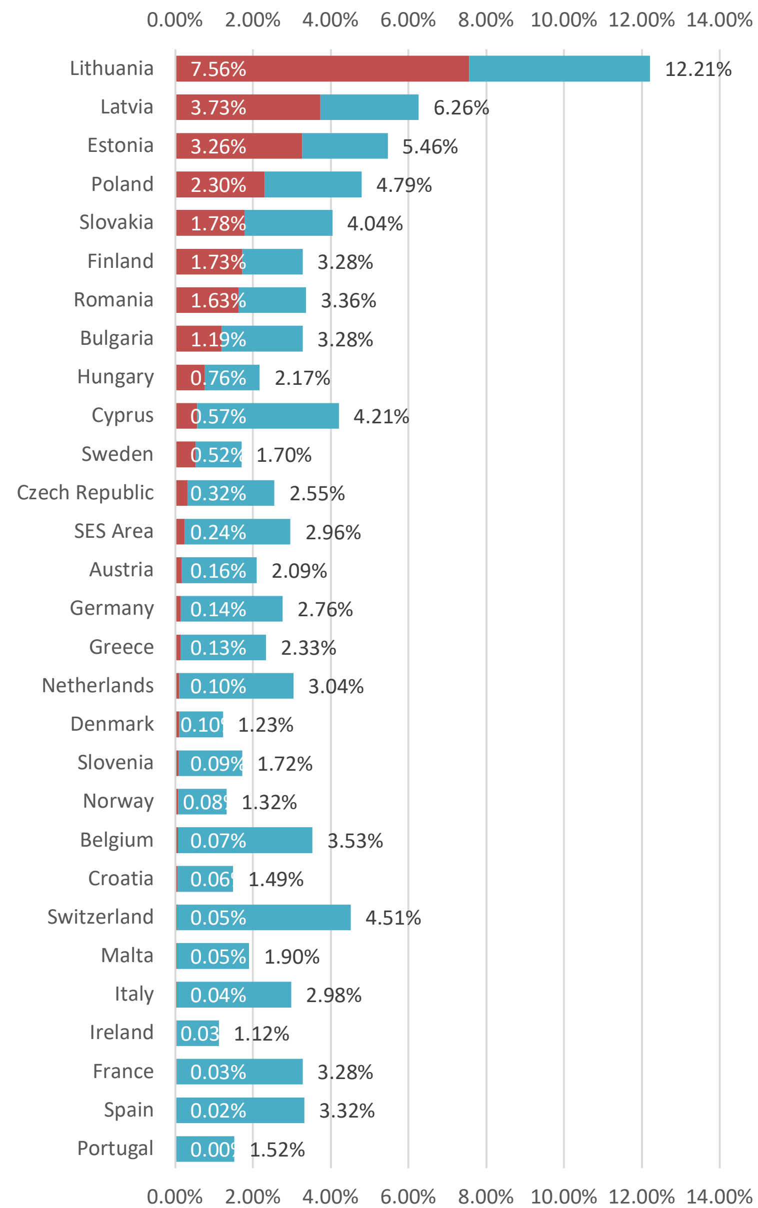
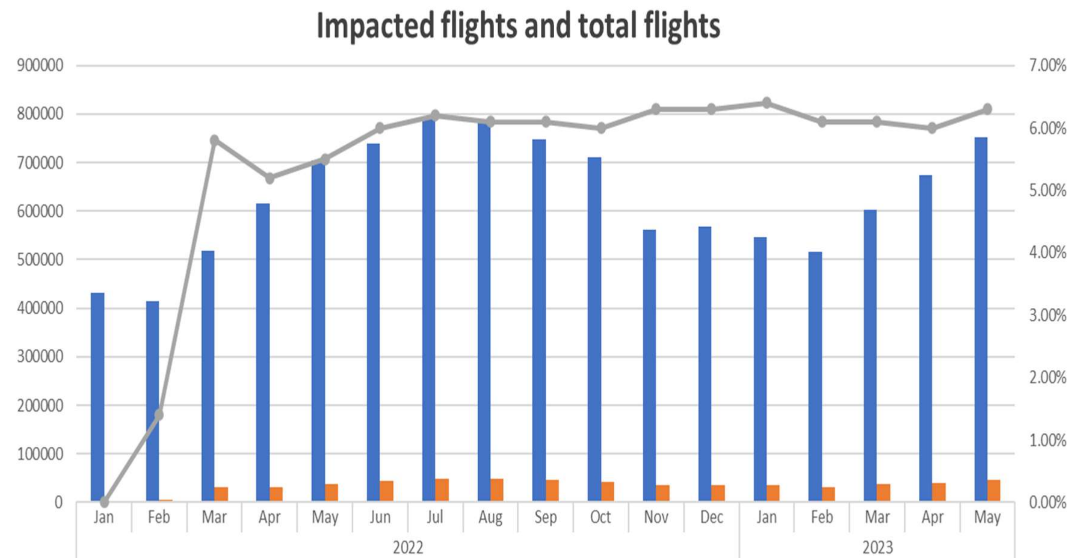


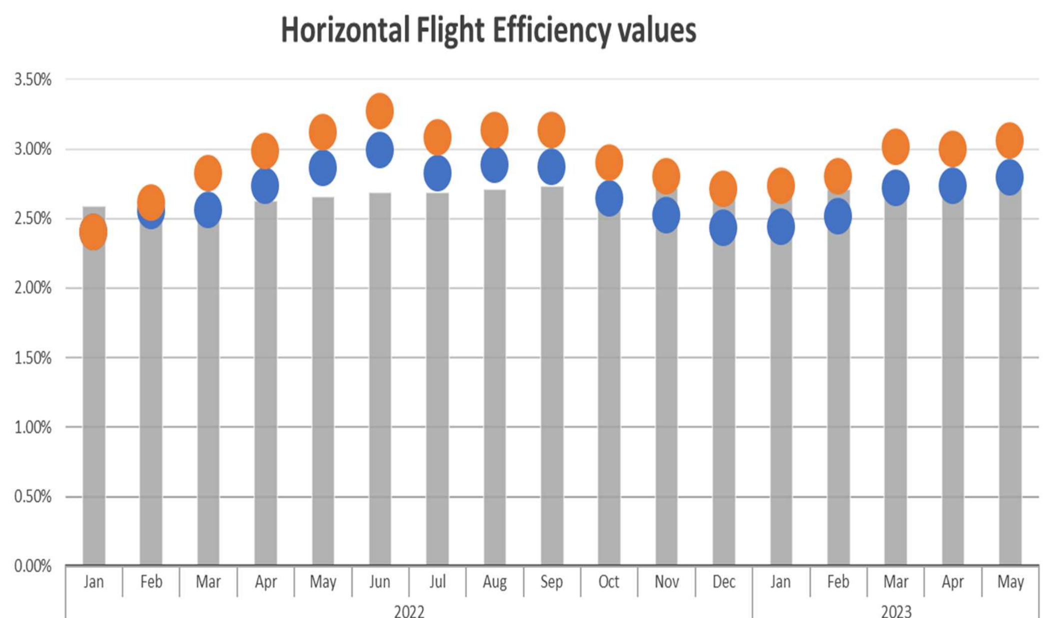
Figure 5: Impact of war on KEA indicator per State, 2022

Areas presented in descending order of the impact of the war on the indicator (year 2022).
The value in the white font and the length of the red bar correspond to the correction applied.
The blue bar length corresponds to the KEA value after correction.
The value in the black font correspond to the value of the KEA indicator, uncorrected (i.e., the sum of the two other values).

4.1 SES Area

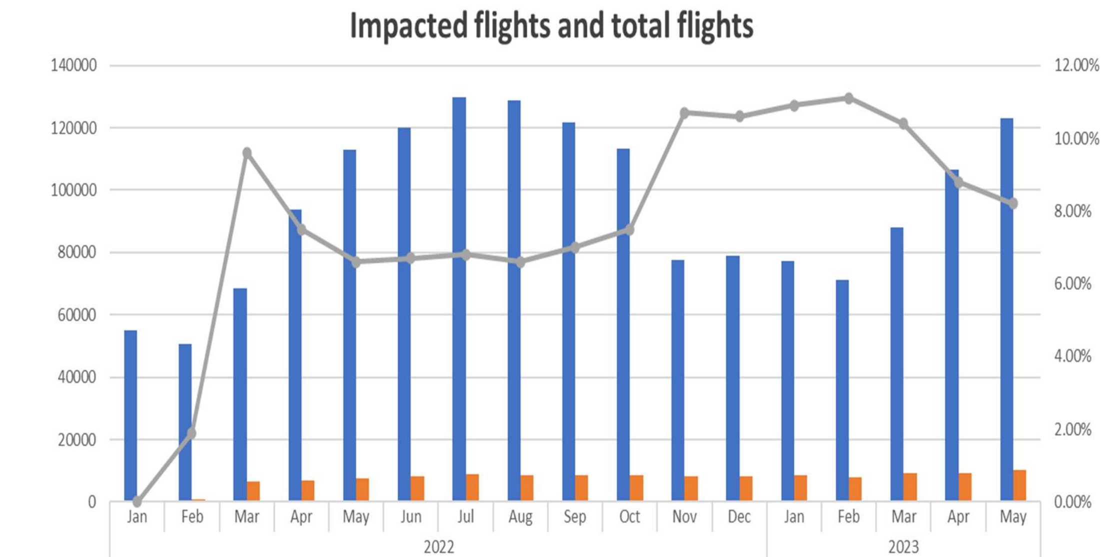


	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023
Flights	430944	414330	518266	616233	703831	740018	790416	788925	747339	710564	561102	568673	547169	516367	602973	674356	751106
Impacted Flights	0	5914	30131	32222	38590	44441	48978	47809	45399	42324	35184	35854	35210	31431	36705	40616	46946
Impacted %	0.00%	1.40%	5.80%	5.20%	5.50%	6.00%	6.20%	6.10%	6.10%	6.00%	6.30%	6.30%	6.40%	6.10%	6.10%	6.00%	6.30%

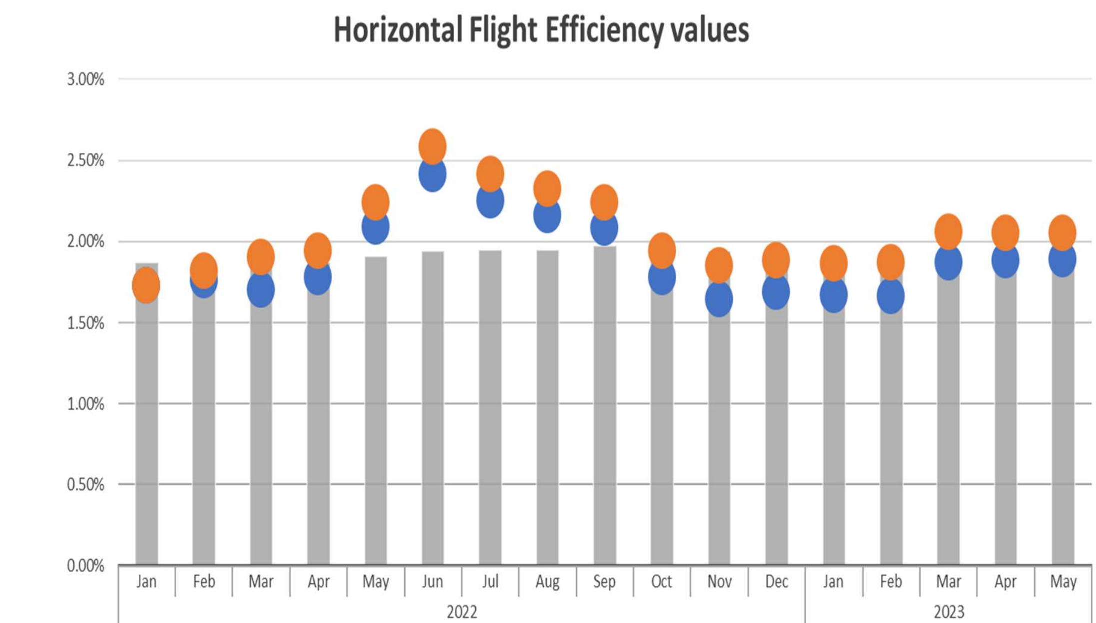


	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023
Corrected KEA	2.59%	2.60%	2.61%	2.63%	2.66%	2.69%	2.69%	2.71%	2.73%	2.73%	2.72%	2.72%	2.71%	2.71%	2.72%	2.72%	2.72%
HFE (corrected)	2.40%	2.55%	2.56%	2.73%	2.86%	2.99%	2.82%	2.88%	2.87%	2.64%	2.52%	2.43%	2.44%	2.51%	2.72%	2.73%	2.79%
HFE	2.40%	2.61%	2.82%	2.98%	3.12%	3.27%	3.08%	3.13%	3.13%	2.90%	2.80%	2.71%	2.73%	2.80%	3.01%	3.00%	3.06%

4.2 Austria

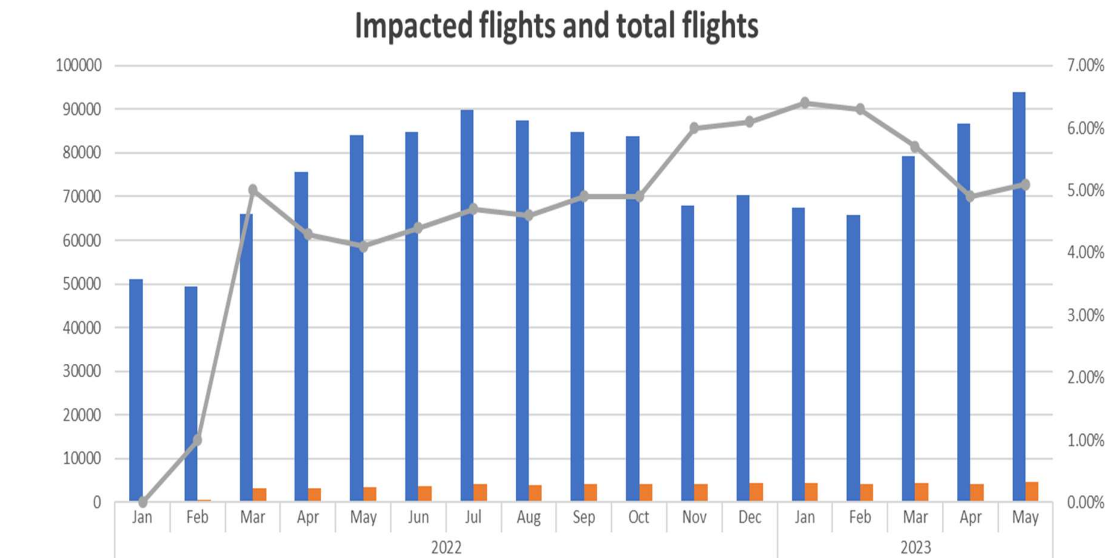


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Flights	55023	50646	68655	93657	112840	120160	129745	128887	121616	113358	77575	79015	77356	71071	87871	106540	123100
Impacted Flights	0	954	6618	7012	7433	8105	8817	8477	8476	8506	8334	8358	8412	7901	9110	9368	10084
Impacted %	0.00%	1.90%	9.60%	7.50%	6.60%	6.70%	6.80%	6.60%	7.00%	7.50%	10.70%	10.60%	10.90%	11.10%	10.40%	8.80%	8.20%



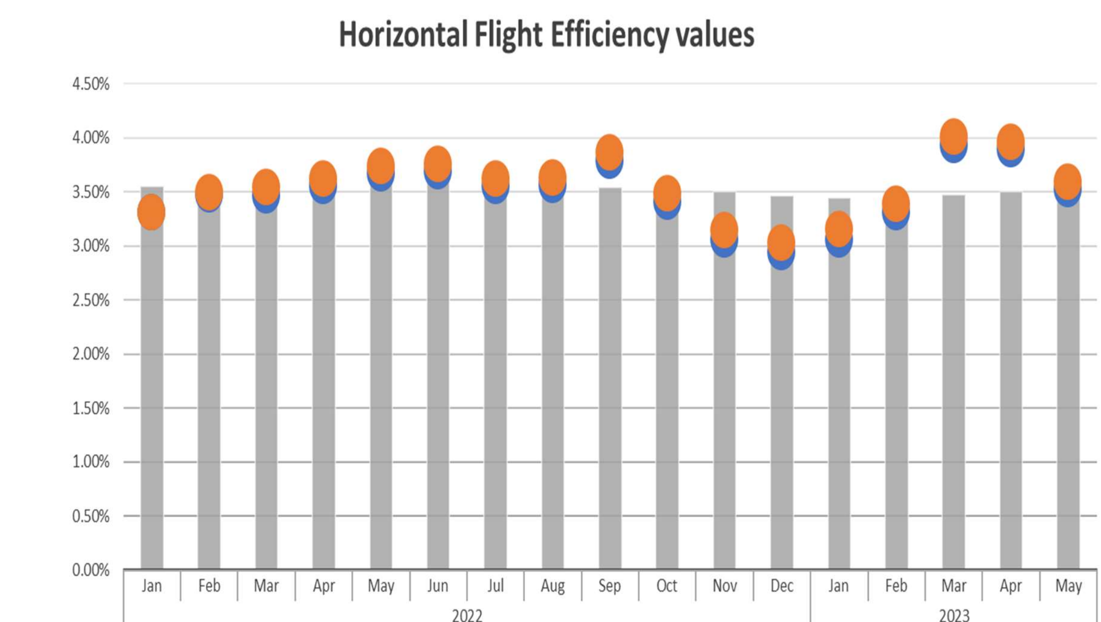
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Corrected KEA	1.87%	1.87%	1.87%	1.87%	1.91%	1.94%	1.95%	1.95%	1.97%	1.96%	1.94%	1.93%	1.93%	1.92%	1.93%	1.93%	1.91%
HFE (corrected)	1.73%	1.76%	1.70%	1.78%	2.09%	2.41%	2.25%	2.16%	2.08%	1.78%	1.64%	1.69%	1.67%	1.66%	1.87%	1.88%	1.89%
HFE	1.73%	1.82%	1.90%	1.94%	2.24%	2.58%	2.41%	2.32%	2.24%	1.94%	1.85%	1.88%	1.86%	1.87%	2.06%	2.05%	2.05%

4.3 Belgium



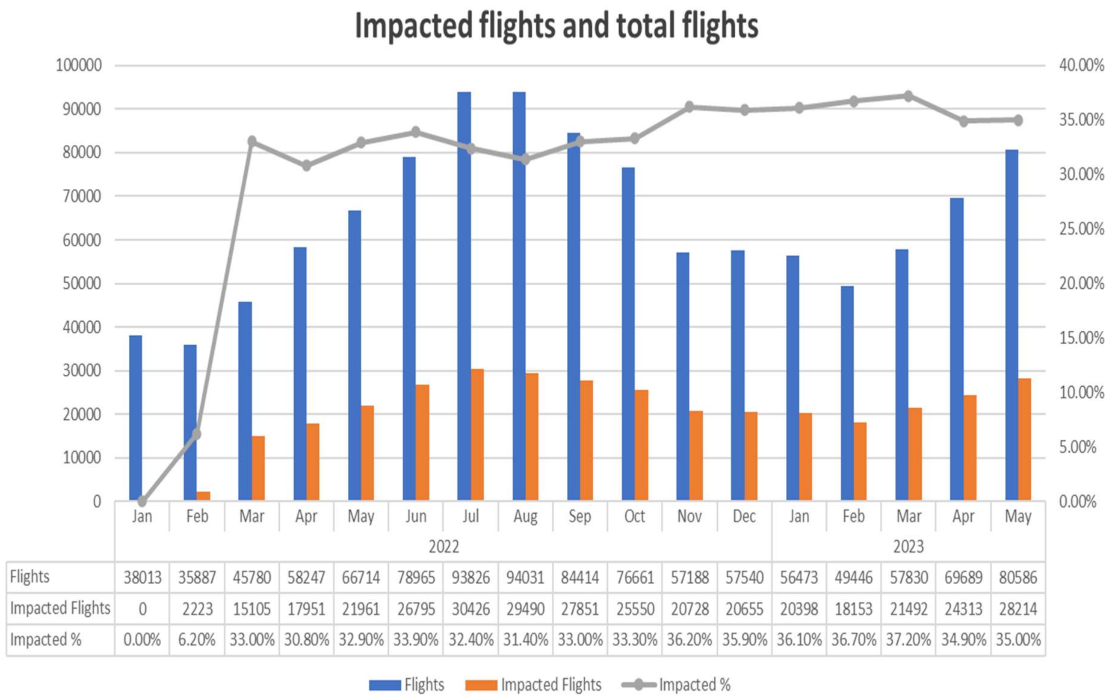
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Flights	51108	49417	65936	75551	84056	84811	89926	87421	84784	83798	67954	70223	67498	65702	79360	86755	93918
Impacted Flights	0	493	3270	3248	3440	3724	4195	4054	4132	4106	4086	4313	4352	4107	4537	4240	4774
Impacted %	0.00%	1.00%	5.00%	4.30%	4.10%	4.40%	4.70%	4.60%	4.90%	4.90%	6.00%	6.10%	6.40%	6.30%	5.70%	4.90%	5.10%

Flights Impacted Flights Impacted %

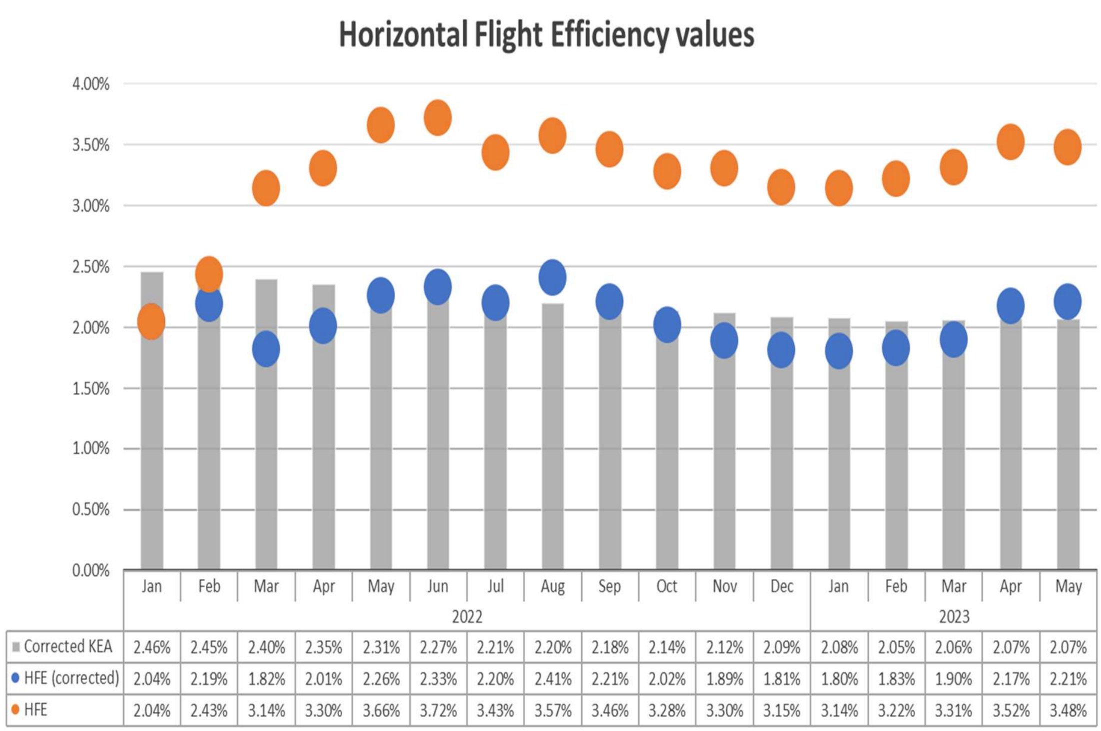


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Corrected KEA	3.55%	3.57%	3.57%	3.58%	3.61%	3.60%	3.56%	3.54%	3.54%	3.52%	3.50%	3.46%	3.44%	3.43%	3.47%	3.50%	3.49%
HFE (corrected)	3.31%	3.47%	3.46%	3.55%	3.67%	3.69%	3.55%	3.56%	3.78%	3.41%	3.06%	2.94%	3.06%	3.31%	3.93%	3.89%	3.52%
HFE	3.31%	3.49%	3.54%	3.62%	3.74%	3.76%	3.62%	3.63%	3.86%	3.48%	3.14%	3.03%	3.15%	3.39%	4.01%	3.96%	3.59%

