2024

Comparison of Operational Air Navigation System Performance

BRAZIL - EUROPE
2019-2024

DECEA Performance Section and
EUROCONTROL Performance Review Unit

BRAZIL
EUROPE

Departamento
de Controle do Espaço Aéreo
Department of Airspace Control

EUROCONTROL

Operational Comparison of ANS Performance

DECEA Performance Section
EUROCONTROL Performance Review Unit

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Preface

A continuing partnership

This fourth edition of the bi-regional Brazil-Europe comparison report of Air Navigation System Performance continues to add transparent and robust data to support an informed discussion about operational performance in both regions. Further, it strengthens the close collaboration between DECEA and EUROCONTROL. This report is jointly developed by the Performance Section of the Department of Airspace Control (DECEA) and EUROCONTROL's Performance Review Unit (PRU).

For any questions, please do not hesitate to contact one of the authoring organisations.

Performance Section, DECEA
Performance Review Unit, EUROCONTROL

Foreword

General Maurício Augusto Silveira de Medeiros
Director General of DECEA

Dr Peter Whysall
Chairman of the Performance Review Commission

The partnership between DECEA and EUROCONTROL continues to consolidate itself as a reference in international technical cooperation aimed at excellence in ATM performance management. The Performance Review Commission (PRC), in particular, has been a strategic partner in deepening comparative studies between Brazil and Europe, with ongoing support for data sharing, indicator analysis, and the adoption of best practices in performance management.

This report reflects the results of that joint effort, which has expanded with each edition. The inclusion of new topics, such as the Point Merge, as well as the comparison related to the Curitiba and Lisbon ACCs, shows that even with distinct regional characteristics and operational specificities, benchmarking is not only possible but highly valuable. It broadens mutual understanding and reinforces the feasibility of applying solutions and concepts to the reality of each system.

This promising journey highlights the evolution of our air navigation system, driven by performance measurement and continuous dialogue with partners such as EUROCONTROL. It demonstrates that we are on the right path — one guided by cooperation, transparency, and a commitment to continuous improvement.

Executive Summary

The Performance Section of the Brazilian Department of Airspace Control and the Performance Review Unit of EUROCONTROL jointly developed this fourth edition of the Brazil-Europe comparison of Air Navigation System Performance. This edition of the bi-regional report builds on the previous comparison reports using commonly agreed metrics and definitions to compare, understand, and improve the performance of air navigation services. This report and previous editions are available via the web-portals of both organisations:

- https://ansperformance.eu/global/brazil or
- https://performance.decea.mil.br/.

This edition expands on the previous comparisons of the Brazilian and European air navigation systems by focussing on the observed performance post COVID, extending the time frame, and incorporating additional analyses. For example, a more detailed characterisation of the Brazilian and European network is included. With the recent deployment of point-merge, operations at Sao Paulo Guarulhos and Lisbon are studied and an initial characterisation is provided. On the center level, this edition also looks into comparing Curitiba and Lisbon ACC. These focussed topics allow to address discussions about performance benefits and may help to highlight the differences between the operations in both regions.

The report focuses on a subset of the eleven Key Performance Areas identified by the ICAO Global Air Navigation Plan, in particular Predictability, Capacity and Efficiency.

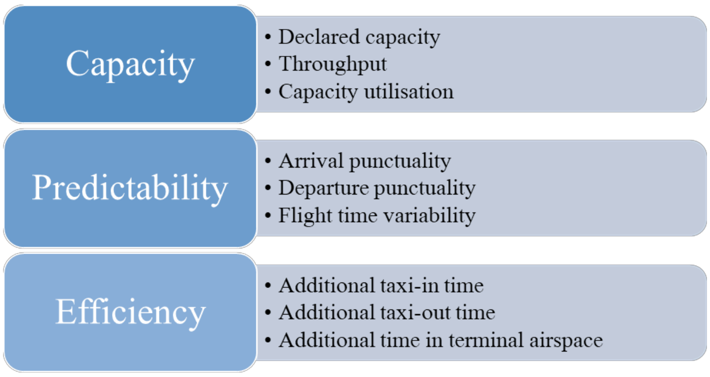


Figure 1: Key Performance Areas addressed in this edition

The comparison shows similarities and differences in the air navigation service provision and observed performance in both regions. Major take-aways of this report include:

- The close collaboration between DECEA and EUROCONTROL is highlighted sharing insights and experiences with the international aviation communities, thus assisting in advancing ATM performance management worldwide.

- While the observed performance levels in both regions differ, similarities and understood differences support more targeted discussions on operational concepts. With Europe closing in on pre-pandemic traffic levels and Brazil now consistently observing demand above the pre-pandemic level, this edition also forms the reference for future iterations.
- Regarding punctuality, unique trends were evident in both regions, not solely attributable to the extent of traffic resurgence. In Brazil, a consistently higher proportion of flights arrived significantly early, a pattern largely unaffected when comparing previous years. Conversely, the documented challenges of European airports in coping with the recovering traffic demand and the record high of network constraints in 2023 and 2024 impact the robustness of the schedule.
- Overall, Europe showed a higher level of throughput as the higher traffic numbers and constraints require a higher level of pressure on the infrastructure. Nonetheless, the constraints of reaching pre-pandemic traffic levels will require attention in terms of increasing efficiency and reducing capacity constraints with future growth. Brazil may benefit from increasing their stance and maintaining current performance levels with the anticipated growth of traffic.
- This report took a first stab at characterising the regional networks for future topic-centric amendments. This will allow to drive future topic studies and provide essential context. As an initial topic-related study, a closer look was taken at two point merge implementations in Brazil and Europe that show different performance outcomes. This is complemented by providing a first look at the operational context of two centres, i.e., Curitiba and Lisbon. This edition helped to frame the work and identify a set of future research questions.

This report will be updated throughout the coming years under the umbrella of the DECEA-EUROCONTROL memorandum of cooperation. It is also planned to establish a web-based rolling monitoring updated on a regular basis.