4.4 Bulgaria

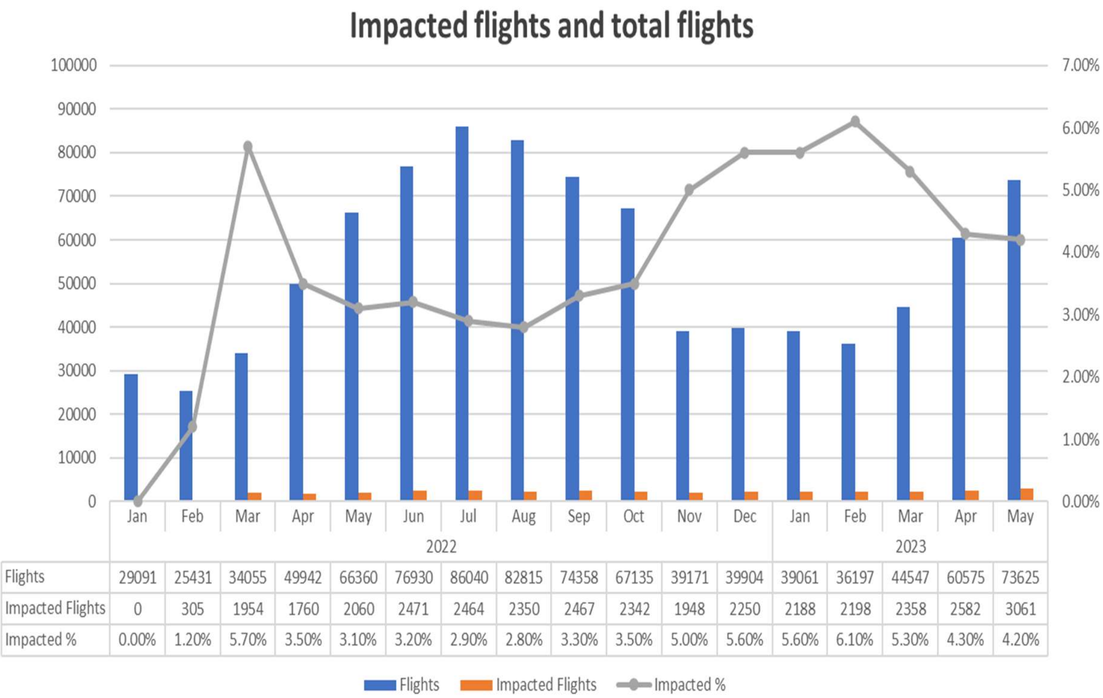


	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023
Flights	38013	35887	45780	58247	66714	78965	93826	94031	84414	76661	57188	57540	56473	49446	57830	69689	80586
Impacted Flights	0	2223	15105	17951	21961	26795	30426	29490	27851	25550	20728	20655	20398	18153	21492	24313	28214
Impacted %	0.00%	6.20%	33.00%	30.80%	32.90%	33.90%	32.40%	31.40%	33.00%	33.30%	36.20%	35.90%	36.10%	36.70%	37.20%	34.90%	35.00%

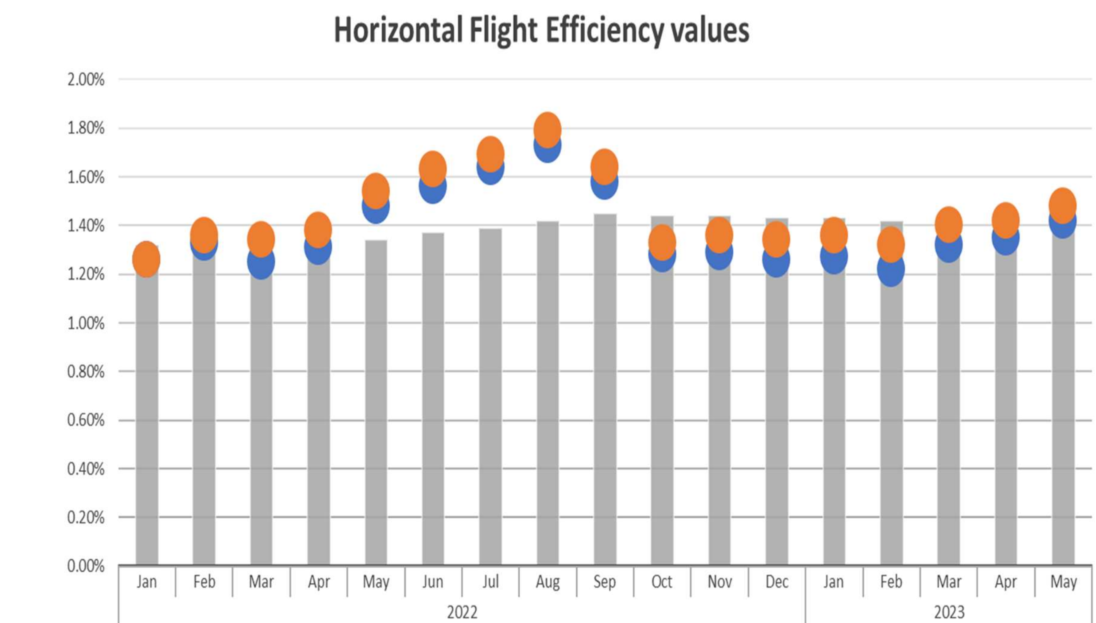


	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023
Corrected KEA	2.46%	2.45%	2.40%	2.35%	2.31%	2.27%	2.21%	2.20%	2.18%	2.14%	2.12%	2.09%	2.08%	2.05%	2.06%	2.07%	2.07%
HFE (corrected)	2.04%	2.19%	1.82%	2.01%	2.26%	2.33%	2.20%	2.41%	2.21%	2.02%	1.89%	1.81%	1.80%	1.83%	1.90%	2.17%	2.21%
HFE	2.04%	2.43%	3.14%	3.30%	3.66%	3.72%	3.43%	3.57%	3.46%	3.28%	3.30%	3.15%	3.14%	3.22%	3.31%	3.52%	3.48%

4.5 Croatia

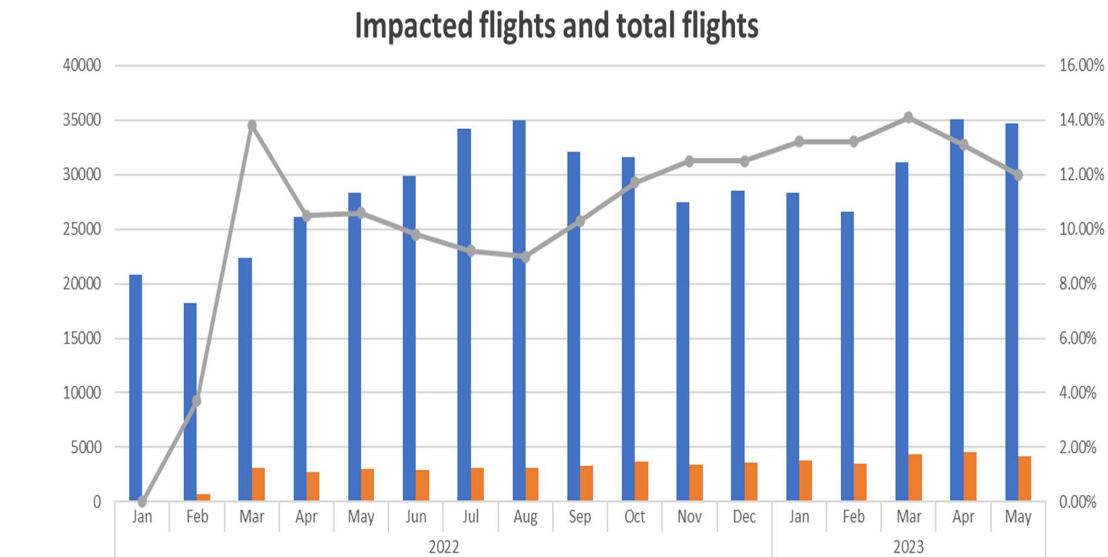


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Flights	29091	25431	34055	49942	66360	76930	86040	82815	74358	67135	39171	39904	39061	36197	44547	60575	73625
Impacted Flights	0	305	1954	1760	2060	2471	2464	2350	2467	2342	1948	2250	2188	2198	2358	2582	3061
Impacted %	0.00%	1.20%	5.70%	3.50%	3.10%	3.20%	2.90%	2.80%	3.30%	3.50%	5.00%	5.60%	5.60%	6.10%	5.30%	4.30%	4.20%

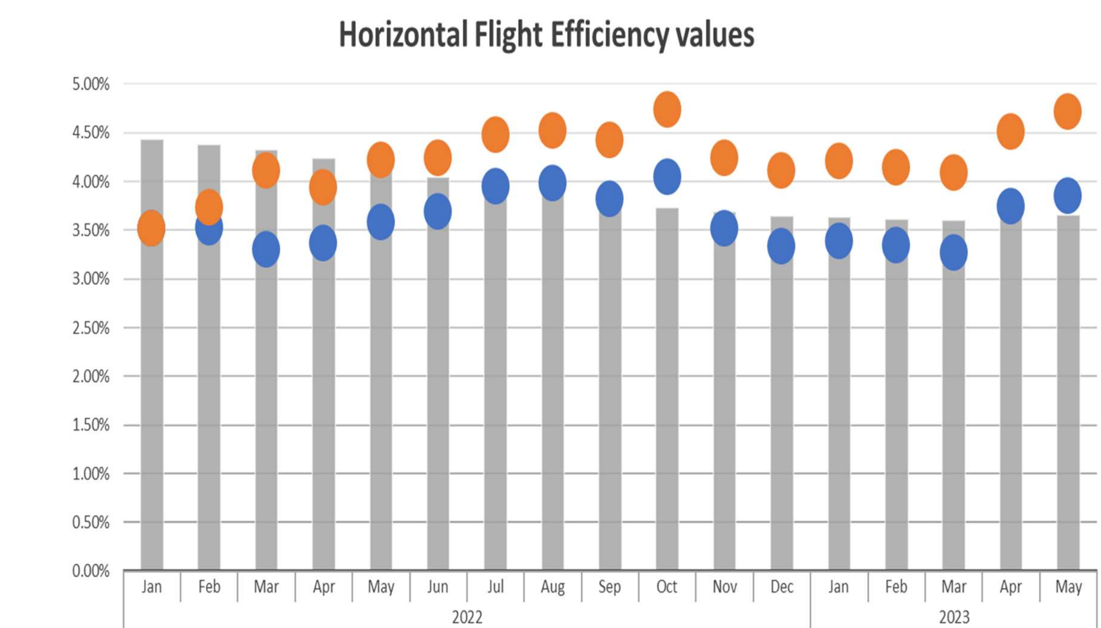


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Corrected KEA	1.32%	1.32%	1.32%	1.32%	1.34%	1.37%	1.39%	1.42%	1.45%	1.44%	1.44%	1.43%	1.43%	1.42%	1.42%	1.43%	1.42%
HFE (corrected)	1.26%	1.33%	1.25%	1.31%	1.48%	1.56%	1.64%	1.73%	1.58%	1.28%	1.29%	1.26%	1.27%	1.22%	1.32%	1.35%	1.42%
HFE	1.26%	1.36%	1.34%	1.38%	1.54%	1.63%	1.69%	1.79%	1.64%	1.33%	1.36%	1.34%	1.36%	1.32%	1.40%	1.42%	1.48%

4.6 Cyprus

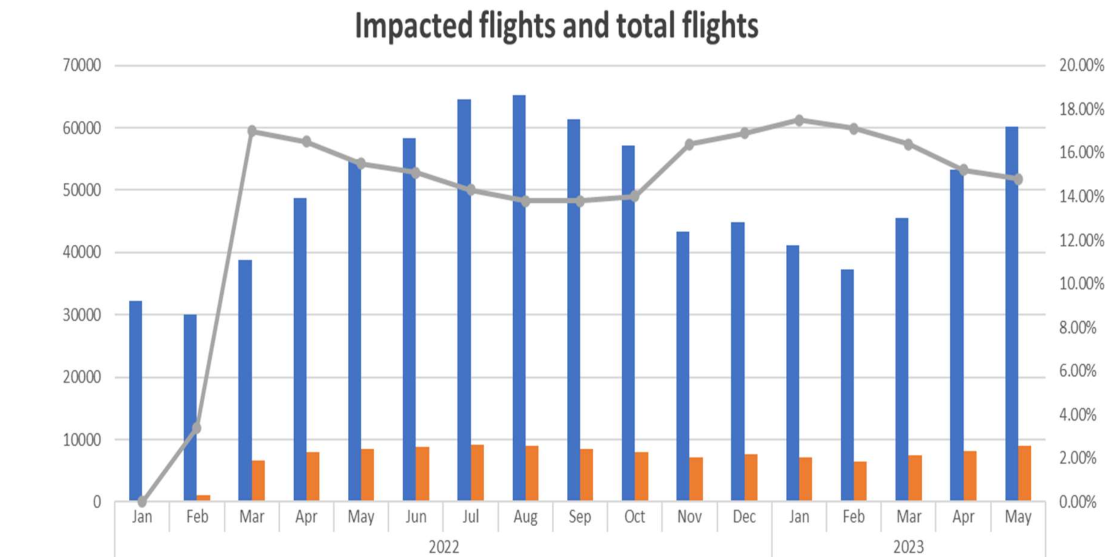


	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023
Flights	20823	18236	22350	26070	28297	29908	34216	34990	32096	31554	27493	28567	28360	26627	31078	35109	34713
Impacted Flights	0	677	3093	2736	3011	2929	3136	3143	3301	3677	3434	3559	3751	3503	4390	4595	4163
Impacted %	0.00%	3.70%	13.80%	10.50%	10.60%	9.80%	9.20%	9.00%	10.30%	11.70%	12.50%	12.50%	13.20%	13.20%	14.10%	13.10%	12.00%

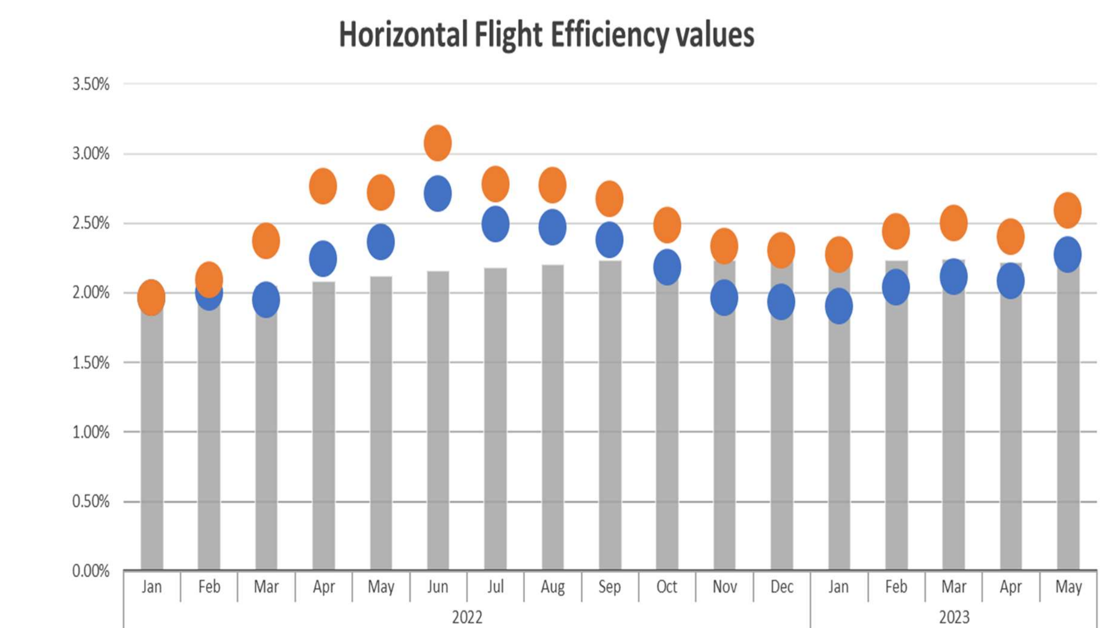


	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023
Corrected KEA	4.43%	4.38%	4.32%	4.24%	4.14%	4.04%	3.95%	3.88%	3.80%	3.73%	3.69%	3.64%	3.63%	3.61%	3.60%	3.63%	3.66%
HFE (corrected)	3.51%	3.53%	3.30%	3.36%	3.58%	3.69%	3.95%	3.98%	3.82%	4.04%	3.52%	3.33%	3.39%	3.34%	3.27%	3.74%	3.85%
HFE	3.51%	3.73%	4.11%	3.94%	4.22%	4.24%	4.48%	4.52%	4.42%	4.73%	4.24%	4.11%	4.21%	4.14%	4.09%	4.51%	4.71%

4.7 Czech Republic

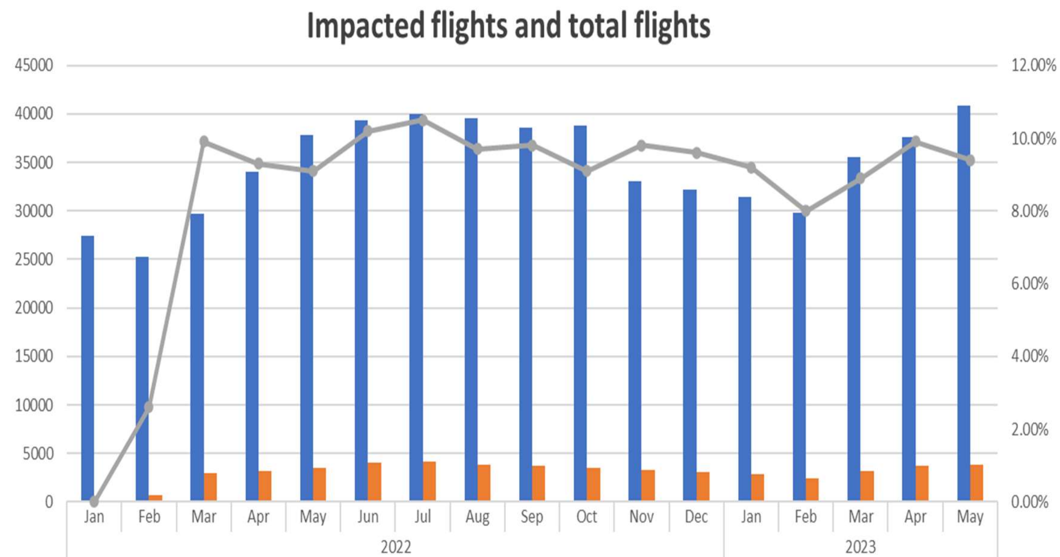


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	32265	30106	38733	48807	54932	58371	64598	65292	61423	57105	43405	44836	41185	37361	45575	53281	60154
Impacted Flights	0	1022	6580	8050	8531	8842	9245	9006	8451	7984	7116	7576	7188	6399	7492	8105	8921
Impacted %	0.00%	3.40%	17.00%	16.50%	15.50%	15.10%	14.30%	13.80%	13.80%	14.00%	16.40%	16.90%	17.50%	17.10%	16.40%	15.20%	14.80%

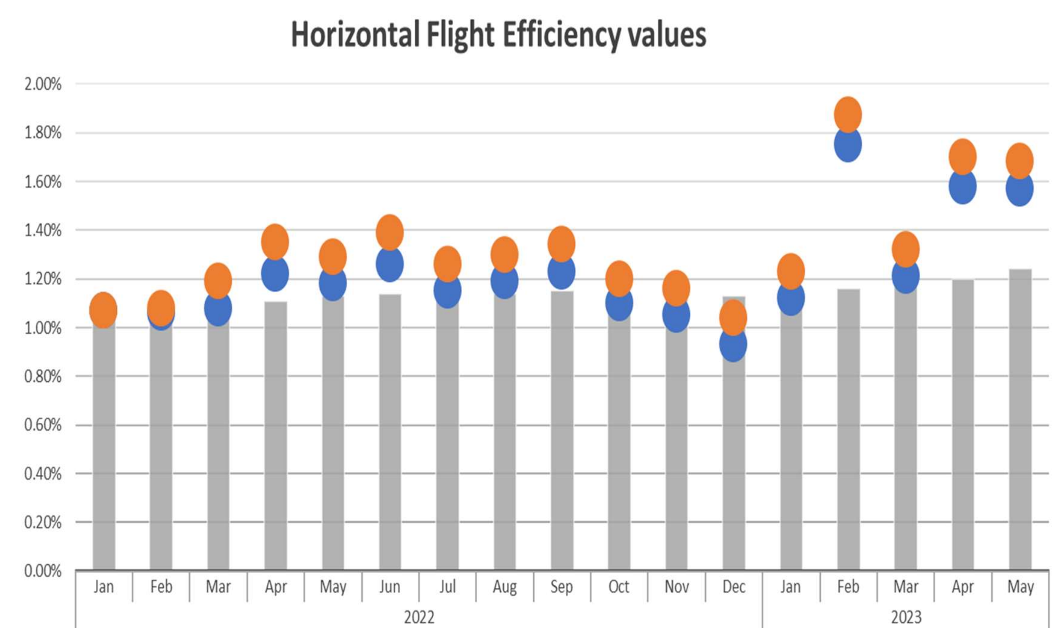


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	2.03%	2.04%	2.05%	2.08%	2.12%	2.16%	2.18%	2.20%	2.23%	2.24%	2.23%	2.23%	2.23%	2.23%	2.24%	2.22%	2.21%
HFE (corrected)	1.96%	2.00%	1.95%	2.24%	2.36%	2.71%	2.49%	2.47%	2.38%	2.18%	1.96%	1.93%	1.90%	2.04%	2.11%	2.08%	2.27%
HFE	1.96%	2.09%	2.37%	2.76%	2.72%	3.07%	2.78%	2.77%	2.67%	2.48%	2.33%	2.30%	2.27%	2.44%	2.50%	2.40%	2.59%

4.8 Denmark

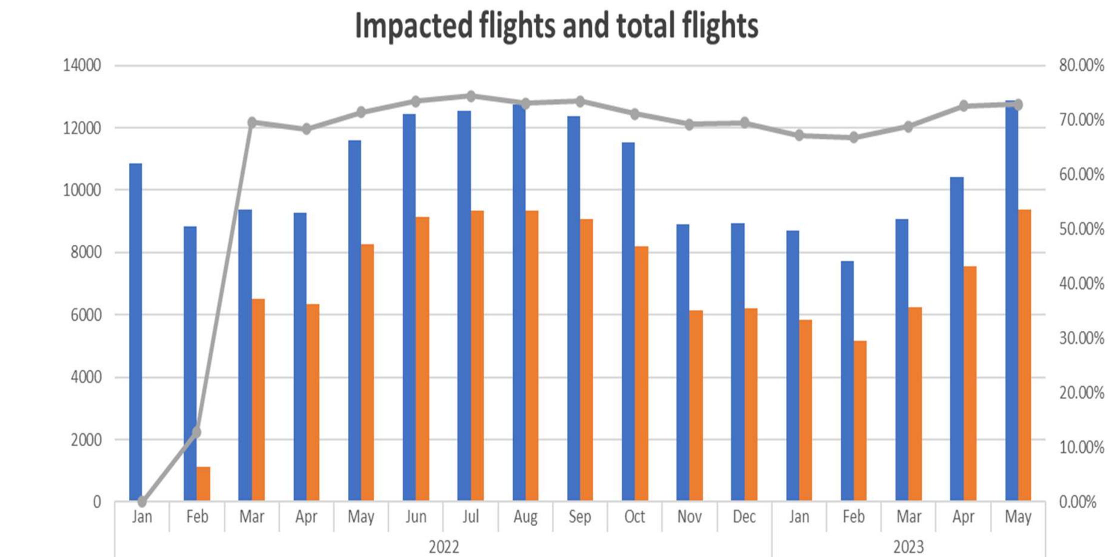


	2022 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2023 Jan	Feb	Mar	Apr	May
Flights	27406	25227	29753	33987	37838	39347	40025	39557	38529	38745	33044	32240	31468	29840	35570	37634	40823
Impacted Flights	0	658	2956	3157	3460	4000	4201	3821	3779	3513	3253	3099	2905	2389	3152	3731	3819
Impacted %	0.00%	2.60%	9.90%	9.30%	9.10%	10.20%	10.50%	9.70%	9.80%	9.10%	9.80%	9.60%	9.20%	8.00%	8.90%	9.90%	9.40%



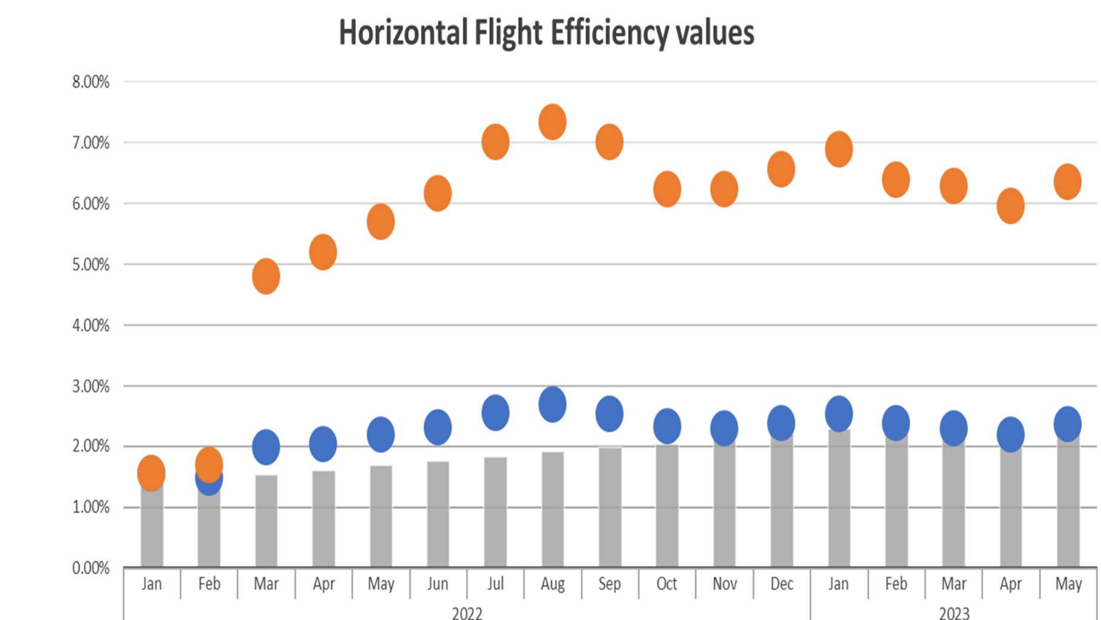
	2022 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2023 Jan	Feb	Mar	Apr	May
Corrected KEA	1.09%	1.09%	1.09%	1.11%	1.13%	1.14%	1.14%	1.14%	1.15%	1.14%	1.14%	1.13%	1.13%	1.16%	1.17%	1.20%	1.24%
HFE (corrected)	1.07%	1.06%	1.08%	1.22%	1.18%	1.26%	1.15%	1.19%	1.23%	1.10%	1.05%	0.93%	1.12%	1.75%	1.21%	1.58%	1.57%
HFE	1.07%	1.08%	1.19%	1.35%	1.29%	1.39%	1.26%	1.30%	1.34%	1.20%	1.16%	1.04%	1.23%	1.87%	1.32%	1.70%	1.68%