Future editions will complement the data time series and support the development of further use-case analyses. The lessons learnt of this joint project will be coordinated with the multi-national Performance Benchmarking Working Group (PBWG) and the ICAO GANP Study sub-group concerned with the further development of the GANP Key Performance Indicators (KPIs).

1 Introduction

1.1 Background

Air transportation is a key economic driver in Brazil and Europe. Both regions share the political goal of a performance-based approach to foster the continual growth and efficiency of air transport. It is recognised that Air Navigation Services (ANS) play a critical role in terms of limiting the constraints on airspace user operations. Accordingly, the analysis and regional comparison of operational ANS performance informs about trends over time, the success of change implementation, and potential performance benefit pools for future exploitation.

With a view to a tighter collaboration between Brazil and Europe, DECEA and EUROCONTROL signed a cooperation agreement in 2015. This agreement encompasses various activities, most notably the cooperation and joint initiatives in the domain of operational performance benchmarking of ANS.

The close technical collaboration of the Performance Section of DECEA and EUROCONTROL's Performance Review Unit comprises the further development and validation of proposed ICAO GANP indicators, regular performance related data exchange, and the production of regional or multi-regional performance reports. An essential part of this work entails the identification and validation of comparable data sources, the development of a joint data preparatory process, and supporting analyses to produce this report or contribute to the aforementioned international activities.
This report represents the fourth edition of a jointly developed comparison report providing insights into the observed operational performance in Brazil and Europe.

1.2 Performance Areas

Establishing a set of shared definitions and a mutual understanding is essential to facilitate comparisons and operational benchmarking activities. Therefore, the work presented in this report is rooted in prior work conducted by ICAO, other regional or multi-regional operational benchmarking initiatives (e.g., PBWG [1]), and practices within various regional or organisational settings.

The key performance indicators (KPIs) utilised in this study have been developed through a rigorous process that integrates the best available data from both the DECEA Performance Section and PRU. It is important to note that the comparative analysis in this iteration of the report does not encompass all eleven Key Performance Areas (KPA) as presented in Figure 1.

[1] The Performance Benchmarking Working Group (PBWG) comprises participants from Brazil (DECEA), China (CAA-OSC), Japan (JCAB), Singapore (CAA), Thailand (AEROTHAI), United States (FAA-ATO), and EUROCONTROL.

From an indicator perspective, the DECEA Performance Section and PRU have reached a consensus to concentrate on operational benchmarking and aligning their efforts with the performance indicators proposed by ICAO in conjunction with the update of the Global Air Navigation Plan (GANP). Discussions are on-going, and future work may also include aspects of cost-effectiveness.

1.3 Geographical Scope

This report's geographical focus encompasses Brazil and Europe.

Airspace control in Brazil is a fully integrated civil-military operation. The Brazilian Air Force is responsible for air defence and air traffic control functions. This ensures air traffic safety while contributing to military defence efforts. Within this framework, the Department of Airspace Control (DECEA) operates as a governmental entity under the authority of the Brazilian Air Force Command. DECEA plays a pivotal role in coordinating and furnishing human resources and technical equipment to all air traffic service units operating within the Brazilian territory.

DECEA is the cornerstone of the Brazilian Airspace Control System (SISCEAB). The department provides air navigation services for the vast airspace jurisdiction covering 22 million square kilometres, including oceanic areas. The Brazilian airspace is further divided into five Flight Information Regions (FIR) and the areas of responsibility of these integrated Centres for Air Defence and Air Traffic Control (CINDACTA) are depicted in Figure 1.1.

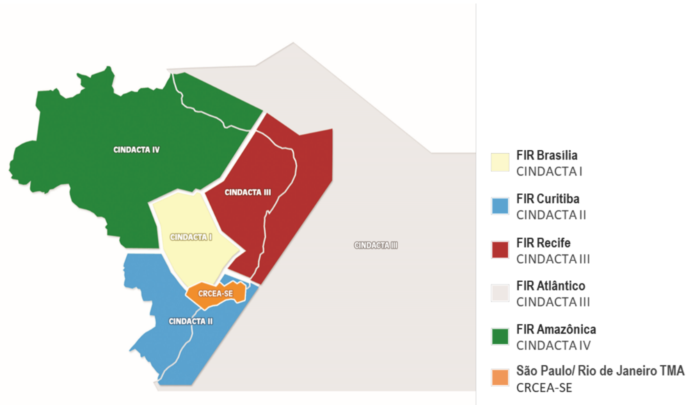


Figure 1.1: Brazilian Airspace Structure/FIRs (CINDACTAs)

The CINDACTAs merge civilian air traffic control with military air defence operations. In addition to the CINDACTAs, there's the Regional Center of Southeast Airspace Control (CRCEA-SE). The latter is tasked with managing air traffic in the densely congested terminal areas of São Paulo and Rio de Janeiro.