4.9 Estonia



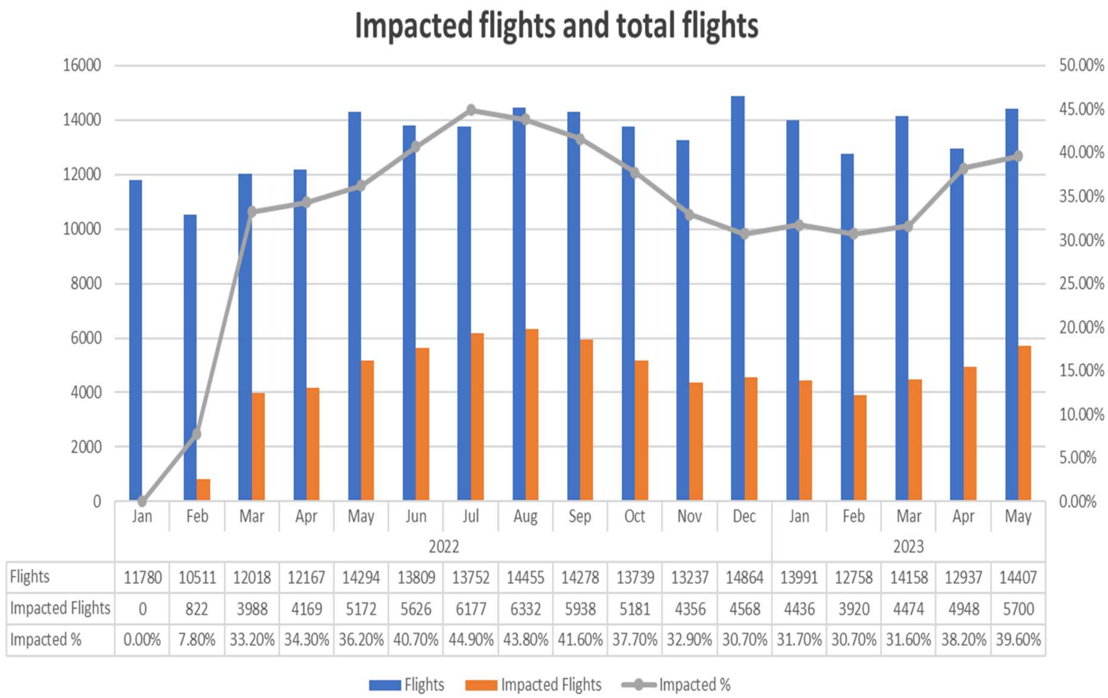
	Jan 2022	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2023	Feb	Mar	Apr	May
Flights	10842	8844	9366	9287	11600	12451	12556	12756	12360	11539	8892	8949	8712	7718	9065	10405	12881
Impacted Flights	0	1130	6521	6342	8281	9134	9337	9326	9069	8206	6151	6221	5853	5157	6238	7549	9392
Impacted %	0.00%	12.80%	69.60%	68.30%	71.40%	73.40%	74.40%	73.10%	73.40%	71.10%	69.20%	69.50%	67.20%	66.80%	68.80%	72.60%	72.90%

Flights, Impacted Flights, Impacted %

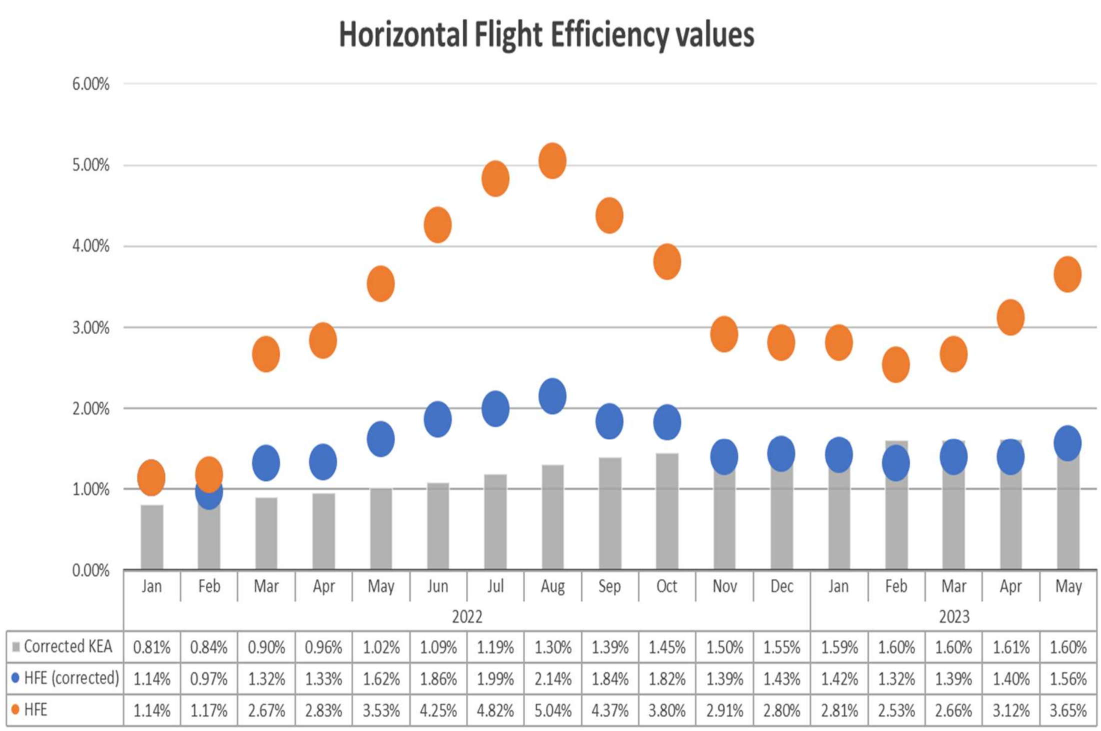


	Jan 2022	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2023	Feb	Mar	Apr	May
Corrected KEA	1.46%	1.48%	1.54%	1.60%	1.68%	1.75%	1.83%	1.91%	1.98%	2.03%	2.11%	2.20%	2.29%	2.36%	2.38%	2.39%	2.40%
HFE (corrected)	1.55%	1.48%	1.98%	2.04%	2.19%	2.31%	2.55%	2.69%	2.54%	2.33%	2.29%	2.38%	2.54%	2.38%	2.30%	2.18%	2.36%
HFE	1.55%	1.68%	4.79%	5.19%	5.69%	6.16%	7.01%	7.33%	7.00%	6.22%	6.23%	6.56%	6.89%	6.39%	6.28%	5.95%	6.34%

4.10 Finland

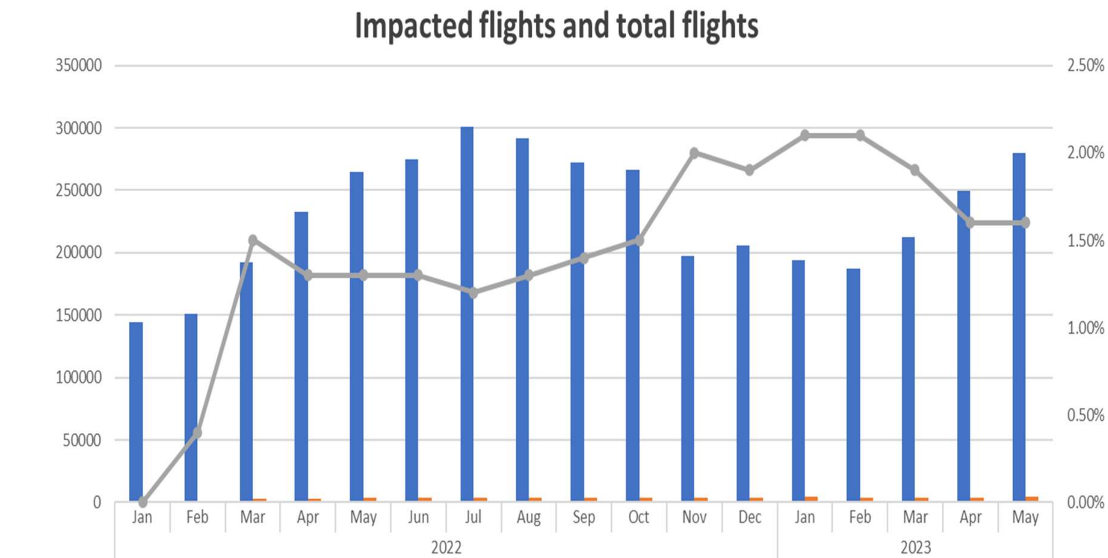


	2022 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2023 Jan	Feb	Mar	Apr	May
Flights	11780	10511	12018	12167	14294	13809	13752	14455	14278	13739	13237	14864	13991	12758	14158	12937	14407
Impacted Flights	0	822	3988	4169	5172	5626	6177	6332	5938	5181	4356	4568	4436	3920	4474	4948	5700
Impacted %	0.00%	7.80%	33.20%	34.30%	36.20%	40.70%	44.90%	43.80%	41.60%	37.70%	32.90%	30.70%	31.70%	30.70%	31.60%	38.20%	39.60%



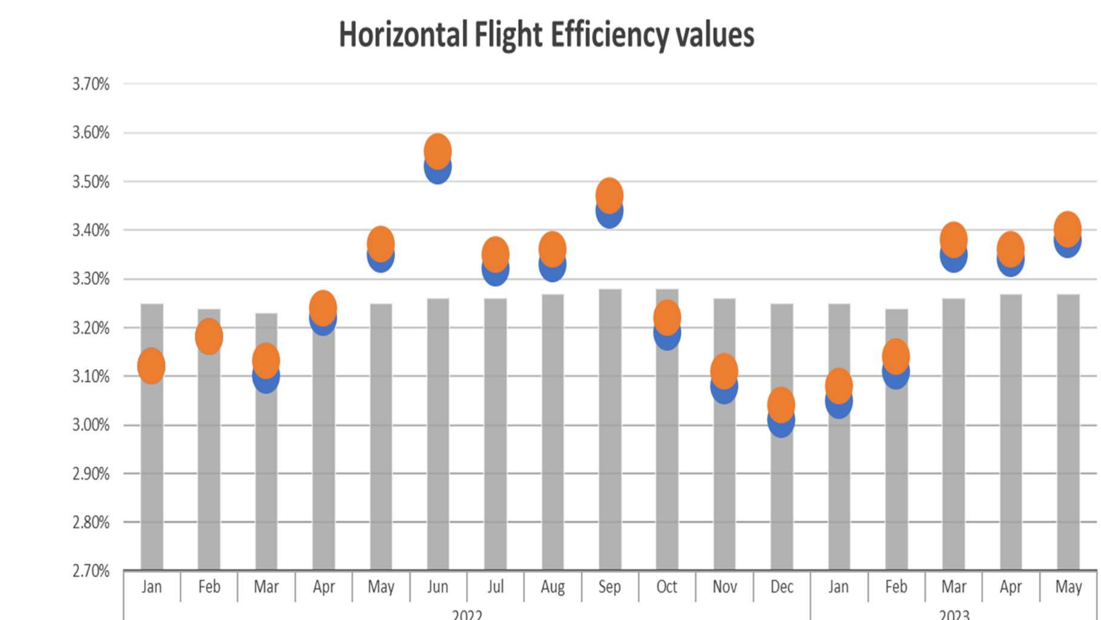
	2022 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2023 Jan	Feb	Mar	Apr	May
Corrected KEA	0.81%	0.84%	0.90%	0.96%	1.02%	1.09%	1.19%	1.30%	1.39%	1.45%	1.50%	1.55%	1.59%	1.60%	1.60%	1.61%	1.60%
HFE (corrected)	1.14%	0.97%	1.32%	1.33%	1.62%	1.86%	1.99%	2.14%	1.84%	1.82%	1.39%	1.43%	1.42%	1.32%	1.39%	1.40%	1.56%
HFE	1.14%	1.17%	2.67%	2.83%	3.53%	4.25%	4.82%	5.04%	4.37%	3.80%	2.91%	2.80%	2.81%	2.53%	2.66%	3.12%	3.65%

4.11 France



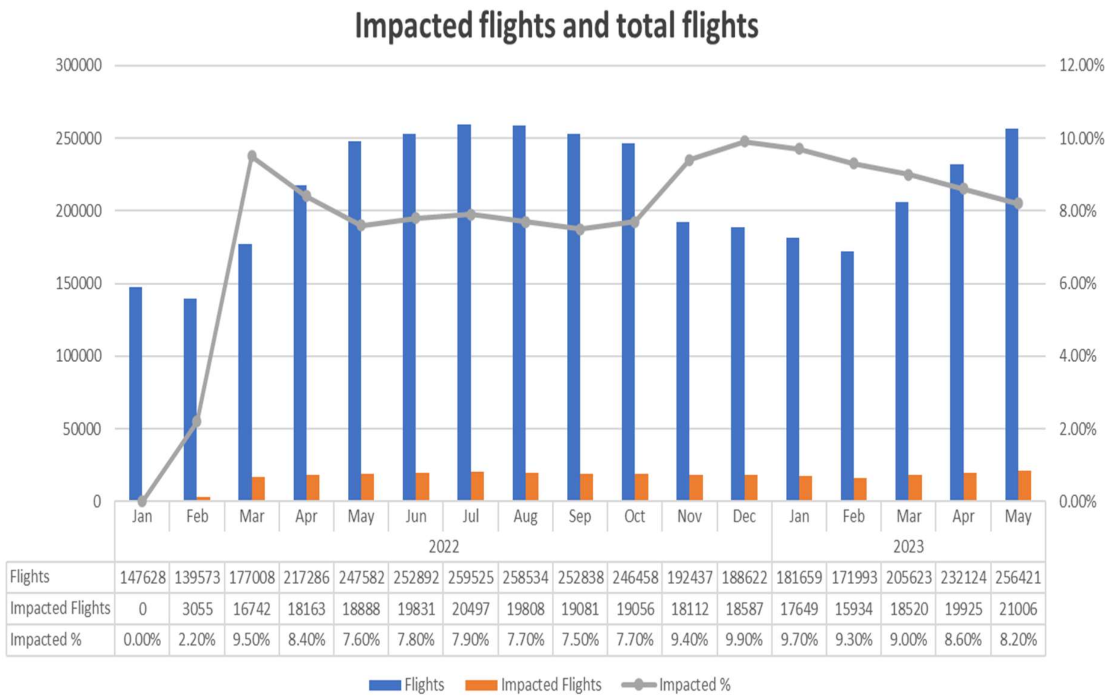
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	144545	151018	192116	232888	264918	274798	300803	291863	272389	266628	197370	205702	194311	187559	212120	249680	280266
Impacted Flights	0	593	2954	2920	3381	3640	3735	3763	3729	3947	3951	3993	4155	3867	4116	4014	4434
Impacted %	0.00%	0.40%	1.50%	1.30%	1.30%	1.30%	1.20%	1.30%	1.40%	1.50%	2.00%	1.90%	2.10%	2.10%	1.90%	1.60%	1.60%

Flights Impacted Flights Impacted %

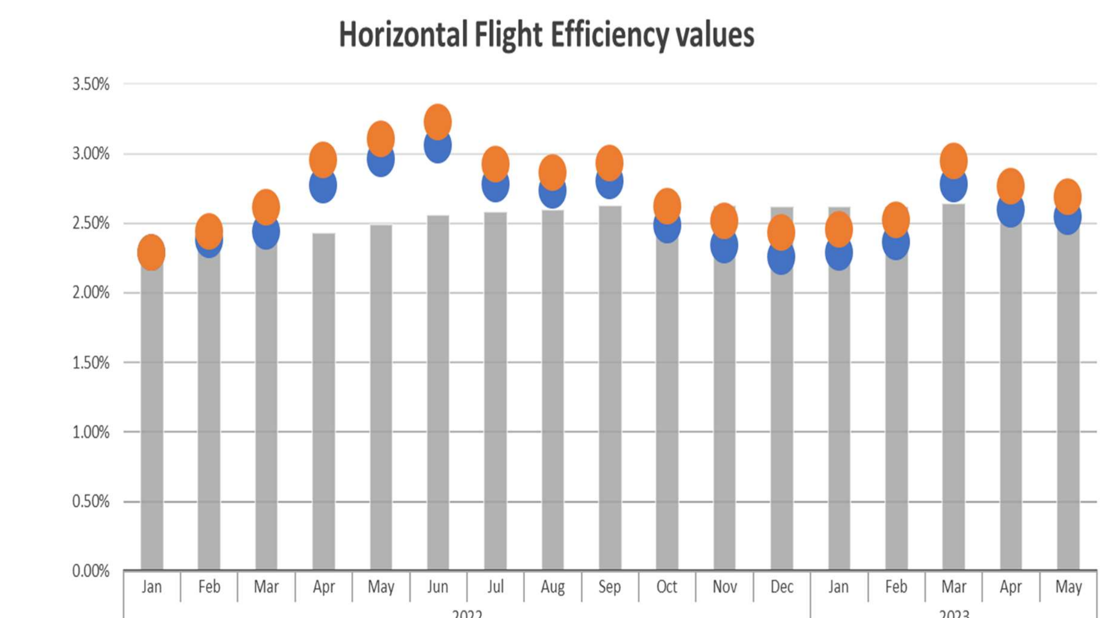


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	3.25%	3.24%	3.23%	3.24%	3.25%	3.26%	3.26%	3.27%	3.28%	3.28%	3.26%	3.25%	3.25%	3.24%	3.26%	3.27%	3.27%
HFE (corrected)	3.12%	3.18%	3.10%	3.22%	3.35%	3.53%	3.32%	3.33%	3.44%	3.19%	3.08%	3.01%	3.05%	3.11%	3.35%	3.34%	3.38%
HFE	3.12%	3.18%	3.13%	3.24%	3.37%	3.56%	3.35%	3.36%	3.47%	3.22%	3.11%	3.04%	3.08%	3.14%	3.38%	3.36%	3.40%

4.12 Germany

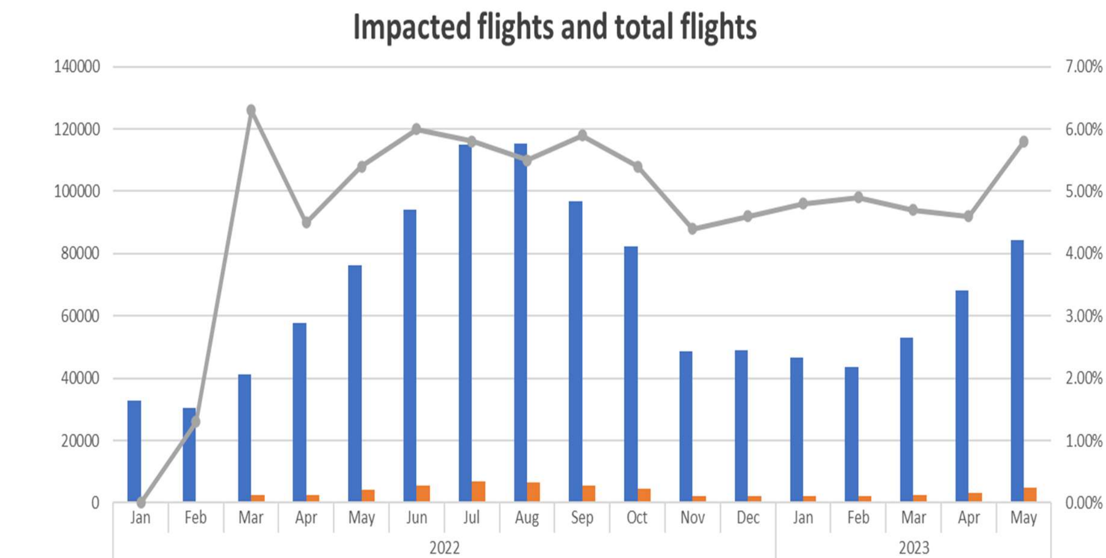


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	147628	139573	177008	217286	247582	252892	259525	258534	252838	246458	192437	188622	181659	171993	205623	232124	256421
Impacted Flights	0	3055	16742	18163	18888	19831	20497	19808	19081	19056	18112	18587	17649	15934	18520	19925	21006
Impacted %	0.00%	2.20%	9.50%	8.40%	7.60%	7.80%	7.90%	7.70%	7.50%	7.70%	9.40%	9.90%	9.70%	9.30%	9.00%	8.60%	8.20%

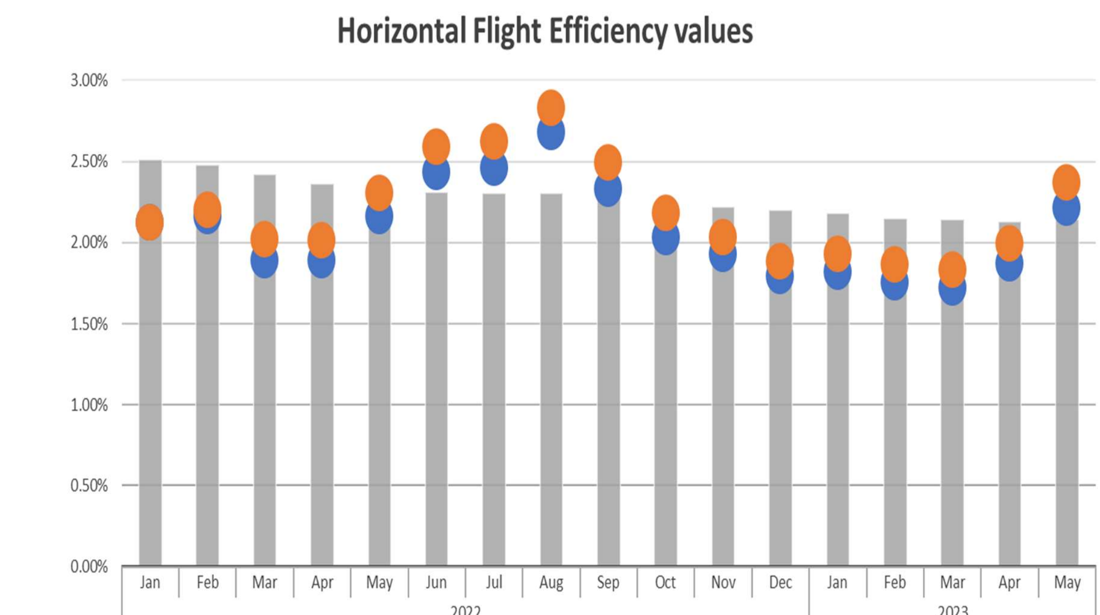


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	2.32%	2.34%	2.37%	2.43%	2.49%	2.56%	2.58%	2.60%	2.63%	2.64%	2.63%	2.62%	2.62%	2.62%	2.64%	2.63%	2.59%
HFE (corrected)	2.29%	2.38%	2.44%	2.77%	2.96%	3.06%	2.78%	2.73%	2.80%	2.48%	2.34%	2.26%	2.29%	2.36%	2.78%	2.60%	2.54%
HFE	2.29%	2.44%	2.61%	2.95%	3.10%	3.22%	2.92%	2.86%	2.93%	2.62%	2.51%	2.43%	2.45%	2.52%	2.94%	2.76%	2.69%

4.13 Greece

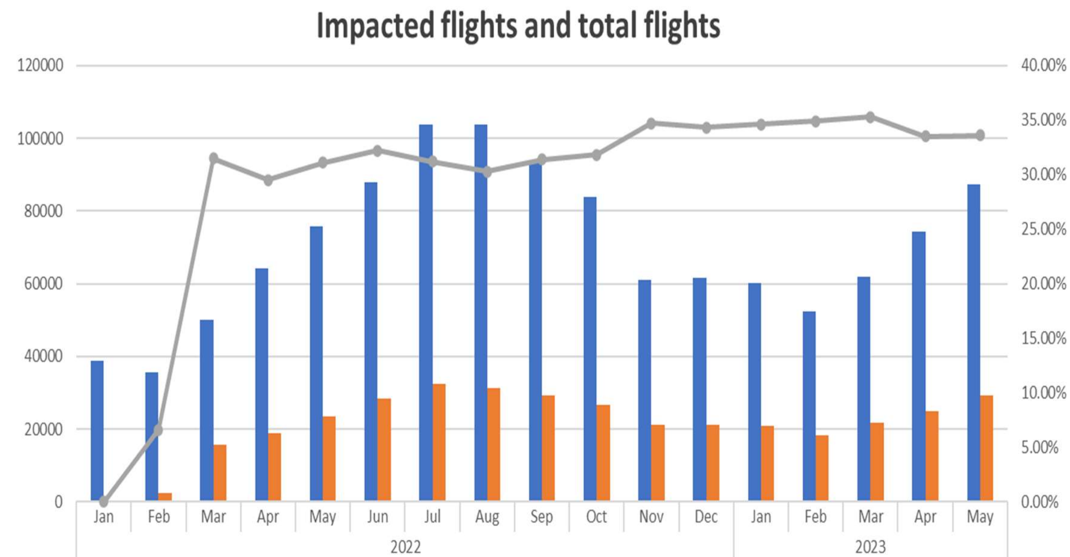


	2022 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2023 Jan	Feb	Mar	Apr	May
Flights	32848	30421	41298	57869	76089	94154	114989	115379	96741	82300	48611	48959	46566	43526	52972	68129	84481
Impacted Flights	0	398	2619	2580	4131	5658	6715	6382	5670	4467	2120	2269	2250	2139	2516	3156	4864
Impacted %	0.00%	1.30%	6.30%	4.50%	5.40%	6.00%	5.80%	5.50%	5.90%	5.40%	4.40%	4.60%	4.80%	4.90%	4.70%	4.60%	5.80%

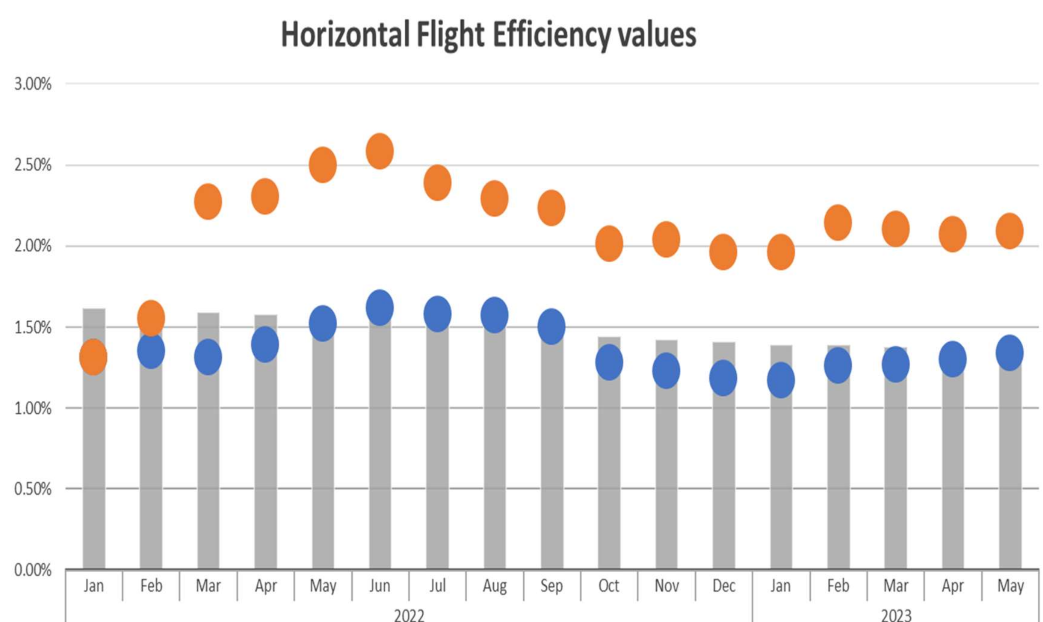


	2022 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2023 Jan	Feb	Mar	Apr	May
Corrected KEA	2.51%	2.48%	2.42%	2.36%	2.33%	2.31%	2.30%	2.30%	2.28%	2.24%	2.22%	2.20%	2.18%	2.15%	2.14%	2.13%	2.14%
HFE (corrected)	2.12%	2.16%	1.89%	1.89%	2.16%	2.43%	2.46%	2.68%	2.33%	2.03%	1.93%	1.79%	1.82%	1.75%	1.72%	1.87%	2.21%
HFE	2.12%	2.20%	2.02%	2.01%	2.30%	2.59%	2.62%	2.83%	2.49%	2.18%	2.03%	1.88%	1.93%	1.86%	1.83%	1.99%	2.37%

4.14 Hungary

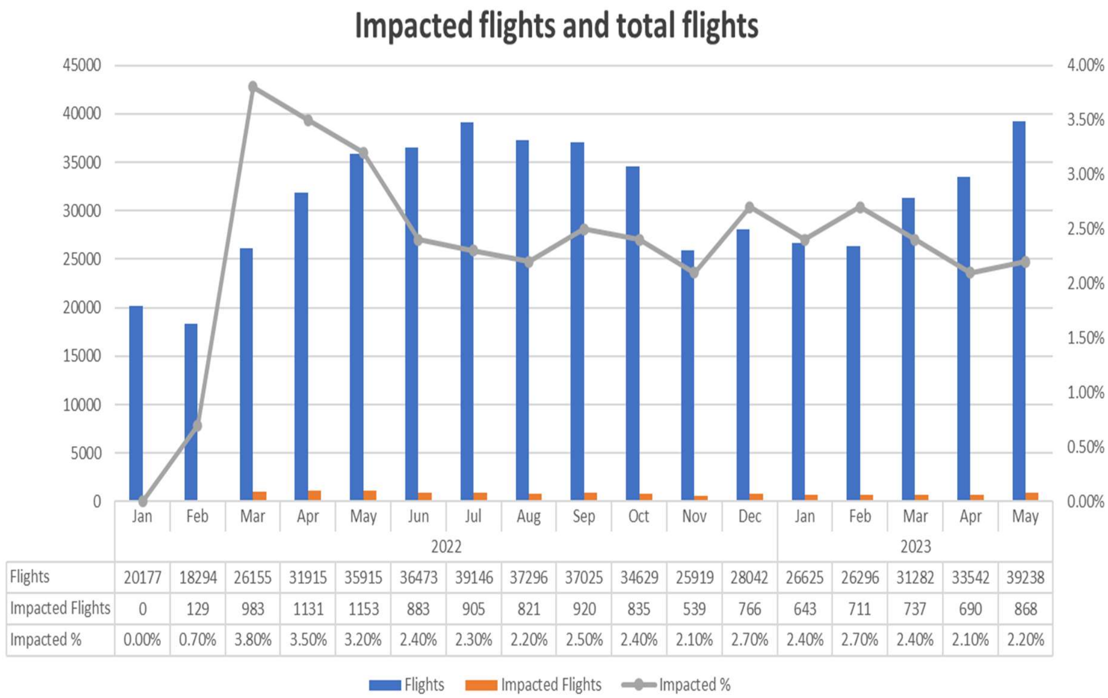


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Flights	38865	35628	50182	64278	75634	87986	103840	103720	93352	83894	61083	61496	60152	52454	61781	74211	87279
Impacted Flights	0	2359	15805	18981	23502	28332	32448	31405	29353	26664	21193	21102	20832	18284	21838	24870	29296
Impacted %	0.00%	6.60%	31.50%	29.50%	31.10%	32.20%	31.20%	30.30%	31.40%	31.80%	34.70%	34.30%	34.60%	34.90%	35.30%	33.50%	33.60%

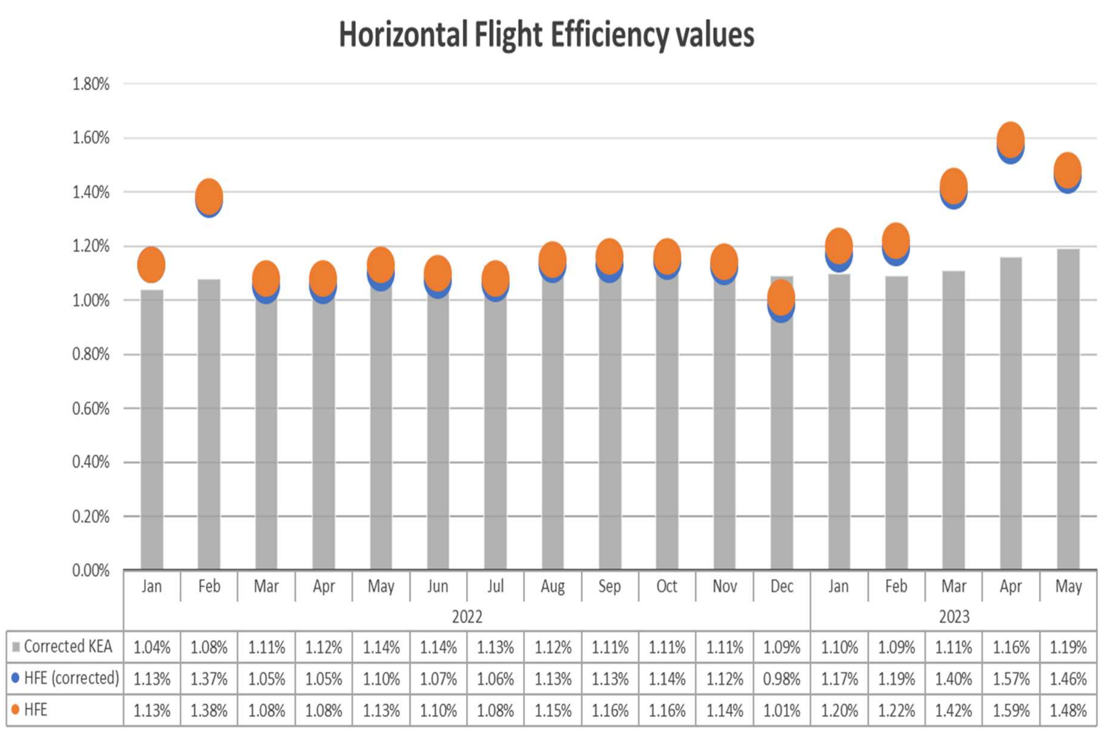


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Corrected KEA	1.62%	1.61%	1.59%	1.58%	1.58%	1.58%	1.56%	1.51%	1.47%	1.44%	1.42%	1.41%	1.39%	1.39%	1.38%	1.38%	1.36%
HFE (corrected)	1.31%	1.35%	1.31%	1.39%	1.52%	1.62%	1.58%	1.57%	1.50%	1.28%	1.23%	1.18%	1.17%	1.26%	1.27%	1.30%	1.34%
HFE	1.31%	1.55%	2.27%	2.30%	2.50%	2.58%	2.39%	2.29%	2.23%	2.01%	2.04%	1.96%	1.96%	2.14%	2.10%	2.07%	2.09%

4.15 Ireland

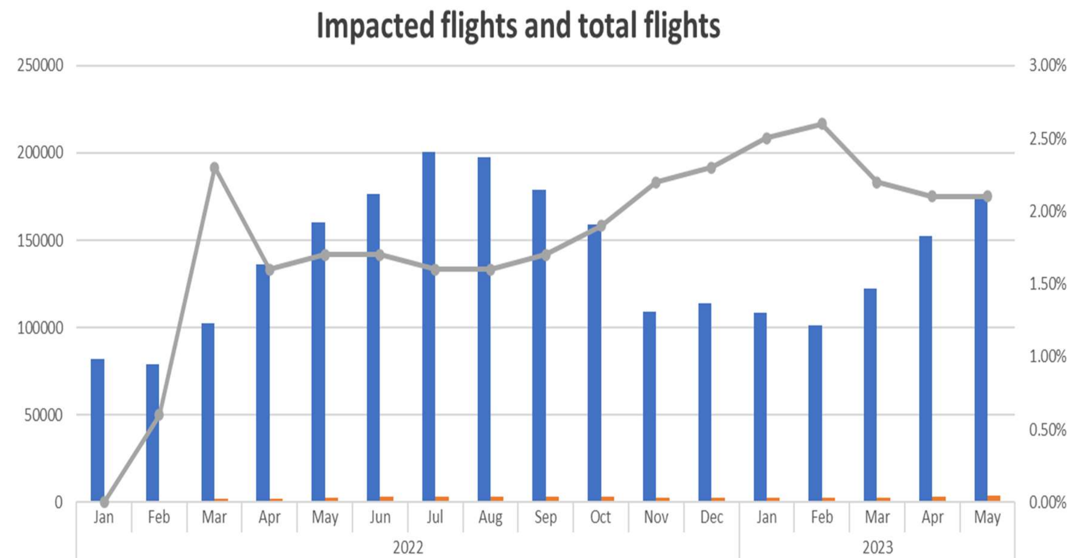


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	20177	18294	26155	31915	35915	36473	39146	37296	37025	34629	25919	28042	26625	26296	31282	33542	39238
Impacted Flights	0	129	983	1131	1153	883	905	821	920	835	539	766	643	711	737	690	868
Impacted %	0.00%	0.70%	3.80%	3.50%	3.20%	2.40%	2.30%	2.20%	2.50%	2.40%	2.10%	2.70%	2.40%	2.70%	2.40%	2.10%	2.20%



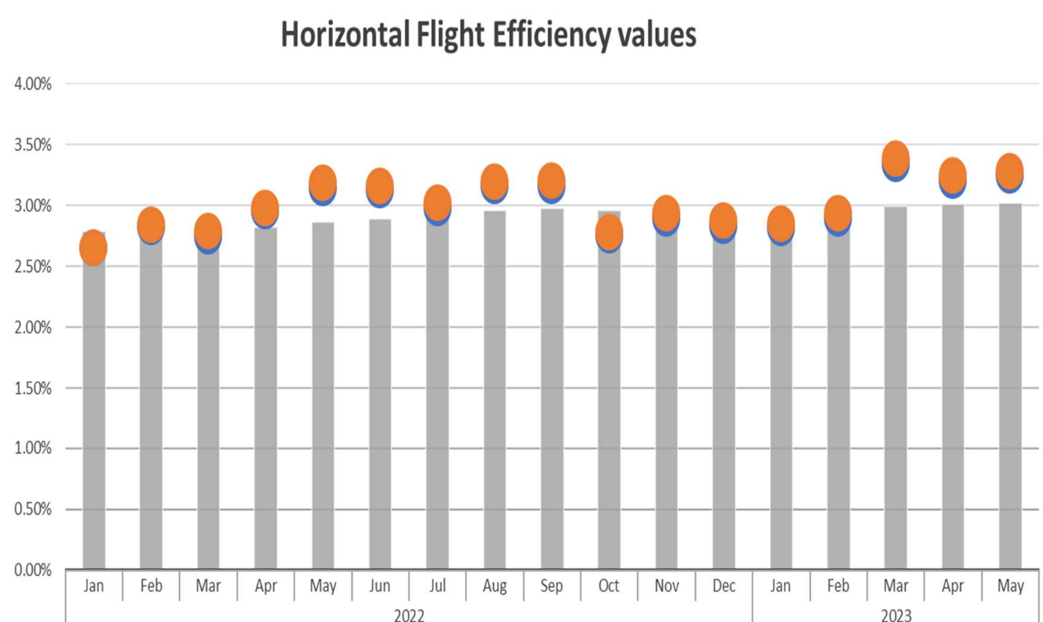
	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	1.04%	1.08%	1.11%	1.12%	1.14%	1.14%	1.13%	1.12%	1.11%	1.11%	1.11%	1.09%	1.10%	1.09%	1.11%	1.16%	1.19%
HFE (corrected)	1.13%	1.37%	1.05%	1.05%	1.10%	1.07%	1.06%	1.13%	1.13%	1.14%	1.12%	0.98%	1.17%	1.19%	1.40%	1.57%	1.46%
HFE	1.13%	1.38%	1.08%	1.08%	1.13%	1.10%	1.08%	1.15%	1.16%	1.16%	1.14%	1.01%	1.20%	1.22%	1.42%	1.59%	1.48%

4.16 Italy



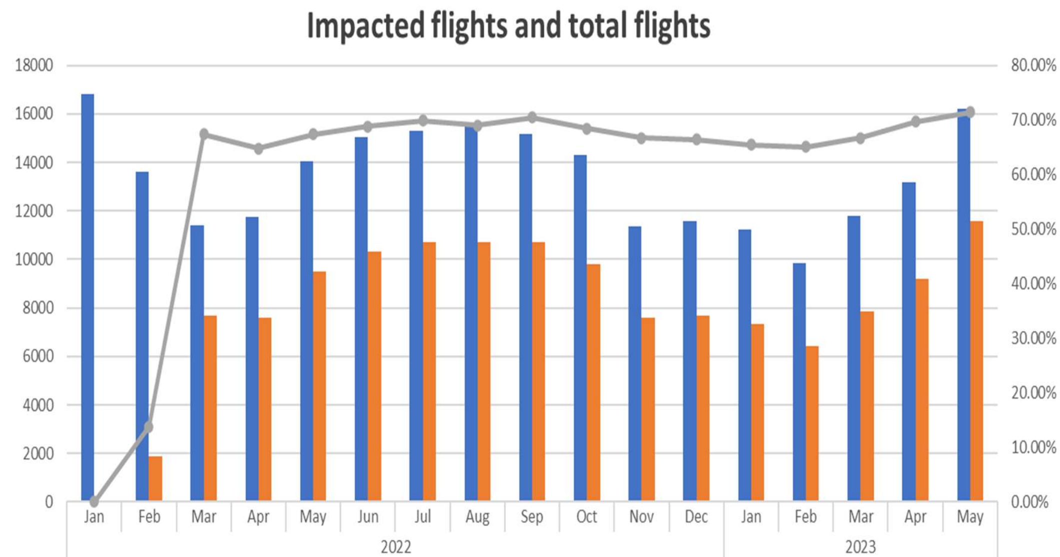
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Flights	82114	78860	102403	135917	160145	176462	200799	197685	178598	159211	109396	114018	108349	101315	122297	152596	173891
Impacted Flights	0	469	2348	2184	2760	3006	3157	3193	3093	3069	2444	2597	2668	2585	2739	3170	3726
Impacted %	0.00%	0.60%	2.30%	1.60%	1.70%	1.70%	1.60%	1.60%	1.70%	1.90%	2.20%	2.30%	2.50%	2.60%	2.20%	2.10%	2.10%

Flights Impacted Flights Impacted %

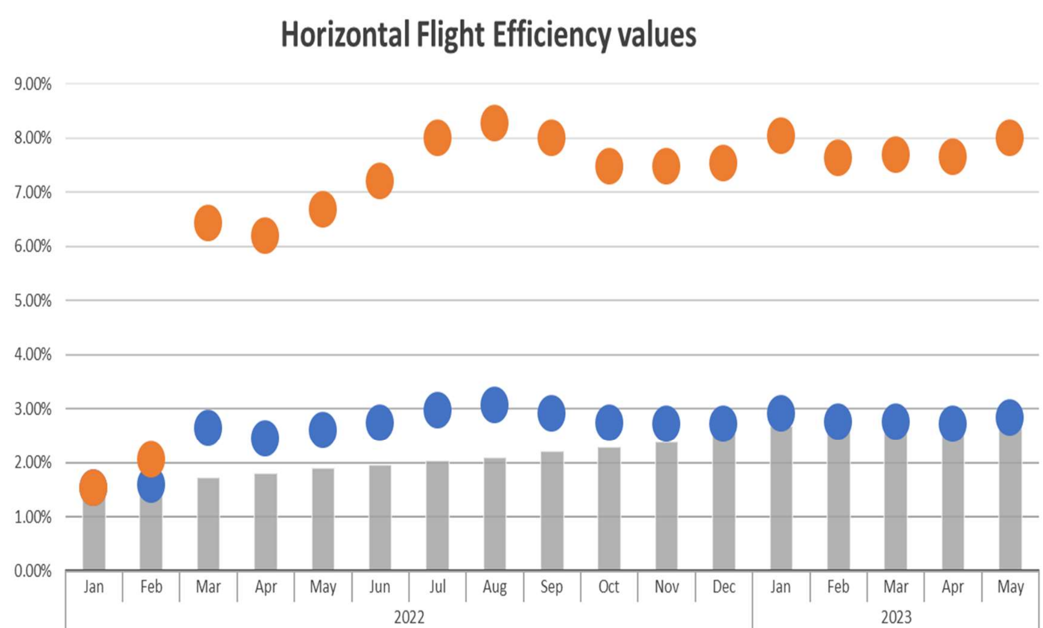


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Corrected KEA	2.79%	2.80%	2.79%	2.82%	2.86%	2.89%	2.91%	2.96%	2.98%	2.96%	2.95%	2.94%	2.95%	2.95%	2.99%	3.01%	3.02%
HFE (corrected)	2.65%	2.82%	2.74%	2.95%	3.14%	3.12%	2.98%	3.16%	3.16%	2.75%	2.89%	2.83%	2.81%	2.89%	3.34%	3.20%	3.24%
HFE	2.65%	2.84%	2.79%	2.98%	3.18%	3.16%	3.02%	3.19%	3.20%	2.78%	2.93%	2.87%	2.85%	2.93%	3.38%	3.24%	3.28%

4.17 Latvia

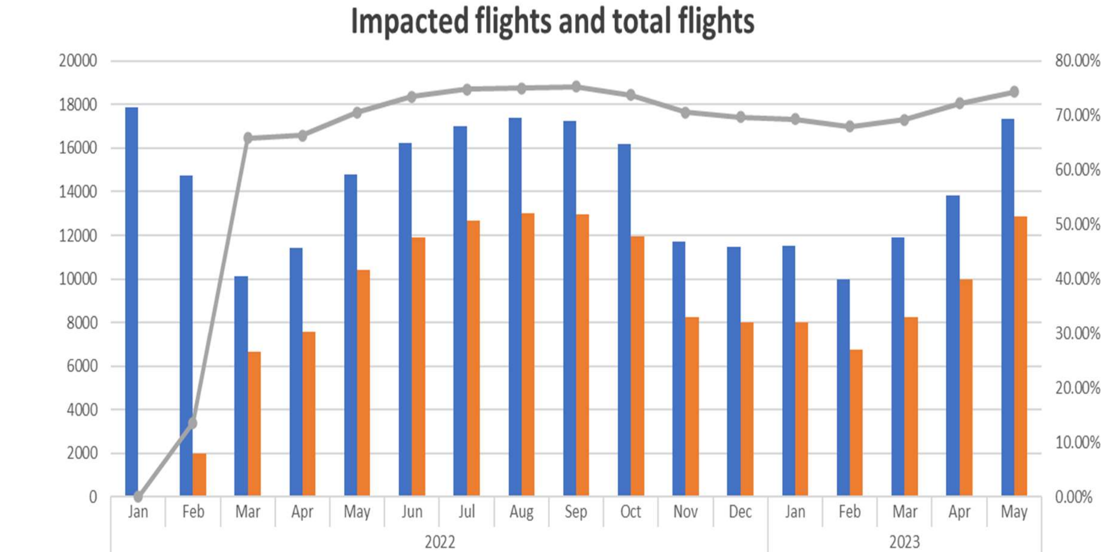


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	16823	13604	11389	11751	14065	15033	15302	15498	15170	14300	11361	11572	11230	9865	11793	13201	16231
Impacted Flights	0	1877	7671	7615	9481	10341	10701	10701	10694	9786	7574	7680	7352	6427	7865	9202	11587
Impacted %	0.00%	13.80%	67.40%	64.80%	67.40%	68.80%	69.90%	69.00%	70.50%	68.40%	66.70%	66.40%	65.50%	65.10%	66.70%	69.70%	71.40%

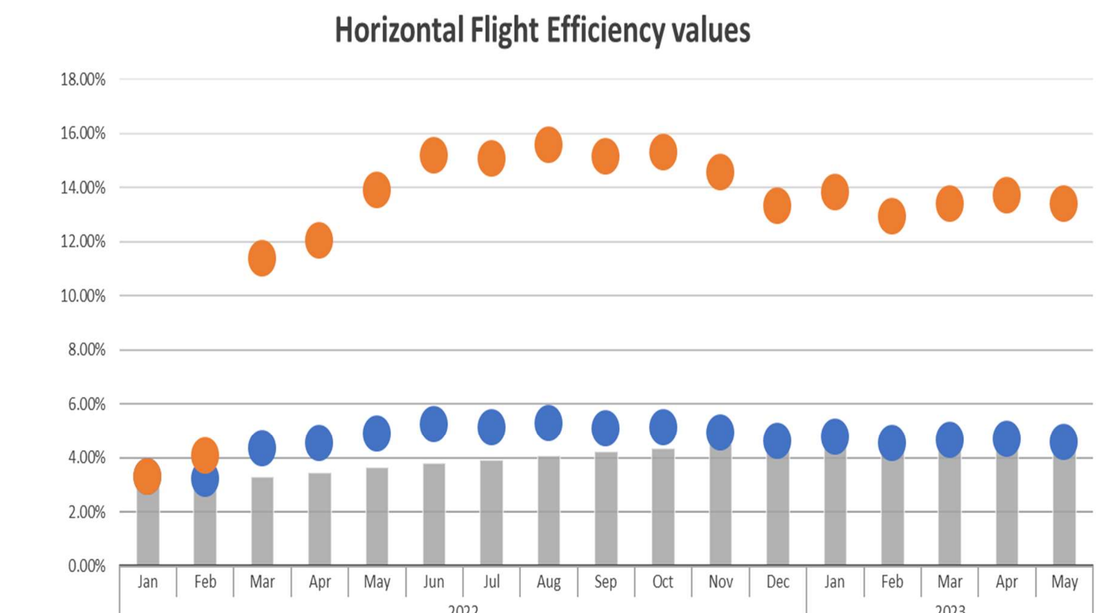


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	1.63%	1.64%	1.72%	1.80%	1.89%	1.95%	2.03%	2.10%	2.20%	2.29%	2.39%	2.53%	2.68%	2.77%	2.78%	2.80%	2.82%
HFE (corrected)	1.53%	1.58%	2.64%	2.45%	2.59%	2.73%	2.97%	3.07%	2.91%	2.74%	2.71%	2.72%	2.90%	2.76%	2.76%	2.72%	2.84%
HFE	1.53%	2.05%	6.42%	6.20%	6.68%	7.21%	8.00%	8.26%	8.00%	7.48%	7.47%	7.54%	8.03%	7.63%	7.69%	7.65%	8.00%