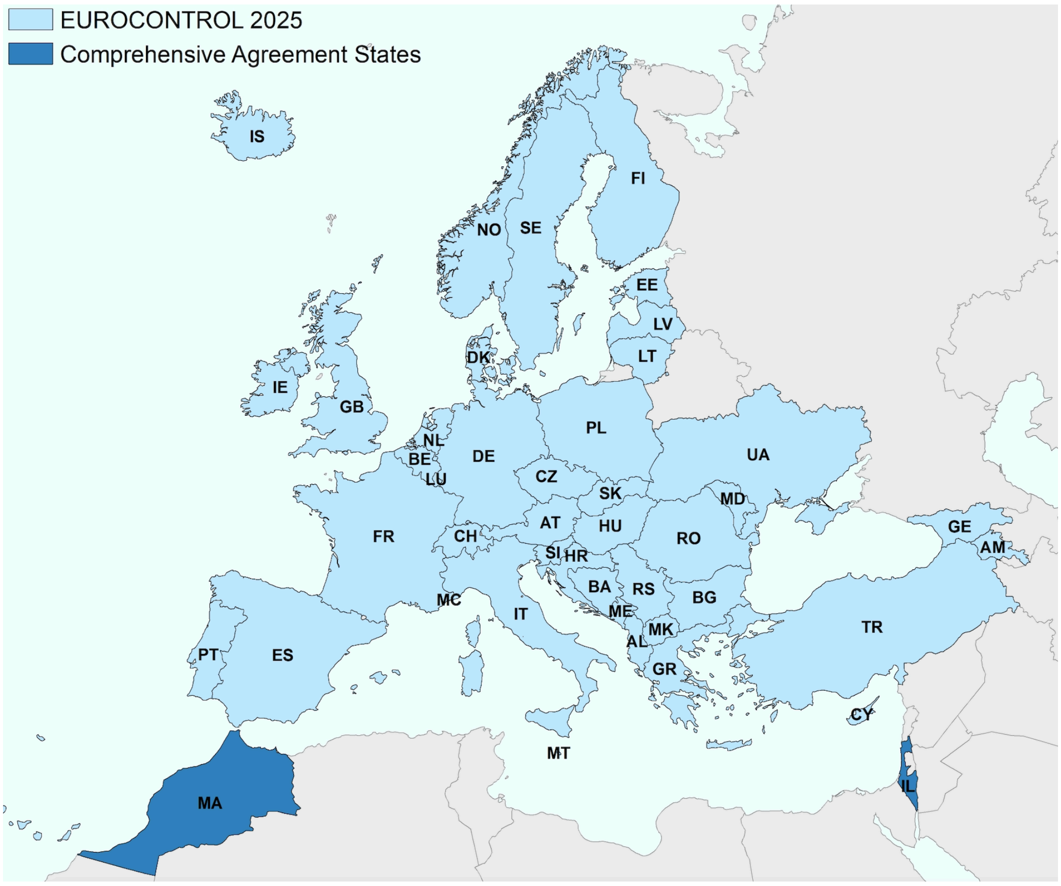


Figure 1.2: European Airspace and EUROCONTROL Member States

In this report, Europe, i.e. the European airspace, is defined as the area where the 42 EUROCONTROL member states provide air navigation services, excluding the oceanic areas and the Canary islands (c.f. Figure 1.2). In 2016, EUROCONTROL signed a comprehensive agreement with Israel and Morocco. Both comprehensive agreement States will successively be fully integrated into the working structures of EUROCONTROL, including performance monitoring, in the coming years. Within this report, these states are included in the reported network traffic volumes.

EUROCONTROL is an inter-governmental organisation working towards a highly harmonised European air traffic management system. In general, air traffic services are provided by - predominantly national or local - air navigation service providers entrusted by the different EUROCONTROL member states. Dependent on the local and national regimes, there is a mix of civil and military service providers, and integrated service provision.
The Maastricht Upper Area Control Center is operated by EUROCONTROL on behalf of 4 States (Netherlands, Belgium, Luxemburg, and Germany). It is the only multi-national cross-border air traffic service unit in Europe at the time being. Across Europe a number of cross-border arrangements are in place. Given the European context and airspace structure, the European area comprises 37 ANSPs with 62 en-route centres and 16 stand-alone Approach Control Units (i.e. totalling 78 air traffic service units).

Europe employs a collaborative approach to managing and servicing airspace and air traffic. This includes the integration of military objectives and requirements which need to be fully

Table 1.1: List of study airports for the Brazil / Europe operational ANS performance comparison

Brazil	Europe
Brasília (SBBR)	Amsterdam Schiphol (EHAM)
São Paulo Guarulhos (SBGR)	Paris Charles de Gaulle (LFPG)
São Paulo Congonhas (SBSP)	London Heathrow (EGLL)
Campinas (SBKP)	Frankfurt (EDDF)
Rio de Janeiro S. Dumont (SBRJ)	Munich (EDDM)
Rio de Janeiro Galeão (SBGL)	Madrid (LEMD)
Belo Horizonte Confins (SBCF)	Lisbon (LPPT)
Salvador (SBSV)	Barcelona (LEBL)
Porto Alegre (SBPA)	London Gatwick (EGKK)
Curitiba (SBCT)	Zurich (LSZH)

coordinated within the ATM System. A variety of coordination cells/procedures exists between civil air traffic control centres and air defence units reflecting the local practices. Many EUROCONTROL member states are members of NATO and have their air defence centres / processes for civil-military coordination aligned under the integrated NATO air defence system.

Further details on the organisation of the regional air navigation systems in Brazil and Europe will be provided in Section 2.1.

1.3.1 Study Airports

As concerns airport-related operational air navigation performance, this edition of the comparison report addresses the performance at a set of selected airports. These airports represent the top-10 or most relevant airports in terms of IFR movements in both regions and allow to make meaningful comparisons.
In Brazil, the selected airports play a significant role for the national and regional connectivity, including the major hubs for international air traffic. These study airports have consolidated systems and structured processes for data collection in support of this comparison report.
For the European context, the study airports comprise the busiest airports in several states exhibiting a mix of national, regional, and international air traffic. These airports are also characterised by varying operational constraints that make them excellent candidates for an international comparison. All of these airports are subject to the performance monitoring under the EUROCONTROL Performance Review System and provide movement related data on the basis of a harmonised data specification.

Figure 1.3 provides an overview of the location of the chosen study airports within both regions. The airports are also listed in Table 1.1.