4.18 Lithuania

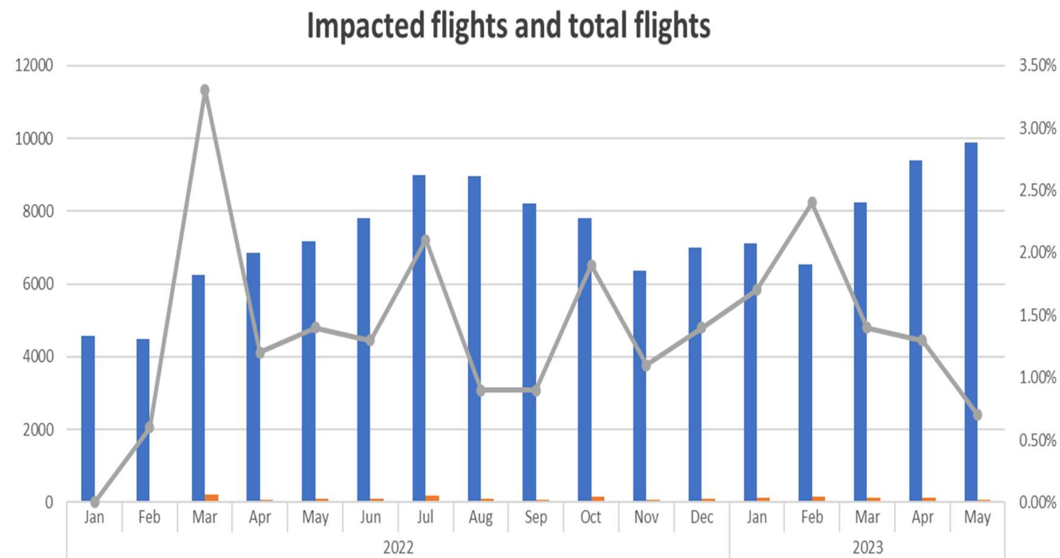


	2022 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2023 Jan	Feb	Mar	Apr	May
Flights	17882	14736	10116	11441	14770	16229	16979	17366	17239	16205	11718	11484	11542	9969	11913	13819	17337
Impacted Flights	0	1999	6659	7585	10431	11910	12693	13027	12978	11939	8270	8000	7999	6778	8247	9982	12881
Impacted %	0.00%	13.60%	65.80%	66.30%	70.60%	73.40%	74.80%	75.00%	75.30%	73.70%	70.60%	69.70%	69.30%	68.00%	69.20%	72.20%	74.30%

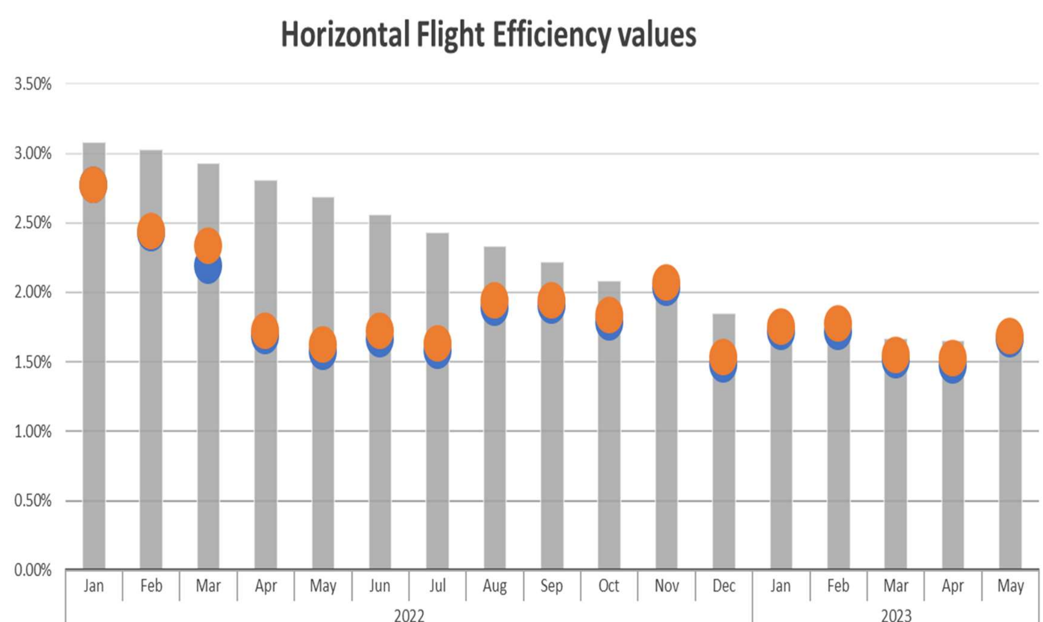


	2022 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2023 Jan	Feb	Mar	Apr	May
Corrected KEA	3.11%	3.17%	3.31%	3.46%	3.65%	3.78%	3.90%	4.06%	4.21%	4.34%	4.49%	4.65%	4.82%	4.92%	4.94%	4.94%	4.91%
HFE (corrected)	3.30%	3.21%	4.34%	4.52%	4.90%	5.22%	5.13%	5.27%	5.07%	5.13%	4.93%	4.62%	4.78%	4.54%	4.66%	4.68%	4.58%
HFE	3.30%	4.07%	11.39%	12.04%	13.89%	15.19%	15.08%	15.55%	15.12%	15.28%	14.57%	13.33%	13.83%	12.94%	13.38%	13.72%	13.38%

4.19 Malta



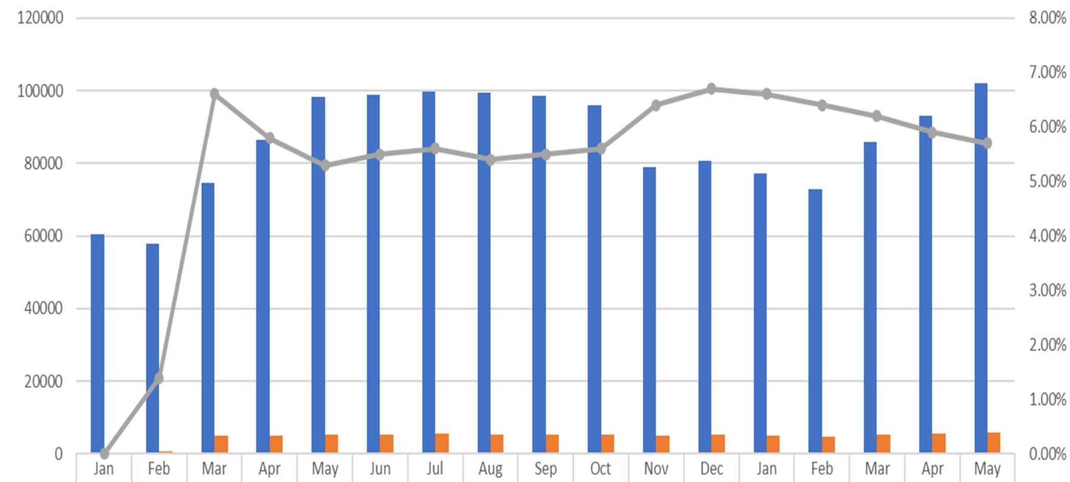
	Jan 2022	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2023	Feb	Mar	Apr	May
Flights	4580	4497	6254	6852	7157	7813	8987	8972	8214	7799	6368	6984	7127	6549	8244	9407	9878
Impacted Flights	0	26	208	79	103	101	192	85	73	151	69	97	121	154	115	125	67
Impacted %	0.00%	0.60%	3.30%	1.20%	1.40%	1.30%	2.10%	0.90%	0.90%	1.90%	1.10%	1.40%	1.70%	2.40%	1.40%	1.30%	0.70%



	Jan 2022	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2023	Feb	Mar	Apr	May
Corrected KEA	3.08%	3.03%	2.93%	2.81%	2.69%	2.56%	2.43%	2.33%	2.22%	2.08%	1.98%	1.85%	1.78%	1.73%	1.67%	1.65%	1.65%
HFE (corrected)	2.77%	2.42%	2.19%	1.68%	1.57%	1.66%	1.58%	1.89%	1.90%	1.78%	2.03%	1.48%	1.71%	1.71%	1.51%	1.47%	1.66%
HFE	2.77%	2.44%	2.33%	1.72%	1.62%	1.72%	1.63%	1.94%	1.94%	1.83%	2.07%	1.53%	1.75%	1.77%	1.55%	1.52%	1.68%

4.20 Netherlands

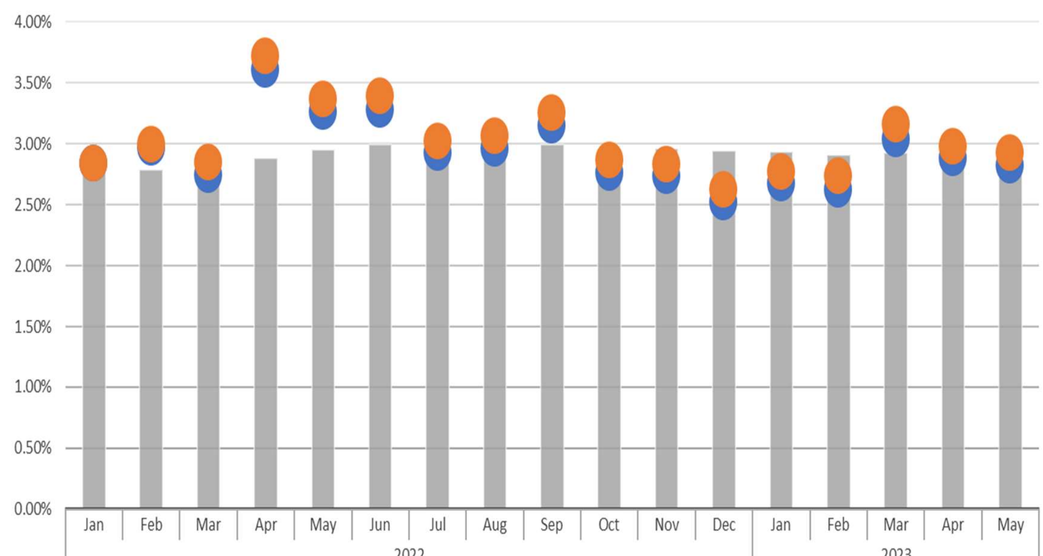
Impacted flights and total flights



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Flights	60402	57934	74537	86497	98196	98825	99651	99551	98437	95915	79061	80660	77083	72779	85880	92942	102051
Impacted Flights	0	839	4945	5029	5244	5404	5621	5359	5391	5371	5062	5431	5082	4638	5333	5494	5846
Impacted %	0.00%	1.40%	6.60%	5.80%	5.30%	5.50%	5.60%	5.40%	5.50%	5.60%	6.40%	6.70%	6.60%	6.40%	6.20%	5.90%	5.70%

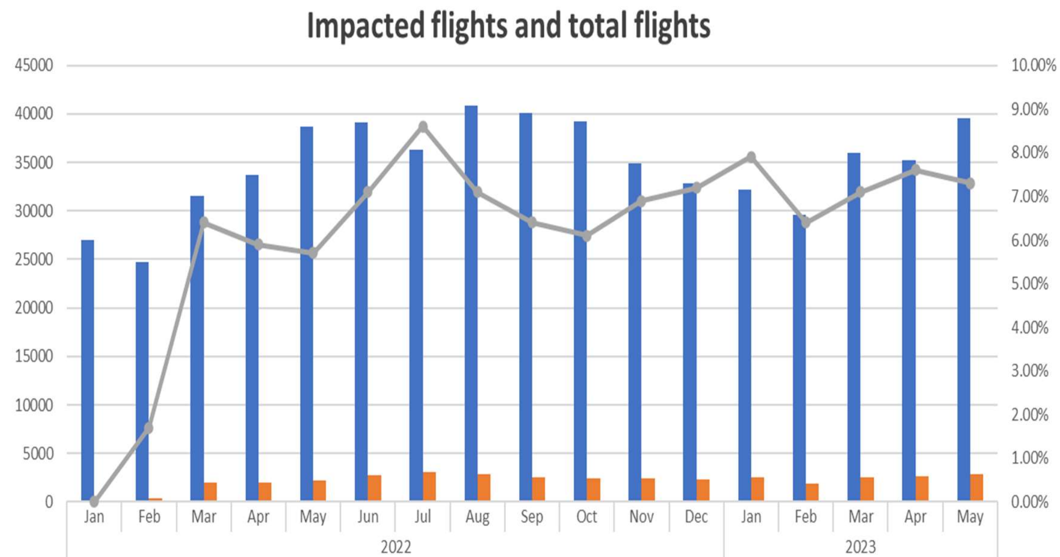
Flights Impacted Flights Impacted %

Horizontal Flight Efficiency values



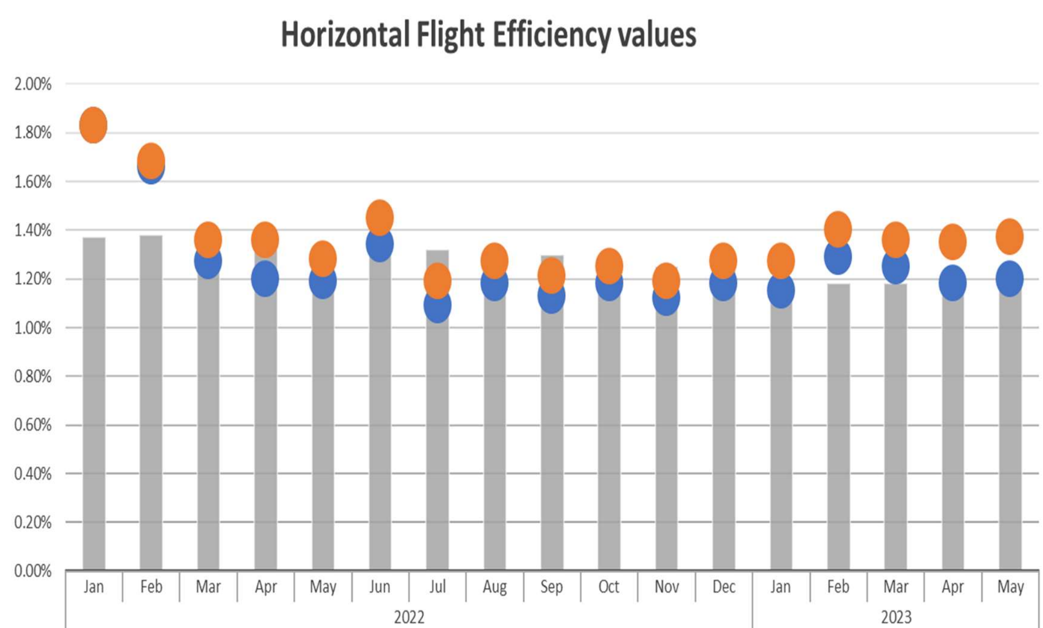
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Corrected KEA	2.76%	2.79%	2.81%	2.88%	2.95%	2.99%	2.98%	2.97%	2.99%	2.96%	2.96%	2.94%	2.93%	2.91%	2.92%	2.89%	2.85%
HFE (corrected)	2.84%	2.97%	2.74%	3.61%	3.26%	3.28%	2.92%	2.96%	3.15%	2.76%	2.73%	2.52%	2.67%	2.62%	3.04%	2.88%	2.82%
HFE	2.84%	2.99%	2.85%	3.72%	3.36%	3.39%	3.02%	3.06%	3.25%	2.86%	2.83%	2.62%	2.77%	2.73%	3.16%	2.98%	2.92%

4.21 Norway



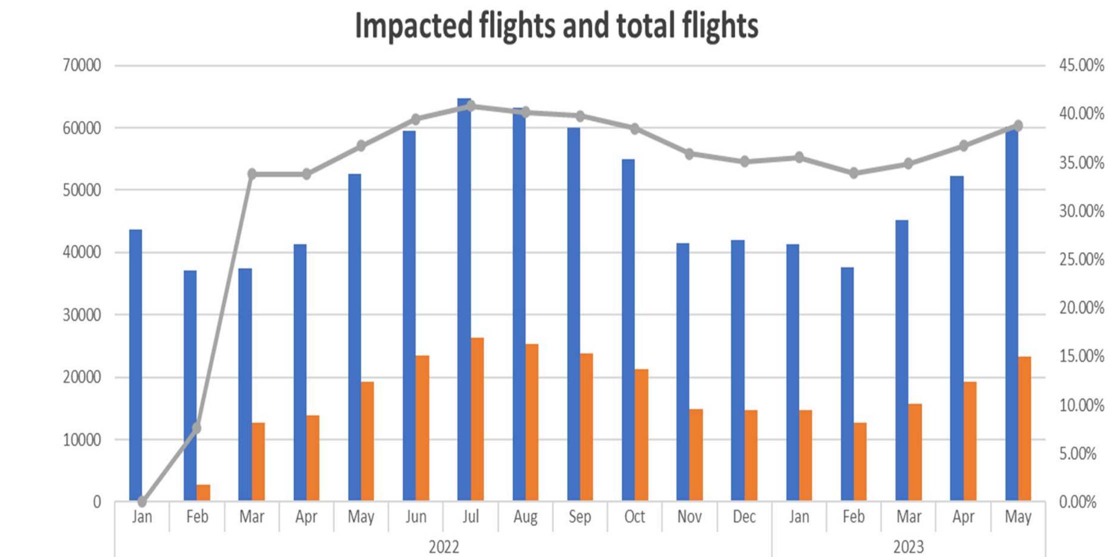
	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023
Flights	27038	24774	31523	33722	38724	39167	36303	40850	40148	39276	34929	32871	32247	29610	35935	35192	39519
Impacted Flights	0	418	2009	1999	2212	2779	3109	2912	2565	2396	2405	2363	2537	1892	2545	2674	2869
Impacted %	0.00%	1.70%	6.40%	5.90%	5.70%	7.10%	8.60%	7.10%	6.40%	6.10%	6.90%	7.20%	7.90%	6.40%	7.10%	7.60%	7.30%

Flights / Impacted Flights / Impacted %

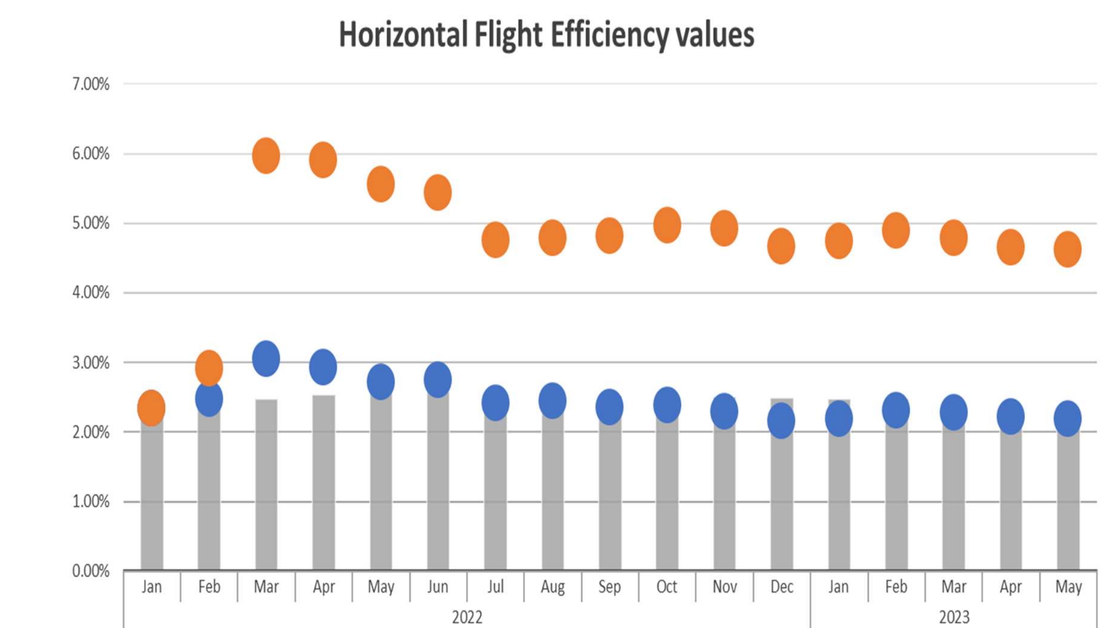


	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023
Corrected KEA	1.37%	1.38%	1.34%	1.32%	1.32%	1.33%	1.32%	1.32%	1.30%	1.28%	1.25%	1.24%	1.19%	1.18%	1.18%	1.18%	1.18%
HFE (corrected)	1.83%	1.66%	1.27%	1.20%	1.19%	1.34%	1.09%	1.18%	1.13%	1.18%	1.12%	1.18%	1.15%	1.29%	1.25%	1.18%	1.20%
HFE	1.83%	1.68%	1.36%	1.36%	1.28%	1.45%	1.19%	1.27%	1.21%	1.25%	1.19%	1.27%	1.27%	1.40%	1.36%	1.35%	1.37%

4.22 Poland

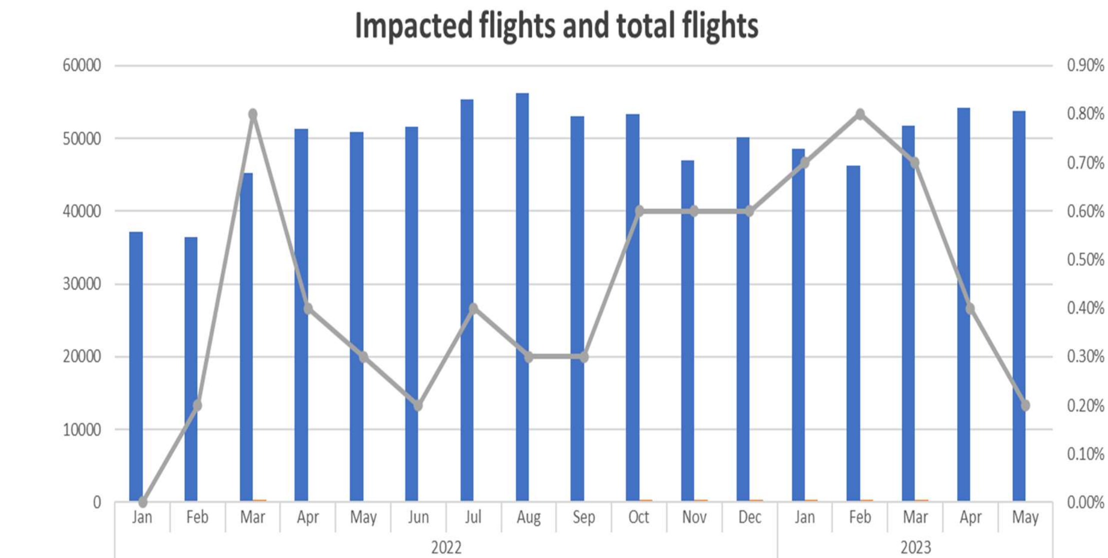


	Jan 2022	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2023	Feb	Mar	Apr	May
Flights	43637	37068	37439	41298	52619	59509	64701	63235	59938	55035	41521	42075	41407	37605	45277	52247	60160
Impacted Flights	0	2823	12657	13950	19285	23525	26398	25402	23863	21214	14917	14779	14687	12754	15787	19194	23358
Impacted %	0.00%	7.60%	33.80%	33.80%	36.70%	39.50%	40.80%	40.20%	39.80%	38.50%	35.90%	35.10%	35.50%	33.90%	34.90%	36.70%	38.80%



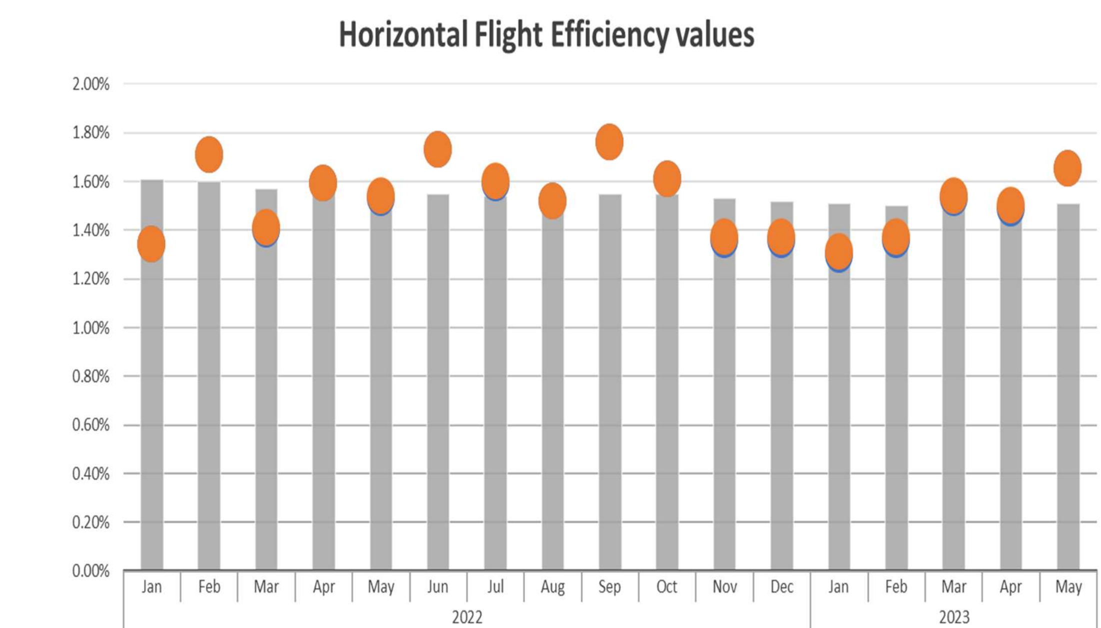
	Jan 2022	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2023	Feb	Mar	Apr	May
Corrected KEA	2.37%	2.41%	2.48%	2.53%	2.57%	2.58%	2.55%	2.53%	2.52%	2.51%	2.51%	2.49%	2.48%	2.47%	2.42%	2.37%	2.32%
HFE (corrected)	2.34%	2.48%	3.05%	2.93%	2.71%	2.75%	2.41%	2.45%	2.35%	2.39%	2.29%	2.16%	2.19%	2.31%	2.27%	2.22%	2.19%
HFE	2.34%	2.91%	5.96%	5.90%	5.56%	5.44%	4.76%	4.79%	4.81%	4.97%	4.92%	4.67%	4.74%	4.89%	4.78%	4.65%	4.62%