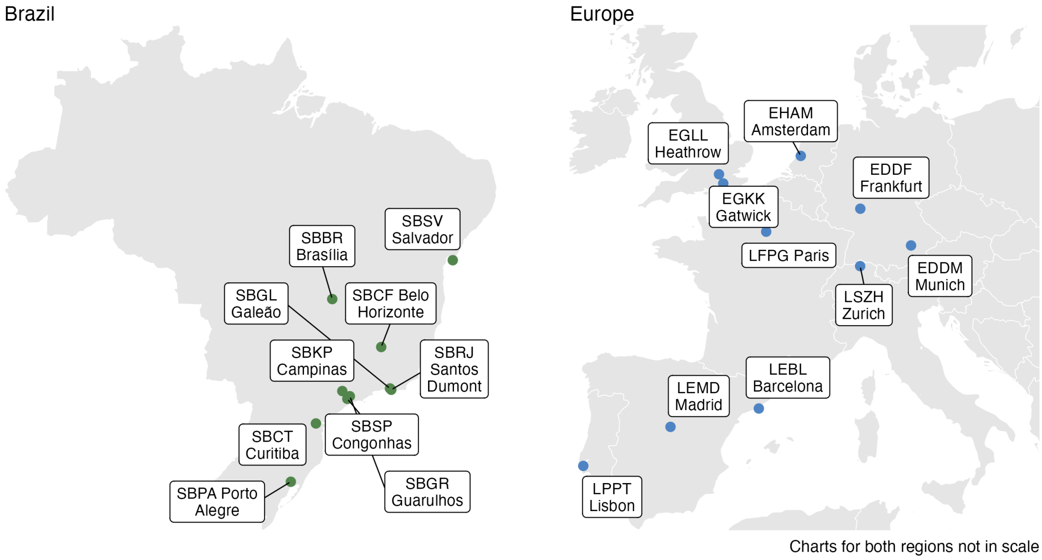


Figure 1.3: Study airports of Brazil/Europe Comparison

1.3.2 Temporal Scope

This report focuses on the period from January 2019 to December 2024 with a focus on the post-pandemic years. This report continues to build a timeline with comparable data to be augmented in future editions.

Throughout the report, summary statistics will be given with reference to calendar years of this comparison study unless highlighted specifically.

1.4 Data Sources

The nature of the performance indicator requires the collection of data from different sources. DECEA Performance Section and PRU investigated the comparability of the data available in both regions, including the data pre-processes, data cleaning and aggregation, to ensure a harmonised set of data for performance comparison purposes.

DECEA mainly uses data from the tower systems of the main airports as a data source for performance studies. The control tower system collects and provides data for each landing and take-off operation automatically. This edition blended ANAC (Brazilian CAA) official and public data with DECEA's data to increase precision for specific indicators, adding a pre-processing phase to the data analytical work. The provided data include such items as the times of operations, gate entry and exit, and flight origin and destination.

Within the European context, PRU has established a variety of performance-related data collection processes. For this report the main sources are the European Air Traffic Flow Management System (ETFMS [2]) complemented with airport operator reported data. These

[2]Enhanced Traffic Flow Management System

sources are combined to establish a flight-by-flight record. This ensures consistent data for arrivals and departures at the chosen study airports. The data is collected on a monthly basis and typically processed for the regular performance reporting under the EUROCONTROL Performance Review System and the Single European Sky Performance and Charging Scheme (EUROCONTROL 2019).

1.5 Structure of the Report

This third edition of the Brazil-Europe comparison report is organised as follows:

- **Introduction** – overview, purpose and scope of the comparison report; short description of data sources used;
- **Air Navigation System Characteristics** – high-level description of the two regional systems, i.e. areas of responsibility, organisation of ANS, and high-level air navigation system characteristics;
- **Traffic Characterisation** – network level and airport level air traffic movements; peak day demand, and fleet composition observed at the study airports;
- **Predictability** observed arrival and departure punctuality;
- **Capacity and Throughput** assessment of the declared capacity at the study airports and the observed throughput, including runway system utilisation comparing achieved peak throughput to the declared capacity;
- **Efficiency** analysis of taxi-in, taxi-out, and terminal airspace operations
- **Topic Studies** presents a high-level view on the use of point merge operations at two study airports, and a center-level characterisation; and
- **Conclusions** summary of this report and associated conclusions; and next steps.

2 Air Navigation System Characterisation

This section presents key characteristics of the air navigation systems of Brazil and Europe. In broad strokes, the provision of air navigation services in both regions relies on similar operational concepts, procedures, and supporting technology. Nonetheless, there are several distinctions between the two systems, which help to account for the similarities and differences in key performance indicators documented in this report.

2.1 Organisation of Air Navigation Services

One of the major differences between the air navigation systems of Brazil and Europe is the respective organisational structure. In Brazil, a single entity serves as the primary air navigation services provider, i.e. the Department of Airspace Control (DECEA). In contrast, in Europe, each member state has delegated the responsibility for service provision to either national or local providers.

DECEA holds the vital role of overseeing all activities related to the safety and efficiency of Brazilian airspace control. Its mission encompasses the management and control of all air traffic within the sovereign Brazilian airspace, with a significant emphasis on contributing to national defence efforts. To achieve this, DECEA operates a comprehensive and fully integrated civil-military system.

In 2021, a public company, NAV Brasil, was created to take over some facilities that were linked to an older airport infrastructure provider company in Brazil (INFRAERO). Today, NAV Brasil has 1698 employees in 44 different units, providing aerodrome control services, non-radar approach, meteorology and aeronautical information for the respective locations. Despite serving a significant number of air transport movements, NAV Brasil does not plan to establish radar facilities or provide en-route services.

The Brazilian airspace, covering an area of approximately 22 million square kilometres (8.5 million square nautical miles of non-oceanic airspace), is divided into five Flight Information Regions. These regions are further subdivided and managed by five Area Control Centers (ACC), 57 Tower facilities (TWR), one digital tower (D-TWR), 41 Approach Units (APP) and 79 AFIS/Remote-AFIS.

The non-oceanic airspace in Europe covers an area of 11.5 million square kilometres. When it comes to the provision of air traffic services, the European approach involves a multitude of service providers, with 37 distinct en-route Air Navigation Service Providers (ANSPs), each responsible for different geographical regions. These services are primarily organised along state boundaries and associated FIR borders, with a number of limited cross-border agreements in place between adjacent airspaces and air traffic service units.
A noteworthy exception to this predominantly national approach is the Maastricht Upper

Area Control, which represents a unique multinational collaboration offering air traffic services in the upper airspace of northern Germany, the Netherlands, Belgium, and Luxembourg.

Civil-military integration levels across European countries vary. Within the European context, the central coordination of Air Traffic Flow Management (ATFM) and Airspace Management (ASM) is facilitated by the Network Manager. The design of airspace and related procedures is no longer developed and implemented in isolation in Europe. Inefficiencies in the design and utilisation of the air route network are recognised as contributing factors to flight inefficiencies in the region. Therefore, as part of the European Union's Single European Sky initiative, the Network Manager is tasked with developing an integrated European Route Network Design. This is achieved through a Collaborative Decision-Making (CDM) process involving all stakeholders.

Another critical responsibility of the Network Manager is to ensure that air traffic flows do not exceed the safe handling capacity of air traffic service units while optimising available capacity. To accomplish this, the Network Manager Operations Centre (NMOC) continuously monitors the air traffic situation and proposes flow management measures through the CDM process in coordination with the respective local authorities. This coordination typically occurs with the local Flow Management Positions (FMP) within the respective area control centres. Subsequently, the NMOC implements the relevant flow management initiatives as requested by the authorities or FMPs.

2.2 High Level System Comparison

Table 2.1 summarises the key characteristics of the Brazilian and European air navigation system for 2024. Comparing the high-level numbers, Brazil observed a steady increase in the number of Air Traffic Controllers (ATCOs) compared to 2019 (e.g. 2023 vs 2019: 17.6%, 2024 vs 2019: 24.4%). In contrast, the European system showed only a mild increase in total ATCOs in service following the strong reduction during the pandemic in terms of work force. The different behaviour suggests a difference in work force flexibility between the systems. Brazil reacted swiftly to the increase of air traffic ranging at 21.4% higher than in 2019. Europe has seen a mild modulation of ATCO numbers with the annual traffic in 2024 ranging about 4% below the 2019 level.
This may be partly explained by the fact that DECEA shares part of the structure used in basic training with other Air Force training processes. This leads to a more centralised and rigid process, in which abrupt reactions in hiring planning are unwanted due to the lengthy process of calling for candidates according to Brazilian laws related to public service jobs. In Europe, there exists a mix of organisational models and labour contracts ranging from public service to fully commercial organisation. Thus, European providers tend to react more conservative to anticipated changes in air traffic demand.

Another key difference affecting performance in both regions for this report is the development of air traffic demand. Unlike in Europe, it is interesting to note that Brazil ended 2022 already servicing air traffic movements above the pre-pandemic level. There is a continual increase in air traffic in Brazil accounting now for 21,4% of more traffic than in 2019. Overall, the volume of air traffic also rebounded in Europe. At the end of 2023, the level reached about 90% of the pre-pandemic air traffic, and with 2024 the gap is closing to about 96%. These recovery numbers are impacted by the geo-political developments. Due to the Russian invasion of Ukraine, a certain share of flights is currently banned to operate to/from Europe.

Table 2.1: High Level Comparison 2024

KPA	Brazil			Europe		
	2019	2023	2024	2019	2023	2024
geographic area (non-oceanic, million km²) [1]	8,5	8,5	8,5	10,9	10,9	10,9
number of en-route ANSPs [2]	1	1	1	37	37	37
number of TWR [3]	59	57 + 1 DTWR	57 + 1 DTWR	382	375	n/a
number of APP [3]	43	41	41	262	268	n/a
number of ACC [3]	5	5	5	57	57	57
number of ATCOs in OPS [3]	3.126	3.677	3.890	16.870	16.973	n/a
controlled flights [4]	1.594.442	1.801.109	1.935.139	11.085.302	10.144.258	10.633.991
flights/ATCO	510	490	497	657	598	n/a
traffic density (non-oceanic, flights/km²)	0,187	0,211	0,227	1,017	0,93	0,976
Notes:	*Brazil: c.f Performance report 2024 / Europe: c.f ACE report 2024*					
	1 excludes Ukraine, Georgia, Serbia, Canary Islands & Oceanic areas					
	2 excludes Ukraine, Georgia, Serbia					
	3 excludes Ukraine, Georgia, Serbia, Canary Islands & Oceanic					
	4 ECAC area					

Both regions operate with similar operational concepts, procedures and supporting technology. Considering the non-oceanic dimension of the airspace, Brazil services an area about 22% smaller than Europe. Brazil, with lower traffic density related to airspace, finds probably a more challenging cost-benefit ratio to maintain communication coverage and surveillance for regions with low-traffic. The higher traffic density in Europe may cross all aspects of flight management. In particular, the European region faces more considerable challenges in coordinating efforts to address operational constraints and service the current demand.

2.3 Network Characterisation

To address the changes in air traffic and develop a better understanding of the nature of the air transportation network, this report expands the characterisation of the network. Figure 2.1 depicts the cumulative share of departures from airports in both regions.