4.23 Portugal



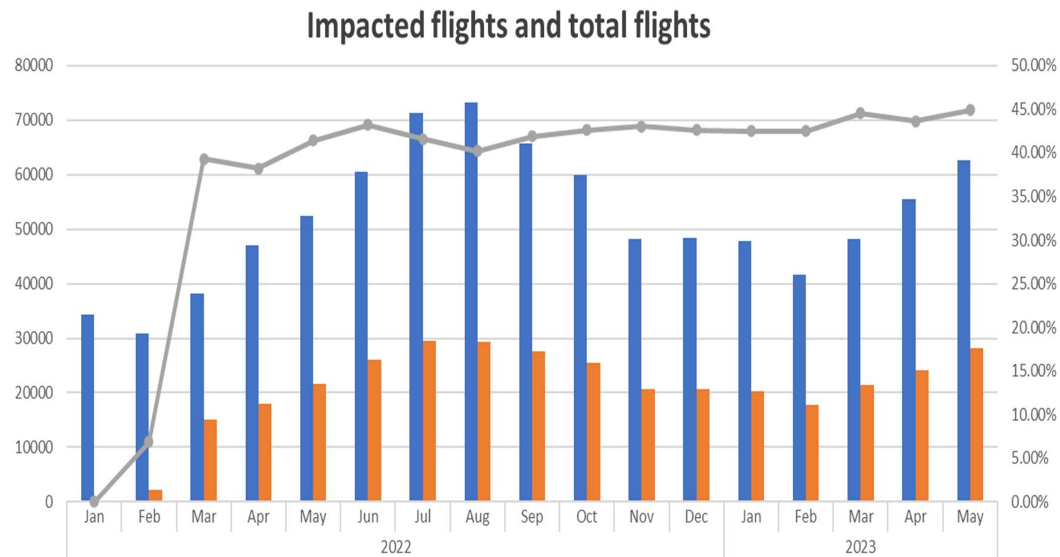
	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	37113	36416	45185	51284	50895	51533	55266	56161	53005	53278	47010	50187	48492	46222	51703	54156	53743
Impacted Flights	0	67	345	196	134	127	233	155	141	305	286	294	361	382	345	232	132
Impacted %	0.00%	0.20%	0.80%	0.40%	0.30%	0.20%	0.40%	0.30%	0.30%	0.60%	0.60%	0.60%	0.70%	0.80%	0.70%	0.40%	0.20%

Flights · Impacted Flights · Impacted %

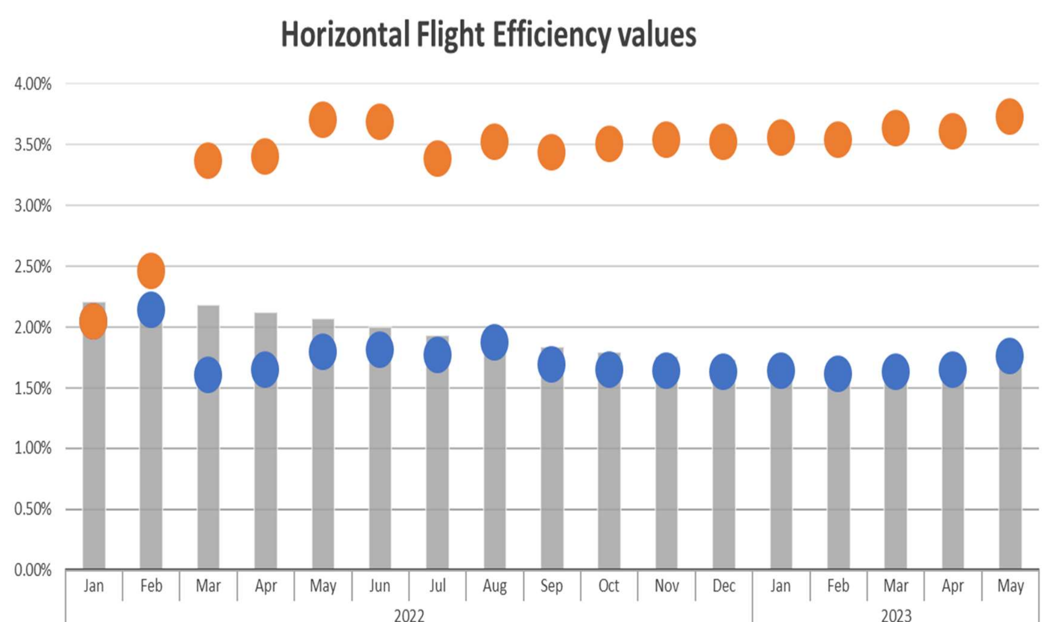


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	1.61%	1.60%	1.57%	1.56%	1.54%	1.55%	1.54%	1.54%	1.55%	1.55%	1.53%	1.52%	1.51%	1.50%	1.51%	1.50%	1.51%
HFE (corrected)	1.34%	1.71%	1.40%	1.59%	1.53%	1.73%	1.59%	1.52%	1.76%	1.61%	1.36%	1.36%	1.30%	1.36%	1.53%	1.49%	1.65%
HFE	1.34%	1.71%	1.41%	1.59%	1.54%	1.73%	1.60%	1.52%	1.76%	1.61%	1.37%	1.37%	1.31%	1.37%	1.54%	1.50%	1.65%

4.24 Romania

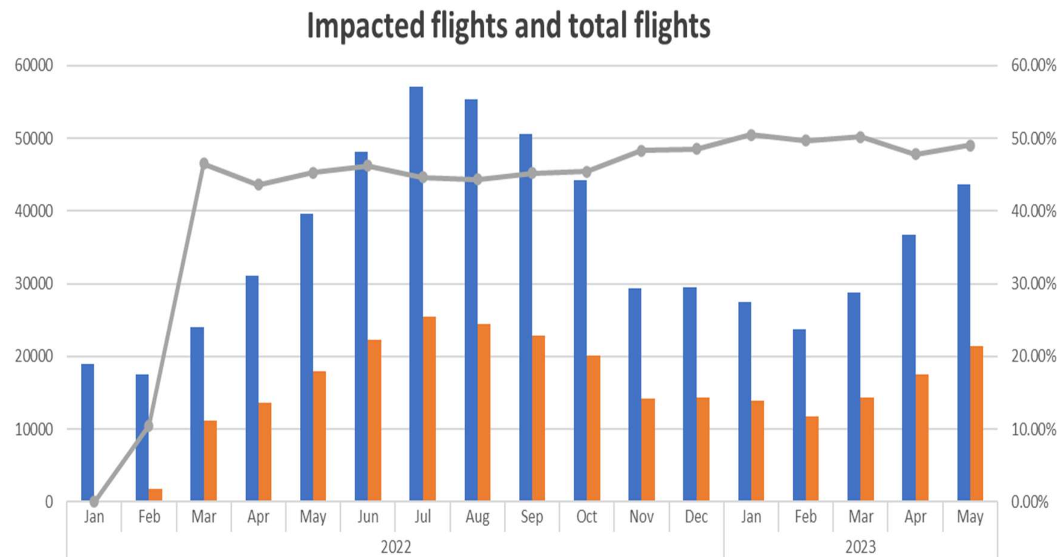


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Flights	34391	30918	38204	46961	52355	60466	71216	73122	65738	59885	48197	48409	47804	41632	48164	55558	62617
Impacted Flights	0	2140	15007	17918	21653	26133	29606	29412	27542	25491	20736	20635	20330	17694	21453	24230	28132
Impacted %	0.00%	6.90%	39.30%	38.20%	41.40%	43.20%	41.60%	40.20%	41.90%	42.60%	43.00%	42.60%	42.50%	42.50%	44.50%	43.60%	44.90%

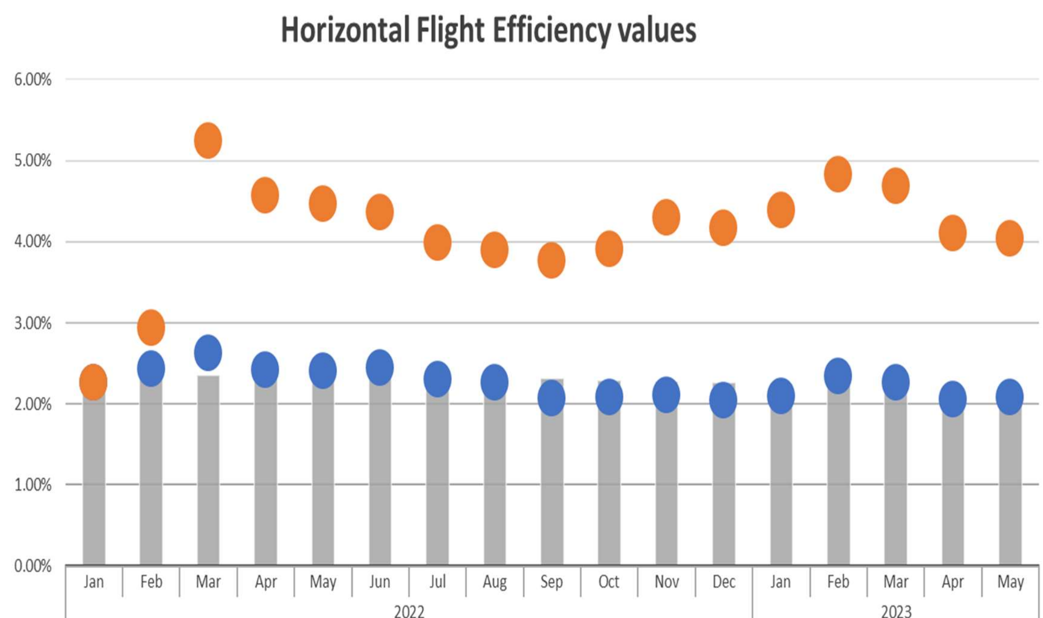


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Corrected KEA	2.21%	2.22%	2.18%	2.12%	2.07%	2.00%	1.93%	1.89%	1.84%	1.79%	1.76%	1.73%	1.71%	1.68%	1.68%	1.68%	1.68%
HFE (corrected)	2.04%	2.14%	1.60%	1.65%	1.79%	1.81%	1.77%	1.87%	1.69%	1.65%	1.64%	1.63%	1.64%	1.61%	1.63%	1.65%	1.76%
HFE	2.04%	2.46%	3.36%	3.40%	3.70%	3.68%	3.38%	3.52%	3.43%	3.50%	3.54%	3.52%	3.55%	3.54%	3.63%	3.61%	3.73%

4.25 Slovakia

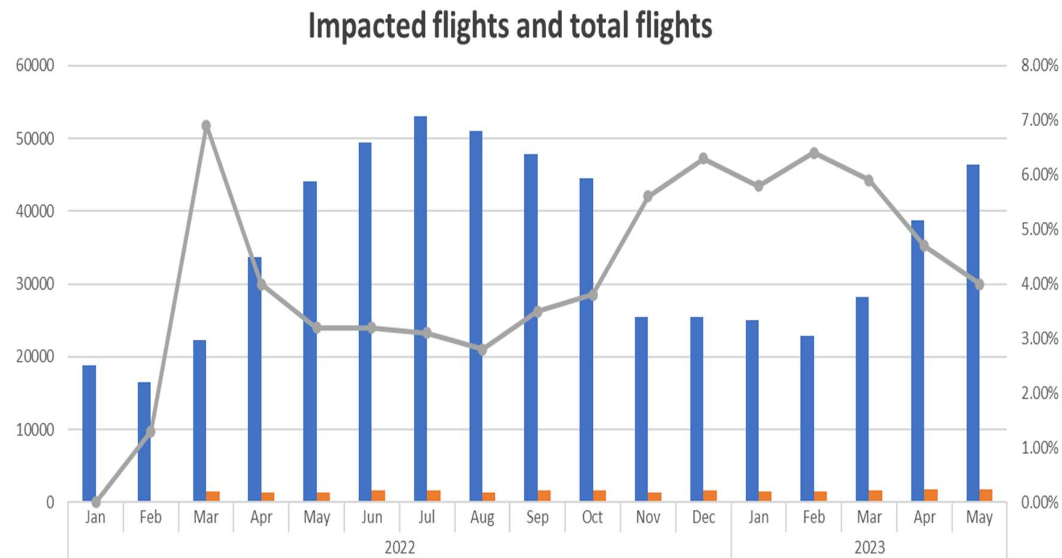


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	18947	17461	24046	31087	39584	48090	57097	55293	50536	44272	29417	29570	27538	23783	28721	36784	43605
Impacted Flights	0	1829	11190	13567	17924	22225	25474	24520	22828	20087	14203	14341	13897	11809	14405	17576	21384
Impacted %	0.00%	10.50%	46.50%	43.60%	45.30%	46.20%	44.60%	44.30%	45.20%	45.40%	48.30%	48.50%	50.50%	49.70%	50.20%	47.80%	49.00%

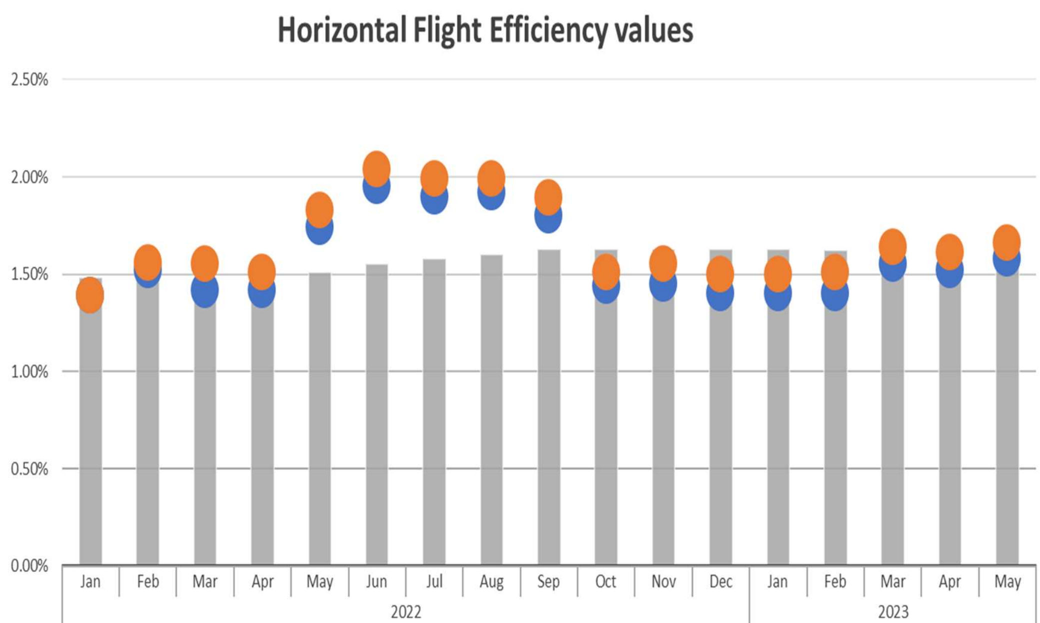


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	2.29%	2.31%	2.35%	2.36%	2.37%	2.38%	2.36%	2.34%	2.32%	2.29%	2.27%	2.26%	2.25%	2.25%	2.23%	2.20%	2.17%
HFE (corrected)	2.26%	2.43%	2.63%	2.42%	2.40%	2.45%	2.30%	2.26%	2.07%	2.08%	2.11%	2.04%	2.09%	2.34%	2.26%	2.06%	2.08%
HFE	2.26%	2.94%	5.24%	4.57%	4.46%	4.36%	3.99%	3.90%	3.77%	3.91%	4.29%	4.17%	4.38%	4.82%	4.68%	4.10%	4.04%

4.26 Slovenia

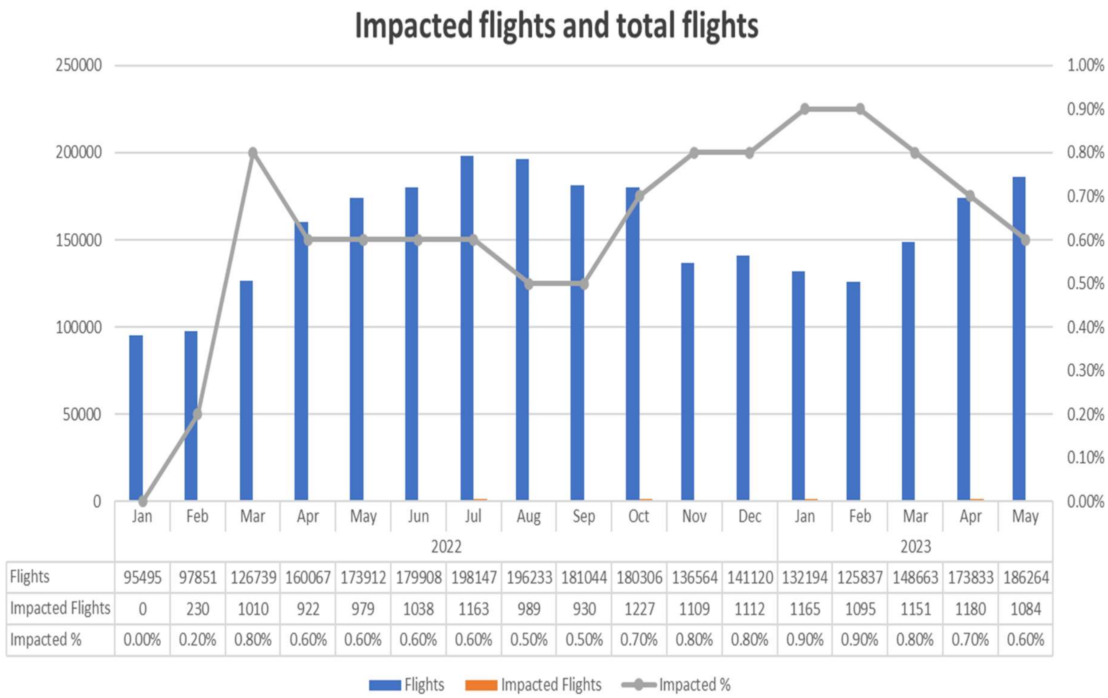


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	18871	16575	22264	33677	44070	49380	53097	51078	47793	44574	25507	25454	24970	22793	28219	38763	46430
Impacted Flights	0	210	1544	1346	1409	1596	1631	1427	1649	1681	1429	1616	1456	1448	1663	1840	1835
Impacted %	0.00%	1.30%	6.90%	4.00%	3.20%	3.20%	3.10%	2.80%	3.50%	3.80%	5.60%	6.30%	5.80%	6.40%	5.90%	4.70%	4.00%

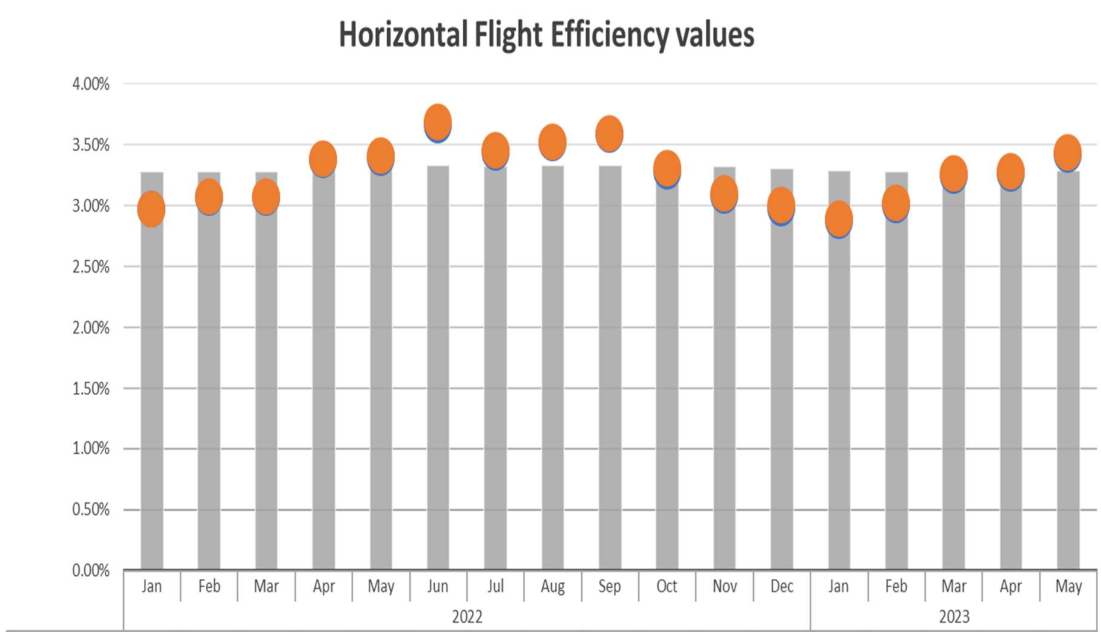


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	1.48%	1.49%	1.48%	1.48%	1.51%	1.55%	1.58%	1.60%	1.63%	1.63%	1.63%	1.63%	1.63%	1.62%	1.63%	1.63%	1.62%
HFE (corrected)	1.39%	1.52%	1.42%	1.42%	1.74%	1.95%	1.90%	1.92%	1.80%	1.44%	1.45%	1.40%	1.40%	1.40%	1.55%	1.52%	1.58%
HFE	1.39%	1.56%	1.55%	1.51%	1.83%	2.04%	1.99%	1.99%	1.89%	1.51%	1.55%	1.50%	1.50%	1.51%	1.64%	1.61%	1.66%

4.27 Spain

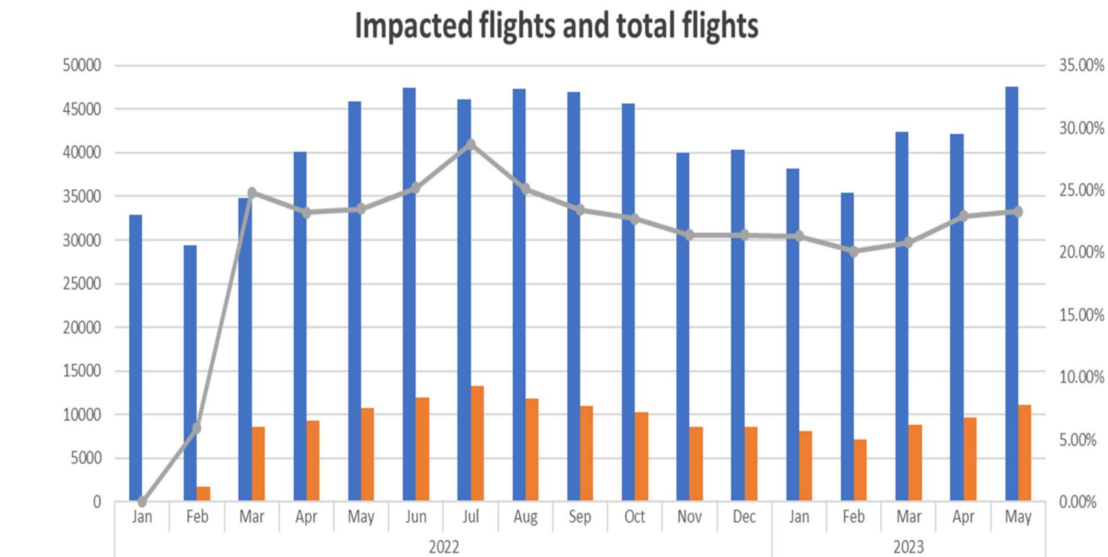


	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	95495	97851	126739	160067	173912	179908	198147	196233	181044	180306	136564	141120	132194	125837	148663	173833	186264
Impacted Flights	0	230	1010	922	979	1038	1163	989	930	1227	1109	1112	1165	1095	1151	1180	1084
Impacted %	0.00%	0.20%	0.80%	0.60%	0.60%	0.60%	0.60%	0.50%	0.50%	0.70%	0.80%	0.80%	0.90%	0.90%	0.80%	0.70%	0.60%



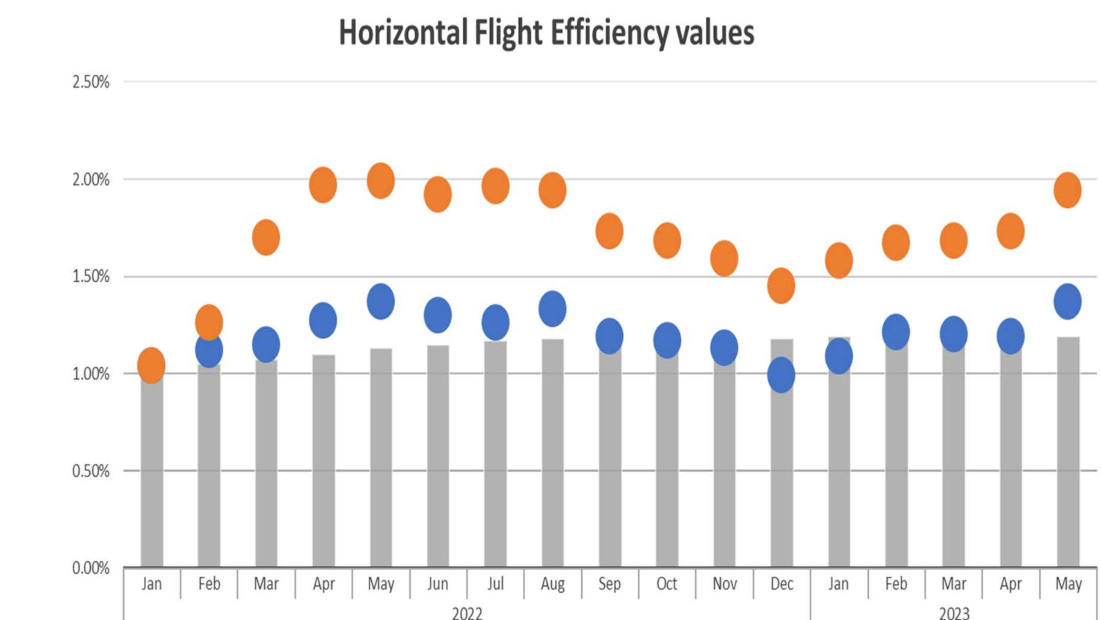
	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	3.28%	3.28%	3.28%	3.30%	3.31%	3.33%	3.32%	3.33%	3.33%	3.33%	3.32%	3.30%	3.29%	3.28%	3.30%	3.29%	3.29%
HFE (corrected)	2.97%	3.06%	3.06%	3.37%	3.39%	3.66%	3.43%	3.51%	3.58%	3.28%	3.08%	2.98%	2.87%	3.00%	3.24%	3.26%	3.42%
HFE	2.97%	3.07%	3.07%	3.38%	3.41%	3.68%	3.45%	3.52%	3.59%	3.30%	3.10%	3.00%	2.89%	3.02%	3.26%	3.28%	3.43%

4.28 Sweden



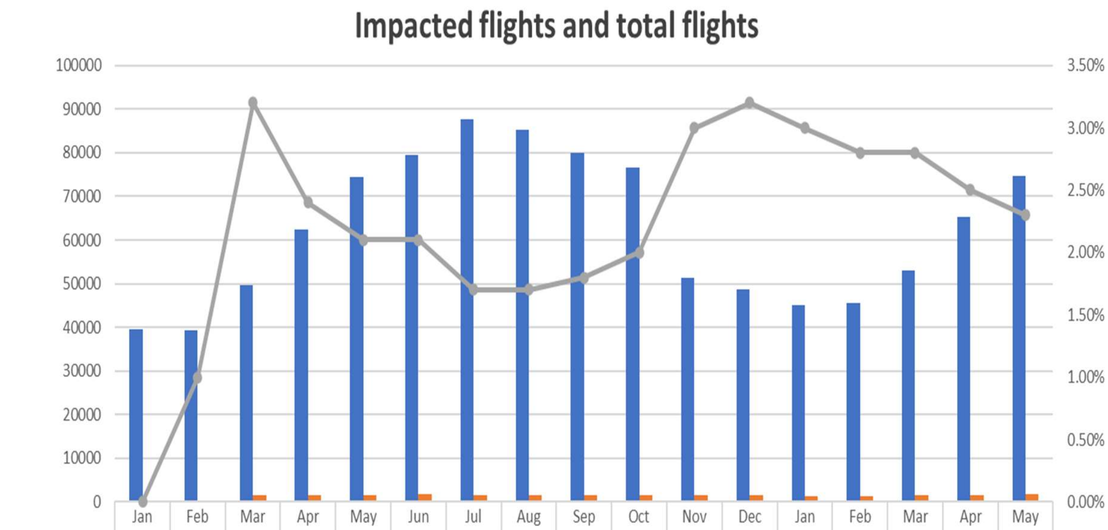
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Flights	32908	29388	34847	40087	45869	47407	46129	47276	46929	45589	39975	40315	38208	35425	42360	42143	47557
Impacted Flights	0	1723	8628	9290	10787	11934	13240	11872	10986	10331	8554	8631	8120	7116	8825	9641	11096
Impacted %	0.00%	5.90%	24.80%	23.20%	23.50%	25.20%	28.70%	25.10%	23.40%	22.70%	21.40%	21.40%	21.30%	20.10%	20.80%	22.90%	23.30%

Flights Impacted Flights Impacted %

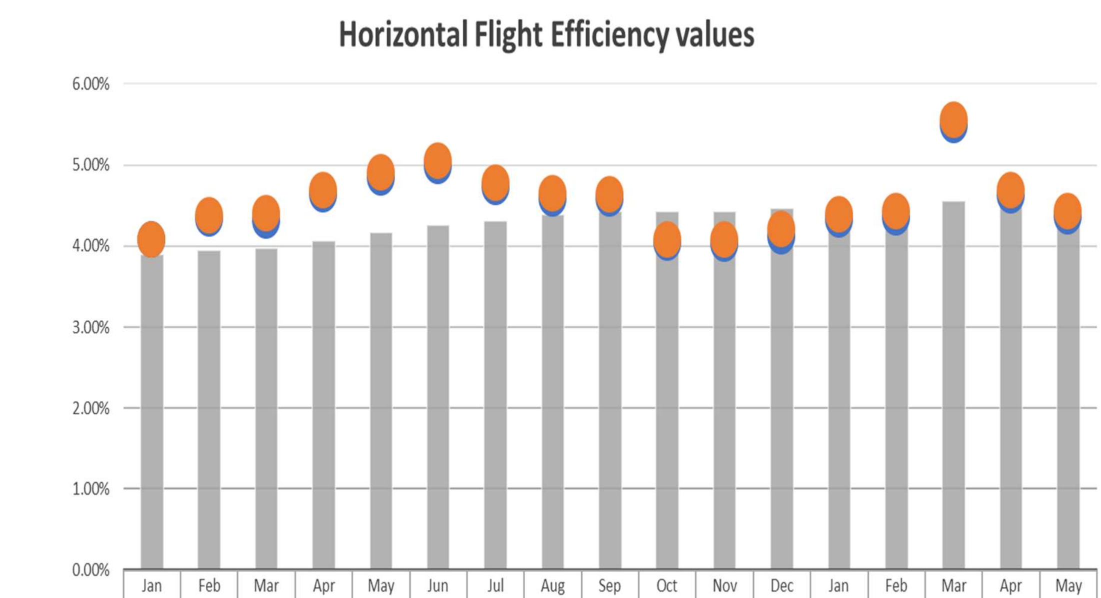


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2022												2023				
Corrected KEA	1.05%	1.05%	1.07%	1.10%	1.13%	1.15%	1.17%	1.18%	1.19%	1.19%	1.19%	1.18%	1.19%	1.20%	1.20%	1.19%	1.19%
HFE (corrected)	1.04%	1.12%	1.15%	1.27%	1.37%	1.30%	1.26%	1.33%	1.19%	1.17%	1.13%	0.99%	1.09%	1.21%	1.20%	1.19%	1.37%
HFE	1.04%	1.26%	1.70%	1.97%	1.99%	1.92%	1.96%	1.94%	1.73%	1.68%	1.59%	1.45%	1.58%	1.67%	1.68%	1.73%	1.94%

4.29 Switzerland



	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Flights	39628	39374	49618	62470	74498	79566	87689	85236	79903	76495	51337	48618	45076	45465	53140	65213	74614
Impacted Flights	0	380	1569	1504	1572	1683	1501	1423	1441	1501	1561	1553	1347	1293	1499	1621	1743
Impacted %	0.00%	1.00%	3.20%	2.40%	2.10%	2.10%	1.70%	1.70%	1.80%	2.00%	3.00%	3.20%	3.00%	2.80%	2.80%	2.50%	2.30%



	2022												2023				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Corrected KEA	3.90%	3.94%	3.97%	4.06%	4.17%	4.26%	4.31%	4.38%	4.43%	4.43%	4.43%	4.46%	4.47%	4.47%	4.55%	4.55%	4.50%
HFE (corrected)	4.08%	4.34%	4.31%	4.63%	4.84%	4.98%	4.72%	4.58%	4.58%	4.03%	4.02%	4.11%	4.32%	4.35%	5.49%	4.62%	4.36%
HFE	4.08%	4.37%	4.40%	4.69%	4.90%	5.05%	4.77%	4.64%	4.63%	4.08%	4.08%	4.20%	4.39%	4.42%	5.55%	4.68%	4.42%

Performance Review Body
Advice on the Union-wide target ranges for RP4

Annex IV – Common Project 1 performance impact

September 2023

Performance Review Body of the Single European Sky | Rue de la Fusée 96, Office 50.659, 1130 Brussels
Office Telephone: +32 (0)2 234 7824 | cathy.mannion@prb.eusinglesky.eu | prb-office@prb.eusinglesky.eu | wikis.ec.europa.eu/display/eusinglesky

SESAR DEPLOYMENT MANAGER

CP1 Performance Impact

September 2023

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Introduction

Pursuant to Commission Implementing Regulation (EU) No 409/2013 of 3 May 2013, the SESAR Deployment Manager (SDM) is responsible for the management level of SESAR deployment governance and associated tasks and plays an important role at the implementation level.

The SDM is responsible, inter alia, for developing, proposing, maintaining and implementing the SESAR Deployment Programme (SDP), a comprehensive and structured workplan to all operational stakeholders involved in the deployment of Regulation (EU) No 2021/116, the so-called Common Project One (CP1).

The Common Project 1 Regulation sets different target deadlines for its implementation, the final one is on the 31 of December 2027: this date is well within the timeframe (2025-2029) of Reference Period 4 (RP4) as described by the Performance Scheme. Therefore, **the full potential of Common Project 1 will be materialised during RP4, also in terms of operational and performance benefits**.

A summary of the implementation and industrialisation target dates for each ATM Functionality (AF) and sub-ATM Functionality (sub-AF), as laid down in the CP1 Regulation, is provided in Figure 1 below.

	ATM Functionality	Sub-ATM Functionality	CP1 Target Date
AF1	Extended AMAN and Integrated AMAN/DMAN in the high-density TMA	Sub-AF 1.1 – Arrival Management Extended to en-route Airspace	31st December 2024
		Sub-AF 1.2 – AMAN/DMAN Integration	31st December 2027
AF2	Airport Integration and Throughput	Sub-AF 2.1 – Departure Management synchronized with Pre-departure sequencing	31st December 2022
	*Initial AOP as from 31st December 2023	Sub-AF 2.2 – Airport Operations Plan	31st December 2027*
		Sub-AF 2.3 – Airport Safety Nets	31st December 2025
AF3	Flexible ASM and Free Route Airspace	Sub-AF 3.1 – ASM and Advanced FUA	31st December 2022
		Sub-AF 3.2 – Free Route Airspace	31st December 2025*
AF4	Network Collaborative Management	Sub-AF 4.1 – Enhanced STAM	31st December 2022
		Sub-AF 4.2 – Collaborative NOP	31st December 2023
		Sub-AF 4.3 – Automated Support for Traffic Complexity Assessment	31st December 2022
		Sub-AF 4.4 – AOP/NOP Integration	31st December 2027
AF5	System Wide Information Management	Sub-AF 5.1 – Common Infrastructure Components	31st December 2024
		Sub-AF 5.2 – SWIM Yellow Profile Technical Infrastructure and Specifications	31st December 2025
		Sub-AF 5.3 – Aeronautical Information Exchange	31st December 2025
		Sub-AF 5.4 – Meteorological Information Exchange	31st December 2025
		Sub-AF 5.5 – Cooperative Network Information Exchange	31st December 2025
		Sub-AF 5.6 – Flights information Exchange (Yellow Profile)	31st December 2025
AF6	Initial Trajectory Information Sharing	Sub-AF 6.1 – Initial air-ground Trajectory Information Sharing	31st December 2027*
		Sub-AF 6.2 – Network Manager Trajectory Information Enhancement	31st December 2027*
		Sub-AF 6.3 – Initial Trajectory Information Sharing Ground Distribution	31st December 2027*

*Sub-AF 3.2: * Final implementation, including cross-border FRA with at least one neighboring State and FRA connectivity with TMAs. Initial FRA Implementation as from 31st December 2022*

*AF6: * Industrialisation target date: 31st December 2023*

Figure 1 – Common Project 1 Regulation deadlines and target dates

The Common Project One was adopted by the Commission after positive opinion of the EU Member States and supported by the operational stakeholders on the basis of a Cost Benefit Analysis (CBA) that demonstrated a positive Net Present Value (NPV).

The benefits calculated in the CP1 CBA are reflecting the CP1 impact on operational performance: they illustrate that the **CP1 has a substantial contribution** across several Network Performance elements, most notably in **airspace capacity** because of fewer delays, and enhanced **flight efficiency** due to more efficient routes.

Given the synchronicity between CP1 implementation and RP4, **CP1 contribution to performance could be taken into account in the target setting of RP4**. As the proposals of targets is strictly conducted by the Performance Review Body (PRB), SDM's role is limited to supporting the PRB by providing the impact on Network Performance measured in the different Key Performance Areas (KPAs) by the different Key Performance Indicators (KPIs) described in the SESAR Deployment Programme (SDP) performance methodology.

The performance improvements that are estimated by the SDM across the different KPIs may not be directly applicable to the indicators that are defining performance in the Performance and Charging scheme. This results from the different purposes of SDM's and PRB's assessments: SDM estimates benefits to calculate CBAs of the CP1 or of the implementation projects, thus **considers benefits against a "do-nothing" ("no CP1") scenario**. This is different from the PRB approach, where the purpose is to show targets in absolute values across the RP4 timeframe. Therefore, SDM inputs are not directly applicable in the definition of the targets for RP4, particularly for the Capacity KPA where CP1 En-Route ATFM delays savings are stemming from simulations from the Network Manager in which the do-nothing scenario confirms a strong increase of these delays in case no CP1 investment is made.

As ground and terminal-related performance are not subject to Union-wide targets, benefits stemming from ATM Functionalities AF1 and AF2[1], although very significant, will not be described in this Annex. The document will focus on the expected savings in **capacity and flight efficiency / environment[2] driven by ATM functionalities AF3 and AF4[3]**, which include in particular the implementation of a full cross border free route airspace by the end of 2025. Within this scope, CP1 savings are not geographically limited, as the Regulation is fully covering the Member States airspaces. Besides, this specific scope is by far the largest contributor to CP1 performance impact, with benefits representing around 85% of CP1 total benefits.[4]

A qualitative description of CP1 expected benefits on **Safety** will also be provided, to highlight the importance of safety investments in the CP1 despite the absence of quantification or monetisation in the CP1 CBA.

[1] AF1: Extended AMAN and integrated AMAN/DMAN in the high density TMA / AF2: Airport Integration and Throughput

[2] The two KPAs are linked, as CO2 savings may only be generated by flight efficiency savings (minutes and fuel savings)

[3] AF3: Flexible ASM and Free Route Airspace / AF4: Network Collaborative Management

[4] AF5/6 benefits were not calculated in the CP1 CBA

1. Background

The CP1 replacing and improving the Pilot Common Project (PCP) was adopted in February 2021. Its final implementation date is December 2027. Within the overall PCP/CP1 technical and geographical scope, the projects awarded by CINEA and coordinated by SDM represent the largest subset, currently around 70% of the CP1 costs and 80% of the CP1 benefits[5]. Their status in June 2023 is as follows:

- 340 ATM modernisation projects (267 completed, 73 ongoing) spread across the 6 ATM Functionalities
- 94 beneficiaries spread in 26 EU Member states plus UK
- 2.7 billion EUR of total investment
- 1.3 billion EUR of EU grants

The latest Monitoring Exercise recently conducted by SDM (status in December 2022) shows that the overall CP1 implementation is well underway, after a significant acceleration occurred during 2022: with the final Regulation deadline set for end of 2027, around 31% of its technical scope is already deployed and entered into operations. The first 4 sub-AFs with regulatory deadline in December 2022 had a compliance rate of 85% in December 2022 and will reach 100% within 2023. The percentage of CP1 which is either already completed or on-going is now 76%, a +8 percentage points increase compared to 2021. Furthermore, operational Stakeholders have already planned to deploy an additional 15% of CP1 scope. Conversely, there is a lack of specific plans only for the remaining 9%, which does not necessarily entail a future non-compliance with CP1.

Within the initial Connecting Europe Facility (CEF) regulation, the successive Transport Calls (2014, 2015, 2016, 2017 Blending Call and 2017) have awarded **EUR 1.3 billion of grants to the PCP/CP1**, leveraging EUR 2.7 billion of investments into ATM modernization. Those past calls have demonstrated a high level of engagement by the ATM industry, all calls being systematically oversubscribed[6] with high quality and relevance projects, confirming grants as a highly attractive incentive to ATM community.

Grants were concentrated on **ground related projects (airport and mainly ANSPs)**, eligible to a funding of up to 50%, rather than on airborne related projects eligible to a funding of up to 20%. According to the Performance and Charging Regulation (EU) 2019/317, the States/ANSPs have to return the funds received through Union assistance programs through a reduction of the unit rates (Article 25-3). SDM is supporting PRB in the reconciliation with the tables used by States/ANSPs to report the amounts received per project, by forwarding to the PRB the relevant data such as planned costs, amounts granted, and actual amounts received.

Within the current CEF regulation (CEF2), the Transport Call 2022 published by in September 2022 is expected to mobilize an additional amount of around EUR 160 million of stakeholders' investment engaging 41 operational stakeholders (Airlines, Airports, ANSPs, Military Authorities and NM) from 22 EU Member States. The Implementation proposal submitted by SDM ("CLEAN ATM proposal") was awarded by CINEA and approved by the EU Member States on 21 June 2023 with a funding envelope of EUR 71 million and shall now be officially adopted by the European Commission.

Regarding future CEF2 calls (Calls 2023 and 2024), if any, the allocation of the Union financial support in the Transport sector is not yet known, nor the part attributed to the implementation of SESAR and ATM

[5] Source: SDM Execution Progress Report Edition 2022-1 from November 2022

[6] Except the 2017 Blending Call, with an envelope of only EUR 40 million for ATM, that was a first attempt to activate financial instruments complementing EU grants.

systems. However, as the CP1 Regulation mandates CP1 investments from ATM operational stakeholders estimated to be in total EUR 3.8 billion and considering the investments already made to date, the needs for financing to complete CP1 are still considerable.

2. Methodology

SDM's performance assessment and CBA methodology contributes to ensure that all benefits expected from the whole CP1 implementation will materialise whilst not exceeding the estimated cost. This includes:

- The use of Key Performance Indicators (KPIs) and their corresponding metrics and monetisation values that allow quantifying benefits;
- The monitoring of the CP1 benefits in a full life-cycle mode, from an initial 'top-down' approach to a 'bottom-up' approach conducted with the Implementation Projects Partners (IPPs) during the execution phase, and a "final check" (ex post assessment) after the projects are completed.

KPAs, KPIs and their monetisation

The Key Performance Areas (KPAs) that are monitored at deployment level are those of the SES performance regulation (EU IR 2019/317) and those reflected in the ATM Master Plan.

There are six Key Performance Areas (KPAs) where direct and quantifiable benefits for the European ATM and aviation are foreseen:

KPAs	Targets
Cost Efficiency (ANS productivity)	Reduced en-route and TMA costs
Capacity	Reduced departure delays
Operational Efficiency	Reduced flight time and fuel burn
Environment	Reduced CO_2 emissions
Safety	High standards
Security	High standards

Table 1 - KPAs

As Safety and Security are not monetised at this stage, the monetised benefits come from the following KPAs: Cost Efficiency (ANS productivity), Capacity, Operational Efficiency and Environment.

The following table gives the Key Performance Indicators (KPIs) used by SDM, in relation to their KPAs.

KPAs	KPIs
Cost Efficiency (ANS productivity)	Gate to Gate ANS cost (in €)
Capacity	Departure Delay (in minute): • Airport ATFM Delay • En-Route ATFM Delay • ATC Delay
	Cancellations (in number of events)
Operational Efficiency	Flight Time (in minute): • Unimpeded ASMA[7] Time • Additional ASMA Time • Unimpeded Taxi-in Time • Additional Taxi-in Time • Unimpeded Taxi-out Time • Additional Taxi-out Time • Horizontal Flight Time
	Fuel consumption (in tons of fuel)
Environment	CO_2 emissions (in tons of CO_2)

Table 2 - KPAs and KPIs

The detailed definition of the KPIs is in line with Implementing Regulation (EU) No 2019/317 and the Performance Review Unit dashboard (PRU), which can be found on the website of the PRU.

The Table above does not mention the master KPI "Horizontal Flight Efficiency" which measures the savings in Nautical Miles during the horizontal phase of the flight, because these Nautical Miles savings are converted into the following three categories of savings: minutes (KPI "Horizontal Flight Time"), tons of Fuel (part of the KPI "Fuel consumption") and tons of CO_2 (part of the KPI "CO_2 emissions").

It must be stressed that "En-Route ATFM delay" savings are calculated in reference to a "do-nothing" (or "no-CP1") scenario which foresees a strong increase of these delays in case no CP1 investment is made.

Figure 2 below shows the KPIs grouped by the operational environment to which they are related. KPIs shown in green refer to "strategic" inefficiencies, for example due to current airspace design, and refer to delay reductions included in airline schedules (flight plan).

KPIs shown in blue refer to "tactical" inefficiencies caused by unpredictable delays on the day of operations that exceeds the delay buffer foreseen in the flight plan.

[7] ASMA: Arrival Sequencing and Metering Area

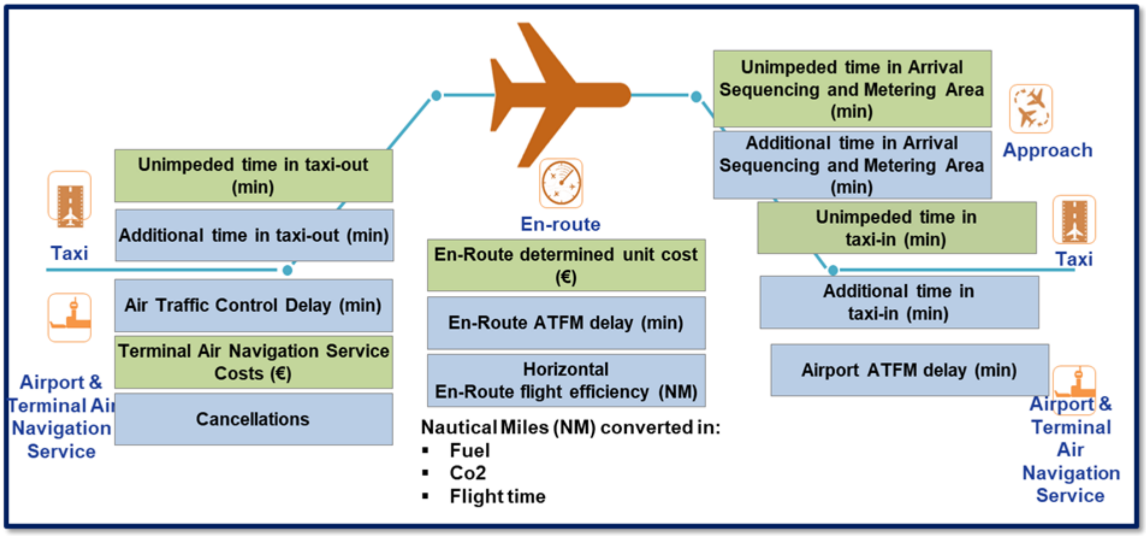

Figure 2 - KPIs and related operational environments

For each KPI, improvements can be monetised by multiplying the savings (expressed in their respective unit) by a valorisation factor: euros per minute, euros per ton of fuel or ton of CO_2 etc. It should be noted that the valorisation factors currently in use in the Deployment Programme are derived from the version 08 of the Eurocontrol "Standard Inputs for Cost and Benefits Analyses" published in January 2018. An update of the monetization factors is performed whenever deemed necessary, following the release of a new version of the Eurocontrol "Standard Inputs for Cost and Benefits Analyses" with significant changes.

Full life-cycle mode and final check

The objective is to provide a monitoring of the CP1 benefits in a full life-cycle mode: starting from high-level benefits estimates as foreseen in the initial CP1 CBA, through more accurate expectations of benefits as monitored during the implementation phase of the projects, to a final benefit determination after the projects have been implemented.

The benefits can include quantitative benefits, such as cost savings or operational efficiency improvements, as well as qualitative benefits, such as noise reduction or social economic impacts.

To illustrate the continuous process, the project performance assessment life-cycle could be represented as in the following figure:

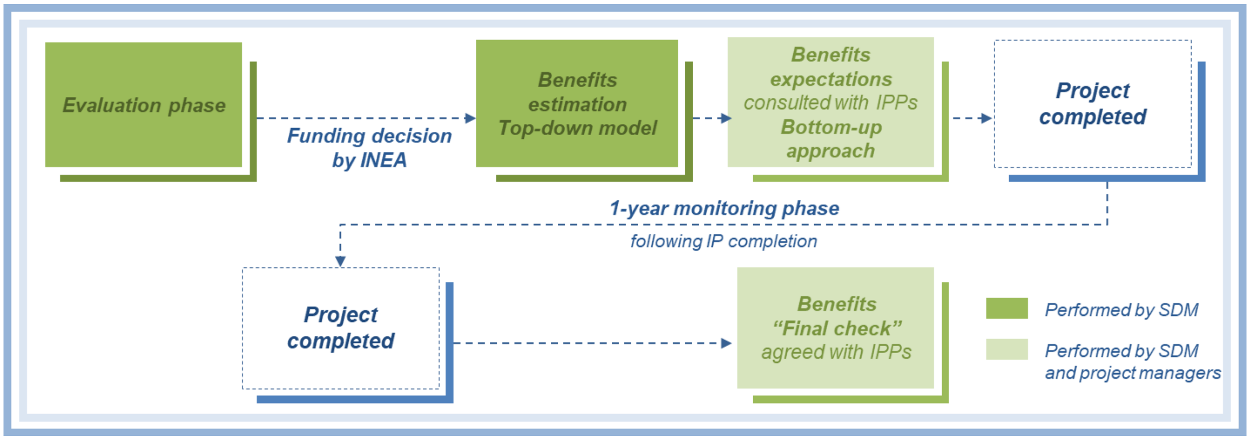

Figure 3 - Project performance assessment life-cycle

While the CP1 CBA and the underlying methodology constitute the general reference for performance expectations at ATM Functionality (AF) level, the projects' contribution to performance and their CBAs are identified and quantified at a greater level of detail. As time passes and more actual information is available, the methodology allows to fine tune from the initial overall top-down approach to a continuous bottom-up approach conducted with the implementing partners and finally to turn from expectations to actual results both on cost and benefits sides. As the global CBA of the deployment programme is built by summing the parts being deployed and the ones already completed, the picture progressively turns from an estimated CBA to a CBA with actual results.