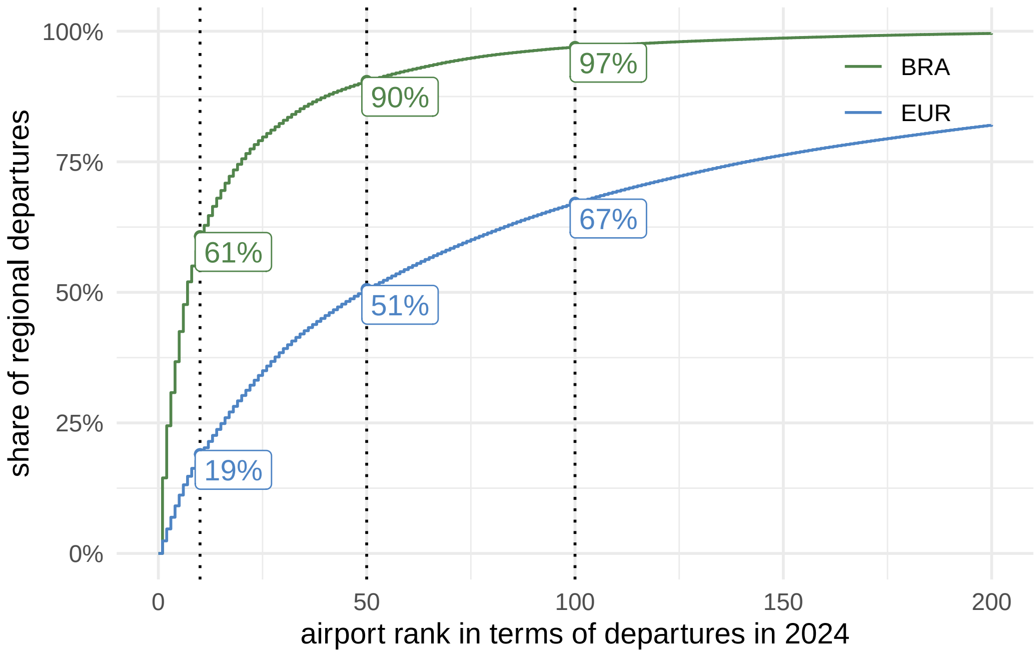


Figure 2.1: Airport Rank Comparison 2024

Table 2.1 lists the overall serviced traffic in both regions. In 2024 Brazil observed just under a fifth (18.2%) of the traffic handled in Europe. With overflights representing a small share of the traffic in both regions, Figure 2.1 focusses on the aerodrome movements considering all observed departures. The distribution of air traffic in Brazil confirms that most flights are concentrated in a small number of airports. Traffic in Europe operates from a larger number of aerodromes. For example, in 2024, the 10 busiest airports in Brazil handled 61% of all departing flights whereas in Europe, the top 10 airports account for 19% of all departures. The spread in shares remains broadly constant up to the 50th rank of all departures and narrows to 30% with the top 100 airports in both regions. The latter marking 97% of all departures in Brazil and 67% in Europe.

The latest edition of Brazil's Annual Performance Report (it can be found on http://performance.decea.mil.br) reflects this reality. It now includes 100 airport locations instead of only the top 34, ensuring that almost all flights are included in the analysis. This distribution shows that many aerodromes operate with low traffic volumes. Because of that, it is important to study alternative ways to provide air traffic services.

In Brazil, the Aerodrome Flight Information Service (AFIS) is an effective strategy to ensure safety at locations where the traffic does not justify the installation of a control tower (TWR). This service, usually provided via radio telephony only, gives essential information to pilots, helping to use resources efficiently and keeping operations safe. Since 2016, Brazil has been expanding the use of remote AFIS units (R-AFIS), especially in strategic areas like the Amazon region. These services are provided from ACCs (Area Control Centers), which means they don't need dedicated local infrastructure. Also, in 2024, demand for air traffic services continued to grow. This shows the need to review and improve how services are organized in Brazil. Expanding the use of the AFIS model in strategic areas may be a cost-effective and safe way to meet future needs and make better use of SISCEAB's resources.

The more spread-out distribution in Europe showcases the historical development of the

European network. The traditional focus on national hubs and carriers resulted in the development of a higher number of major aerodromes (typically servicing the capital, major metropoles, or economic centers) interconnecting with other national hubs across the continent. There exists a mix of the organisation of smaller operations in Europe. Dependent on the national or local setup, the resources of the national service provider are often complemented by local service providers. Thus, the provision of services varies between smaller manned towers and remotely provided FIS functions provided by nearby ACCs. This includes instrument procedures to approach (and depart) from an uncontrolled aerodrome. Given this mix of organisation and funding in Europe, no consolidated pan-European data was available to specifically account for local AFIS services. Across Europe, there is an interest in consolidating aerodrome control services at important low frequency sites through the deployment of digital remote tower operations. This ranges from site specific remote tower operations (e.g. Cork/Ireland) to a multi-remote tower center (e.g. Stockholm/Sweden, Bodo/Norway) servicing multiple airports simultaneously.

While the view on the concentration of air traffic provides first insights, the level of connectivity is not immediately identifiable.

Figure 2.2: Share of international and regional/domestic traffic in 2024

Figure 2.2 shows the distribution of regional/domestic and international departures. For both regions we observe a share of less than 12% of serviced traffic are flights operating to and from the regions. The majority of flights operate within the region, i.e., within the domestic Brazilian network and conversely the European network spanning across EUROCONTROL Member States.

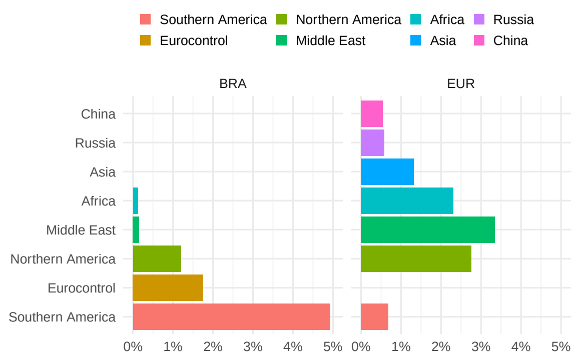


Figure 2.3: Share of destinations in 2024

From an international perspective both regions are interconnected differently. Figure 2.3 sees a spread of the international traffic to other regions. Traffic from Brazil to Europe (i.e., Eurocontrol Member States) accounts for just under 2% of the total traffic volume in Brazil. Connections to other Southern America states represent the major international destinations accounting for about 5%. Europe has a shallow share of flights going to Southern America, including Brazil. The Middle East, Northern America, and Africa represent the biggest international markets ranging between 2.3-3.3% of all departures in Europe.

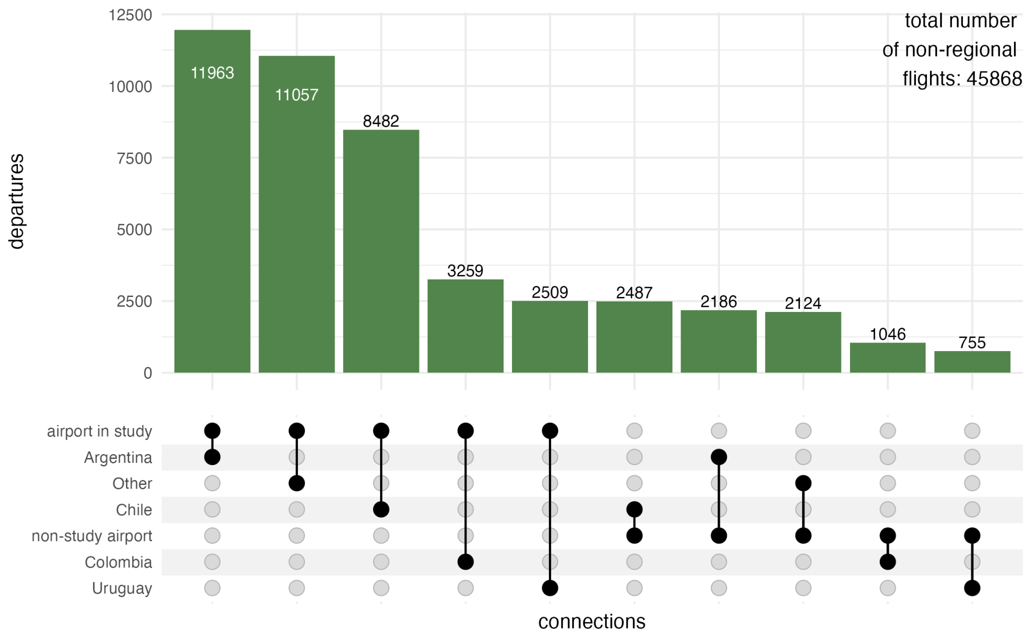


Figure 2.4: Connections to adjacent countries

With Figure 2.4 we observe just under 46.000 flights in 2024 operated to adjacent countries in South America. A strong segment of the market represents flights to/from Argentina and Chile accounting for about half of the flights departing from the airports in this study. Accordingly, flights to Colombia and Uruguay from the study airports account for a smaller fraction, and there is a multitude of other connections to South America and the Caribbean. Flights operating from airports not included in this study account for smaller shares. This confirms the selection of the study airports for Brazil, as the major airports handle most of the pan-regional traffic with a strong connection to Argentina and Chile.

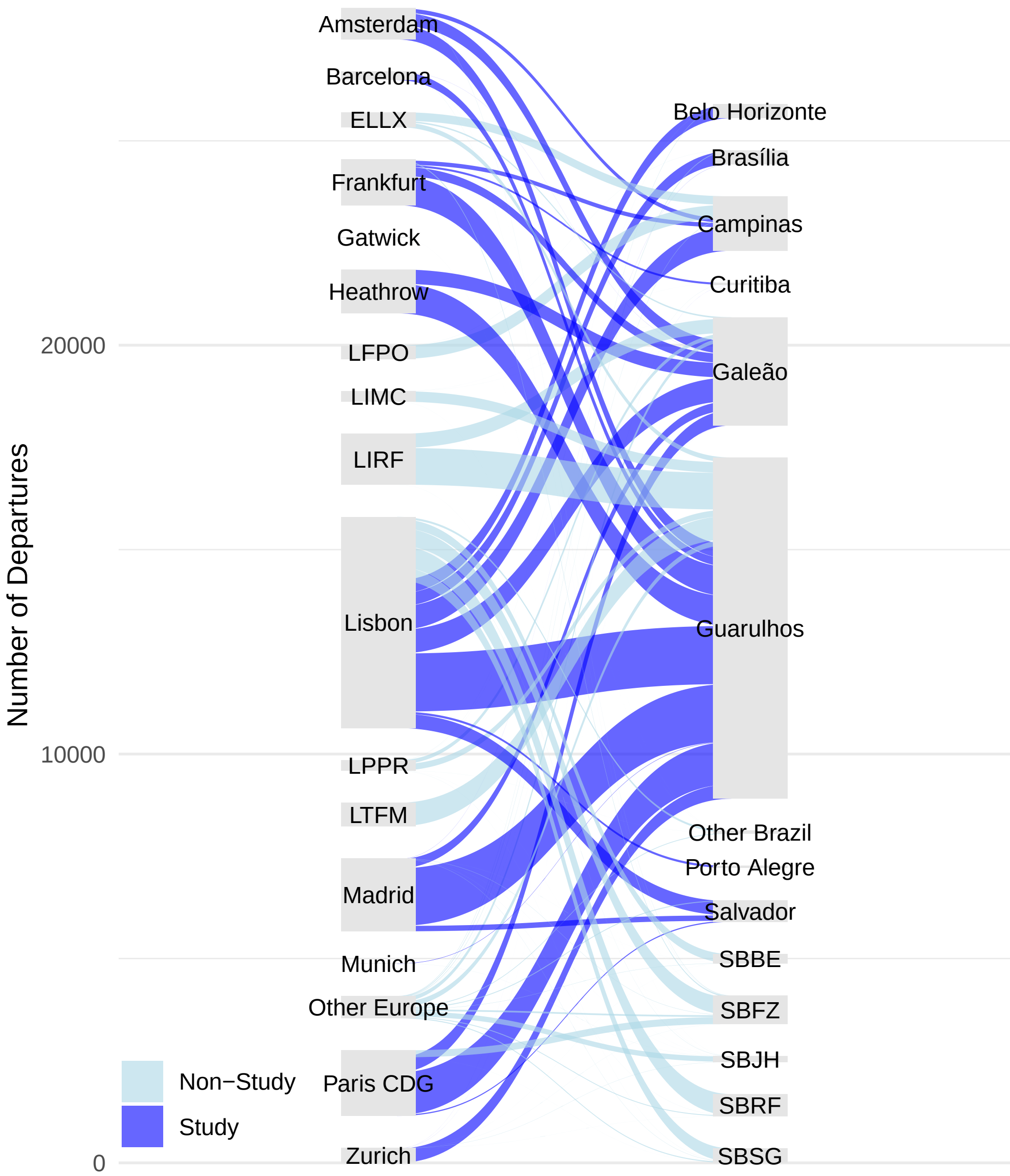


Figure 2.5: Connections between the study regions in 2024

Figure 2.5 shows the connections between Europe and Brazil in 2024. Individual connections of less than 90 flights per year are aggregated into an "other" group. These largely reflect specific individual flights (e.g. State flights, special cargo operations), and only contribute to a small extent to the overall traffic between both regions.
Guarulhos (SBGR) and Lisbon (LPPT) are the main airports for connectivity between both regions. Due to its prominent role, this edition considers operations at LPPT in a more prominent manner.