It should be noted that the performance of completed projects can be monitored after a period of a minimum of one year of operations, in order to have a more accurate measurement.

Models used in the performance assessment

Grouping of projects into threads

In many cases, projects are combined into "threads" to facilitate the calculation of the performance gains and associated benefits: a thread is a group of projects whose benefits are inter-related.

Indeed, in many cases individual Implementation Projects (IPs) cannot be assessed alone: study projects aiming to find an appropriate implementation method, interdependent projects, cross-border initiatives, infrastructure enabler projects etc. In such cases, a grouping of projects is needed to have a more realistic assessment which also includes synergies. In practice, threads are usually composed of one to three-four interrelated IPs.

Of course, after the performance and benefits calculation is performed, consolidation occurs both on benefits and on costs to build a global CBA for the specific thread.

Top-down model for AF1 and AF2

To define the benefit expectations during the execution phase, a top-down model is used at the first stage of the evaluation.

For AF1 and AF2, SDM is using a model with defined improvement percentages for each Family and each relevant performance indicator, based on different sources: S3JU Deliverables, Flights Demo Reports and expert judgement.

The performance gains are then calculated on a yearly basis based on the KPI improvement percentage of the Family in the model, multiplied by a yearly ramp-up factor, multiplied by the reference KPI value for the selected location (for instance the level of taxi delays in minutes at the selected airport), multiplied by the gap coverage of the project (or thread) within the Family, finally multiplied by the volume of traffic for the given location. Some correction factors for specific locations or projects may also be used in the calculation.

Simulations for AF3 and AF4

For AF3 and AF4 the simulations are run by the Network Manager and take into consideration a harmonised network approach that ensures the consistency between the Network Operations Plan (NOP), the European Route Network Improvement Plan Part 2 (ERNIP) and the relevant projects proposed in the context of AF3 and AF4. This consistency must be maintained for all the subsequent updates of the Deployment Programme and the gaps identification.

Capacity Assessment with respect to the AF3 and AF4 projects:

- The capacity assessment is based on the Capacity Assessment and Planning Guidance document that has been approved by the Network Manager Board in June 2013, as part of the Network Operations Plan Approval. The reference to this document is given in all the successive editions of the Network Operations Plan.
- In the capacity assessment, the percentages of improvement brought by the project or thread are taken into account together with the flight profiles derived from STATFOR data assuming routing via the shortest routes available on the future ATS route network, with generally unconstrained vertical profiles.
- The Network Manager has ensured a full consistency between the last available version of the Network Operations Plan and the evaluation of the operational performance potential of the AF3 and AF4 projects.
- A do-nothing scenario was developed to compare to the potential of the various AF3 and AF4 related projects listed in the last available version of the Network Operations Plan. The assessments take into consideration a harmonised network approach.

Flight Efficiency Assessment with respect to the AF3 and AF4 projects:

- The flight efficiency assessment is based on the overall flight efficiency evaluations made in the context of the last version of the European Route Network Improvement Plan, Part 2 – ARN Version.
- The Network Manager has ensured a full consistency between the European Route Network Improvement Plan, Part 2 last ARN version and the evaluation of the operational performance potential of the AF3 and AF4 projects with respect to flight efficiency.
- The evaluations made in the previous editions of the European Route Network Improvement Plan, Part 2 demonstrated that the operational performance improvements achieved were in line year on year with the estimations made.

No benefits monetisation for AF5 and AF6

AF5 and AF6 are support to other AFs, with transversal benefits that are difficult to quantify separately. They are also enablers for future ATM technologies, outside the scope of the CP1 but included in the Airspace Architecture Study and the ATM Master Plan. Therefore, in the CP1 CBA no benefits were directly quantified in AF5 and AF6.

Although no monetised benefits have been assigned to AF5 and AF6, they remain key SESAR functionalities. A qualitative description of their benefits would include:

- For AF5, reduction in charges (Cost Efficiency) from the rationalisation of the existing infrastructures; increase of ANS Productivity (Cost Efficiency) from more resilient and seamless information data access, higher levels of automation in the management of information, reduction in misalignments between different stakeholders, increased trust in the exchanged data; increase of Safety from a better situational awareness and collaborative decision-making; Capacity, Operational efficiency and Environment savings, from enhancements in future functionalities that are critical to enhance airport management, en-route/approach ATC processes, network management, functionalities related to the flight object etc.

- For AF6, improved predictability from the sharing and use of on-board 4D trajectory data by the ground ATC system and NM system, facilitating more efficient business trajectories; ANS productivity gains (Cost Effectiveness), from less tactical interventions, automated assistance to controller for seamless coordination and adaptation to actual traffic situation; Capacity gains in both en-route and TMA airspace, from improved network planning and better airspace management; Flight Efficiency improvements in Time & Fuel/CO2, from improved de-confliction and the reduction of tactical interventions, allowing the aircraft to fly as much as possible on direct routes across sectors/centres/FABs, and better descent profiles.

Matching between SDM performance assessment and PRB targets

Capacity

As defined by the performance and charging scheme, the PRB proposes targets in terms of Union-wide En-Route ATFM delays.

SDM uses an envelope of En-Route ATFM delays saved due to CP1 implementation. This envelope is an absolute figure compared to a do-nothing scenario. Therefore, the KPIs are not directly comparable: PRB value is a target of En-Route ATFM delay per flight and SDM value is the total saving compared to a do-nothing scenario.

Considering the CP1 scope, the table below shows how to translate savings into a saving per flight (example for the year 2027):

En Route ATFM minutes saved due to CP1 implementation in 2027 (Source: Network Manager simulation, updated with traffic from STATFOR April 2023)	26,615,468
Flight movements in 2027 (Source: STATFOR April 2023)	11,490,000
CP1 capacity impact in 2027 (against the do-nothing scenario)	**2.3 minutes/flight**

Table 3 – Conversion of En-Route ATFM delay savings to impact per flight

This impact represents the CP1 contribution based on NOP and ERNIP data used for the simulation. It must be stressed, that this saving is measured against the do-nothing scenario on the same year (here

2027) and should be taken into account as such, not applying this impact to any historical reference (like year N-1 for instance).

The simulated evolution of CP1 contribution over the period 2025 2035, extracted from the Airspace Architecture Study[8] from 2019, is shown on the figure below.

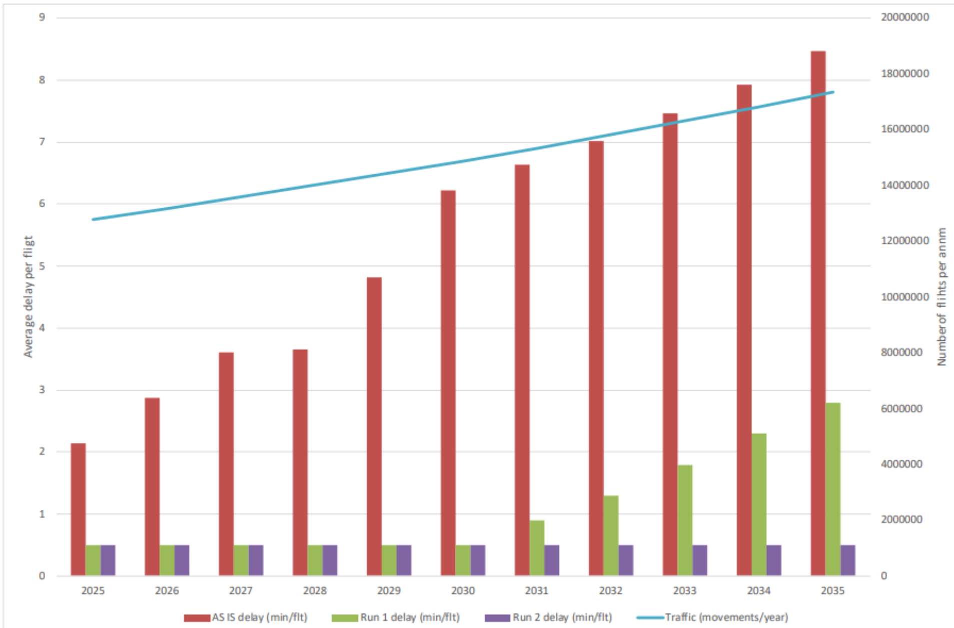

Figure 4 – Predicted En-Route ATFM delays (Airspace Architecture Study)

This graph shows the En-Route ATFM delays evolution as predicted by the Network Manager in 2019, based on the traffic forecast from 2019:

- Red bars - simulation without any implementation (do-nothing scenario)
- Green bars - simulation with PCP/CP1 implementation
- Blue bars - with additional future SESAR solutions.

It demonstrates the importance of PCP/CP1 implementation, even when tangible delay savings could not be traced. It highlights as well, that without further investment but with rising traffic the overall delay per flight would start raising from 2031 onwards up to >2min/flight.

Environment

PRB proposes the Union-wide targets in terms of horizontal efficiency by using the Key performance Environment indicator based on Actual trajectory representing the percentages of additional distance between the great circle distance and the actual trajectory (KEA).

SDM uses the envelope of Nautical Miles saved due to CP1 implementation. This envelope is an absolute figure compared to a do-nothing scenario. Therefore, the KPIs are not directly comparable.

[8] A Proposal for the future architecture of the European airspace, by SESAR Joint Undertaking and Eurocontrol

Considering the CP1 scope, the table below shows how to translate savings into an average percentage per flight (example for the year 2027):

Nautical Miles saved due to CP1 implementation in 2027 (Source: Network Manager simulation, updated with traffic from STATFOR April 2023)	45,138,340
Flight movements in 2027 (Source: STATFOR April 2023)	11,490,000
Average distance flown per flight *(Source: Eurocontrol Standard Inputs for Economic Analyses Edition 2020)*	*659*
Nautical Miles flown in 2027 (Average distance flown x movements)	7,571,910,000
Average CP1 savings per flight in 2027 (against the do-nothing scenario)	**0.6 %**

Table 4 – Conversion of Nautical Miles savings average percentage per flight

This impact represents the CP1 contribution, based on NOP and ERNIP data used for the simulation. Again, it must be stressed that this saving is measured against the do-nothing scenario on the same year (here 2027) and should be taken into account as such, not applying this impact to any historical reference (like year N-1 for instance).

3. Capacity

SDM calculates the savings on capacity and especially the En-Route ATFM delays savings based on a simulation done by Network Manager. The initial simulation, dated from 2015, has been continuously updated by SDM and the impact of COVID has significantly reduced the initial savings (see the years 2020 and 2021 in Figure 5 below). The savings are estimated against a do-nothing scenario which foresees a strong increase of these delays in case no CP1 investment is made (see Figure 4 above from the Airspace Architecture Study).

In the CP1 CBA, En-Route ATFM delays savings are stemming from AF3 (60%) and AF4 (40%). Figure 5 below shows the CP1 initial envelope (before COVID), the CP1 updated envelope (based on the latest STATFOR traffic forecast from April 2023), and the En-Route ATFM delays savings generated by all AF3/AF4 projects coordinated by SDM (the estimated data values per Member State was exchanged with PRB).

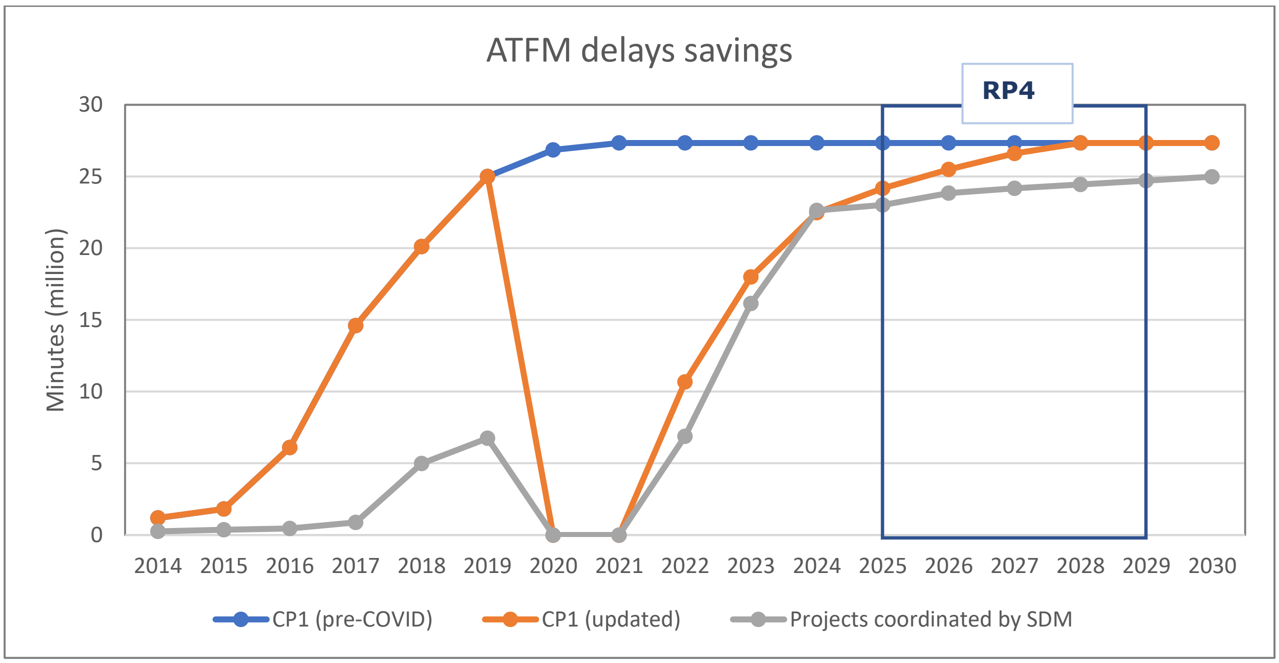

Figure 5 – CP1 En-Route ATFM delays savings

The figure shows that the yearly savings from CP1 should continue to rise during RP4, from 22.5 million minutes in 2024 (last year of RP3) to 24.2 million minutes in 2025 (first year of RP4) and 27.3 million minutes in 2029 (last year of RP4). A large part of these savings (more than 90%) is generated by the projects coordinated by SDM. The values are shown in Table 5 below.

		RP4				
En-Route ATFM delays savings (million)	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
CP1 (updated)	22.5	24.2	25.5	26.6	27.3	27.3
Projects coordinated by SDM	22.5	23.0	23.8	24.2	24.4	24.7

Table 5 – Values of CP1 En-Route ATFM delays savings

Evidence of savings on capacity

SDM monitors the performance impact of the awarded projects, both the ongoing ones (estimated performance) and the completed ones (final check). The En-Route ATFM delays results are depicted on the grey line in Figure 5 above. It shows that the updated estimations on the ongoing projects and the final checks performed on the first completed projects are confirming the updated CP1 envelope. The difference between the two lines (overall CP1 in orange and awarded projects in grey) is explained by the fact that not all AF3/AF4 investments projects are coordinated by SDM.

Examples of projects already completed that passed the final check with significant positive impact on capacity:

- NAV PORTUGAL / Interface to Network Manager Systems (AF4)
- EUROCONTROL-NM: Trajectory Prediction (AF4)
- BULATSA / tCAT in Sofia ACC (AF4)
- EUROCONTROL-NM: ASM FUA (AF3)
- EUROCONTROL-NM / Implementation of target times (ATFCM) (AF4)
- Czech Republic / Traffic Complexity Tool (AF4)
- EUROCONTROL-NM / Flight Evolution and upgrade of interfaces (AF4)
- COOPANS / Harmonisation of technical ATM platform (AF3)

Examples of projects without final check yet, but with expected significant positive impact on capacity:

- DSNA / 4-Flight (AF3)
- DFS / ICAS (AF3)
- Many other examples (Borealis, PANSA, BULATSA, ENAIRE…)

4. Environment

In the CP1, this KPA is mainly driven by optimized flight paths during the En-Route phase, where AF3 functionalities will improve the En-Route horizontal flight efficiency and reduce the CO2 footprint of European aviation sector. CO2 savings during the En-Route phase due to AF3 represent more than 80% of the total CO2 savings from the CP1.

The additional savings in CO2 (20%) are generated during the approach and taxi-in & out phases by AF1 and AF2 but, as noted above, not all locations are mandated to implement AF1/AF2 in the CP1 Regulation. Moreover, some of these functionalities may be outside of the responsibility of ANSPs.

Therefore, this section will focus on CO2 savings from AF3, namely Airspace Management (ASM) and Flexible Use of Airspace (FUA), initial Free Route and full cross border Free Route airspace (the later by the end of 2025).

The master KPI used to calculate CO2 savings in the En-Route phase is the number of Nautical Miles saved, which can easily translate into minutes of flight, tons of fuel and tons of CO2 by using the following conversion factors:

- 1 Nautical Mile = 1/7.3 minute
- 1 minute = 60 kg fuel
- 1 kg fuel = 3.15 kg CO2

The figure below shows the CP1 initial envelope of Nautical Miles savings (before COVID), the CP1 updated envelope (based on the latest STATFOR traffic forecast from April 2023), and the Nautical Miles savings generated by all AF3 projects coordinated by SDM.

For the CP1, it can be noted there is an intermediate level after 2022 (initial Free Route by the Member States) and a final level after 2025 (Cross Border functionality), corresponding to the due dates in the CP1 Regulation (the estimated data values per Member State was exchanged with PRB).

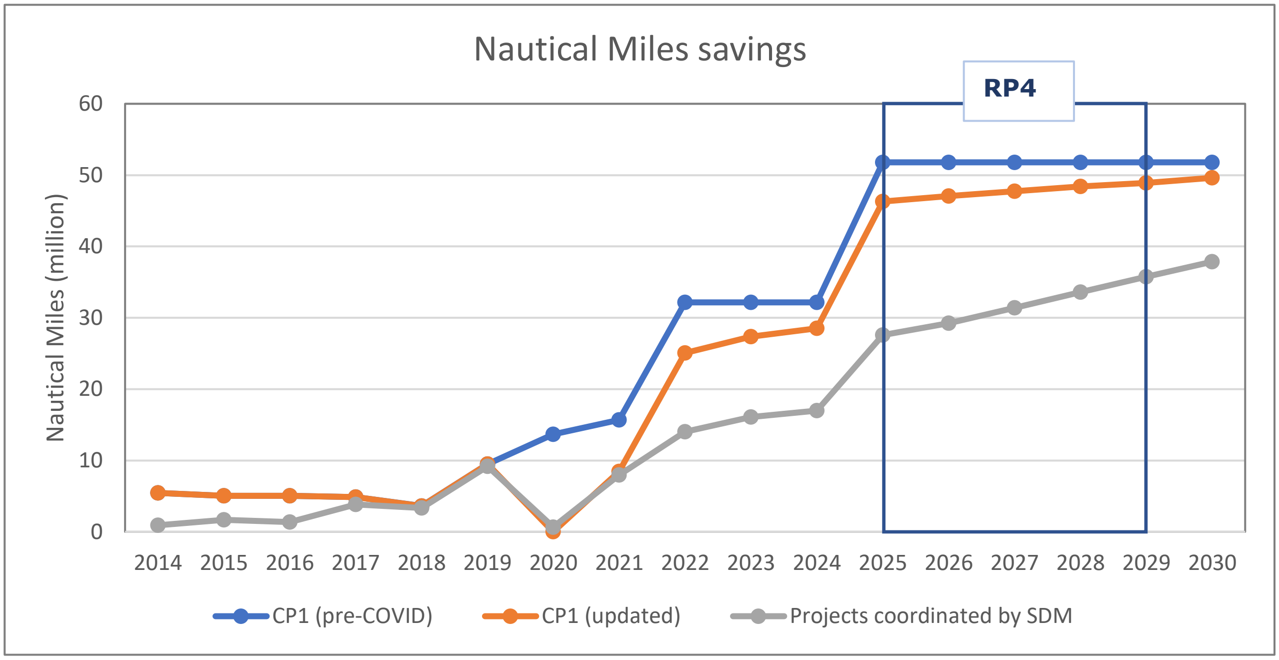

Figure 6 - CP1 En-Route Nautical Miles savings

The figure shows that the yearly savings from CP1 should continue to rise during RP4, from 28.5 million Nautical Miles in 2024 (last year of RP3) to 46.3 million NM in 2025 (first year of RP4) and 48.9 million NM in 2029 (last year of RP4). A large part of these savings (more than 65%) is generated by the projects coordinated by SDM. The values are shown in Table 6 below.

		RP4				
En-Route Nautical Miles savings (million)	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
CP1 (updated)	28.5	46.3	47.1	47.7	48.4	48.9
Projects coordinated by SDM	17.0	27.6	29.3	31.4	33.6	35.7

Table 6 – Values of CP1 En-Route Nautical Miles savings

Evidence of savings on flight efficiency:

SDM monitors the performance impact of the awarded projects, both the ongoing ones (estimated performance) and the completed ones (final check). The Nautical Miles results are depicted on the grey line in Figure 6 above. It shows that the updated estimations on the ongoing projects and the final checks performed on the first completed projects are confirming the updated CP1 envelope. The difference between the two lines (overall CP1 in orange and awarded projects in grey) is explained by the fact that not all AF3 investments projects are coordinated by SDM.

Examples of AF3 projects already completed that passed the final check with significant impact on environment:

- BOREALIS / NEFRA Free Route Implementation (AF3)
- ENAV / Free Route Italy (AF3)
- HUNGARO CONTROL / Free Route & ATM System Upgrade (AF3)
- EUROCONTROL-NM: DCT FRA Support (AF3)
- EUROCONTROL-NM: ASM FUA (AF3)
- EUROCONTROL-NM: Interactive Rolling NOP & Network Collaborative Management (AF4)
- CROATIA CONTROL / SEAFRA Simulation & Implementation (AF3)
- NAV PORTUGAL / ASM (AF3)

In general, SDM expects a reduction of fuel per flight in the range of (35-58kg), depending on the size and structure of the airspace.

5. Safety

Safety benefits are, although clearly being an important performance area, not monetised in the CP1 CBA. This mainly results from the lack of a universal methodology to comprehensively assess safety benefits. If such a methodology could be used, monetised benefits would likely be significant as **safety appears in all the ATM Functionalities under the CP1:**

AF1: Safety benefits are expected from AMAN/DMAN integration and extended AMAN due to the increased predictability that enables a lower complexity and reduces traffic congestion. Additionally, the assurance that military aircraft operate same procedures as civil aircraft reduces mixed traffic operations that always raise safety concerns. It must be noted however that such procedures themselves may require the optimisation or upgrades of existing safety nets e.g., Area Proximity Warning and Mid Term Conflict Detection as foreseen under AF3 below.

AF2: AF2 is likely to be the most safety-related ATM Functionality in the CP1. Safety is expected from all the functionalities associated to Airport safety nets and from Electronic Clearance Input supporting Airport safety nets.

AF3: Safety is expected from the upgrade of ATM systems to support Free Route RA. Dynamic Area Proximity Warning (APW) and Mid Term Conflict Detection (MTCD) developed under this family would be of use for AF1.

AF4: One of the key purposes of AF4 is to reduce tactical interventions by air traffic controllers and improve de-confliction of aircraft. As such it aims at reducing the workload of ATCOs, with safe and expeditious movements of air traffic as a consequence.

AF5: Safety benefits expected would be of direct or indirect nature, as integration of different information systems with SWIM will lower the complexity with a reduced risk of system outages during operations and make information more easily available thus providing air traffic controllers with more accurate information, leading to better situational awareness.

AF6: Air-Ground Trajectory Information Sharing can contribute to improving safety.

Consequently, the following top key risk areas as identified by the EASA Annual Safety Reviews are addressed explicitly by the functionalities in the CP1:

Runway collisions: runway excursions, ground collisions and deviation of taxiing procedures have a high number of ATM/ANS related incidents and accidents, with direct ATM/ANS contribution. AF2 makes an impactful contribution to this.

Airborne collisions: AF3 and AF1 are addressing separation minima infringements and unauthorised penetration of segregated airspace in the Free Route Airspace (FRA) or in the Terminal Maneuvering Area (TMA); AF1 is also addressing deviations from operational procedures and missed approaches.

The need to handle future traffic after Covid recovery without impacting safety and security calls for continuous investments in safety related projects. In particular, even without precise quantified justifications, the upmost **importance of safety investments in the CP1 justifies that the target levels of safety should at least be maintained during RP4** like they were between 2014 and 2019 despite a double-digit increase of traffic, which will demonstrate a global increase of safety from a relative perspective.

Conclusion

- The CP1 implementation has been supported by CINEA through the Connecting Europe Facility funding. This helped significantly to accelerate a synchronized deployment conducted by SDM.

- Because CP1 implementation due dates are well within the timeframe (2025-2029) of RP4, CP1 contribution to performance should be taken into account in the target setting of RP4.

- SDM uses an envelope to estimate the benefits stemming from CP1 implementation. This envelope is an absolute figure compared to a do-nothing scenario. Therefore, the KPIs and their estimated values are not directly comparable with the targets proposed by the PRB.

- Despite this, within the KPAs addressed in the Performance and Charging regulation, there are strong evidences of significant savings from CP1 across the RP4 timeframe in Capacity and Environment, driven by ATM Functionalities AF3 and AF4.

- There is a harmonised network approach that ensures the consistency between the Network Operations Plan (NOP), the European Route Network Improvement Plan Part 2 (ERNIP) and the relevant projects proposed in the context of CP1 (e.g. AF3 and AF4).

- The measured savings from CEF awarded projects by SDM are currently indicating that the initial simulations and envelopes were correctly estimated. SDM will continue providing an utmost realistic view on the expected improvements through continuously maintained data.

- Equally important to stress are the qualitative improvements enabled by the CP1 in the Safety area.