Future work may highlight to what extent resources within both regions are bound to establishing basic connectivity and what type of services are provided to accommodate the demand.

Further research can explore how both regions can maximise installed capacity, benefit from novel operational or technical concepts, and suggest improvements for ANS provision.

2.4 Regional Approach to Operational Performance Monitoring

The previous report detailed the historic setup of the performance monitoring systems in Brazil and Europe.

The implementation of the performance-based approach is not a fundamental new activity in Europe. The Performance Review Commission (PRC) was established within EUROCONTROL in 1998 aiming to establish and implement an independent European air traffic management (ATM) performance review capability in response to the European Civil Aviation Conference (ECAC) Institutional Strategy. The main goal of the PRC is to offer impartial advice on pan-European ATM performance to EUROCONTROL's governing bodies. Supported by the Performance Review Unit (PRU), the PRC conducts extensive research, data analysis, and consultations to provide objective insights and recommendations. EUROCONTROL's performance review system, a pioneering initiative in the late 1990s, has influenced broader forums like ICAO's global performance approach and the Single European Sky (SES) performance scheme. Collaborating internationally, particularly with ICAO, the PRC aims to harmonise air navigation practices. The PRC produces annual reports (ACE and PRR) and provides operational performance monitoring through various data products and online tools. Continuous efforts are made to expand the online reporting for stakeholders and ensure access to independent performance data for informed decision-making.

It is noteworthy to recall that DECEA, influenced by ICAO publications, embraced a performance-based approach, notably advancing the national state-of-the-art in collaboration with EUROCONTROL. Beginning with the SIRIUS Brazil Program in 2012, DECEA faced challenges defining metrics, but made significant progress after signing a Cooperation Agreement with EUROCONTROL in 2015. DECEA published crucial documents for ICAO's Global Air Navigation Plan, prompting an organisational transformation and adaptation of practices. Establishing the ATM Performance Section in 2019, akin to EUROCONTROL's PRU, DECEA accelerated the build-up of expertise in operational performance monitoring. This culminated in the publication of the first Brazilian ATM Performance Plan for 2022-2023. Actively fostering an open culture of knowledge-sharing within South America, DECEA engaged in workshops and seminars, and inviting EUROCONTROL for collaboration.

Finally, it should be noted that the recurrent use of indicators by EUROCONTROL and DECEA and the close technical collaboration taking place during the analysis periods for joint conclusions enrich not only the two regions but also have a global impact. Embracing transparency, both agencies made indicators and databases publicly accessible, perpetuating a culture of reciprocity and transparency for mutual advancement. Looking for broader validation and harmonisation, the lessons learned from this scheme are systematically shared with the multi-national Performance Benchmarking Working Group (PBWG) and the Performance Expert Group of the ICAO GANP Study Group, which deals with the development of GANP Key Performance Indicators (KPIs). In this respect, this collaboration between both parties serves as a role model for ANS performance management on a global level.

Updated dashboards, previous work, and supporting historical data are available at https://ansperformance.eu/global/brazil/ or https://performance.decea.mil.br/.

2.5 Summary

While both regions operate on similar operational concepts and technologies, there exists key characteristics and distinctions in both regions. One of the key differences is the overall organisation of air navigation services. Brazil's air navigation services are centralised under DECEA, overseeing all airspace control and contributing to national defence. In contrast, Europe's air navigation services are provided by multiple entities and ANSPs operating predominantly within their national state boundaries and FIR borders.

Also remarkable is the comparison of the number of air traffic controllers between Brazil and Europe during the pandemic. This revealed contrasting trends. Brazil experienced an increase in ATCOs in line with the overall traffic growth. ATCO numbers in Europe marginally increased in comparison to 2019 in 2023. This disparity underscores a significant difference in the systems' responsiveness, partly attributed to Brazil's centralised and rigid hiring process. At the same time, European providers operate with greater independence with varying organisational setups (public vs private organisation, unions). Adjustments of the ATCO workforce tend to be more conservative.

The distribution of commercial flights in 2022 indicated that only a subset of airports handled 80% of commercial take-offs. In 2024 - with the stabilising air traffic levels - the top-10 airports in Europe handled 19% of the network departures, while in Brazil the top-10 accounted for 61%; considering the top-100 airports in both regions, this group handled 67% of all departures in Europe, and 97% in Brazil. The concentration effect is higher in Brazil than in Europe. On the other hand, the distribution also showed that a significant number of airports operating commercial flights handle only a marginal share of the movements in both systems. This duality may inform decision-makers about potential performance benefit pools with a view to allocate scarce ANS resources and capabilities and ensure the proper balancing of demand and capacity.

This report documents the close collaboration between DECEA and EUROCONTROL. The effort benefits the two regions and contributes globally by sharing insights and lessons learned with international aviation communities, aiding the development of ATM performance management worldwide.

3 Traffic Characterisation

To facilitate operational benchmarking comparisons, it is crucial to have a good understanding of the level and composition of air traffic. The preceding section provided an overview of the context and organisation of air navigation services in Brazil and Europe, and the overall network characteristics. This chapter presents some air traffic characteristics for both regions to provide a framework for the observed operational performance in subsequent parts of the report.

3.1 Network Level Air Traffic

Figure 3.1 shows the regional traffic development in Brazil and Europe for the period 2019 to 2024.

For Brazil, it is important to remember that Figure 3.1 shows the aggregated movements per airport at the whole network level. The shown total does not necessarily reflect the total number of flights. Another important observation related to the data is that Brazil's number of airports served with the TATIC tool (Tower ATC System) has increased. Despite raising the processed total daily flight number, this difference is mostly transparent for this study as these additional airports handle only a small number of movements on a day-to-day basis.

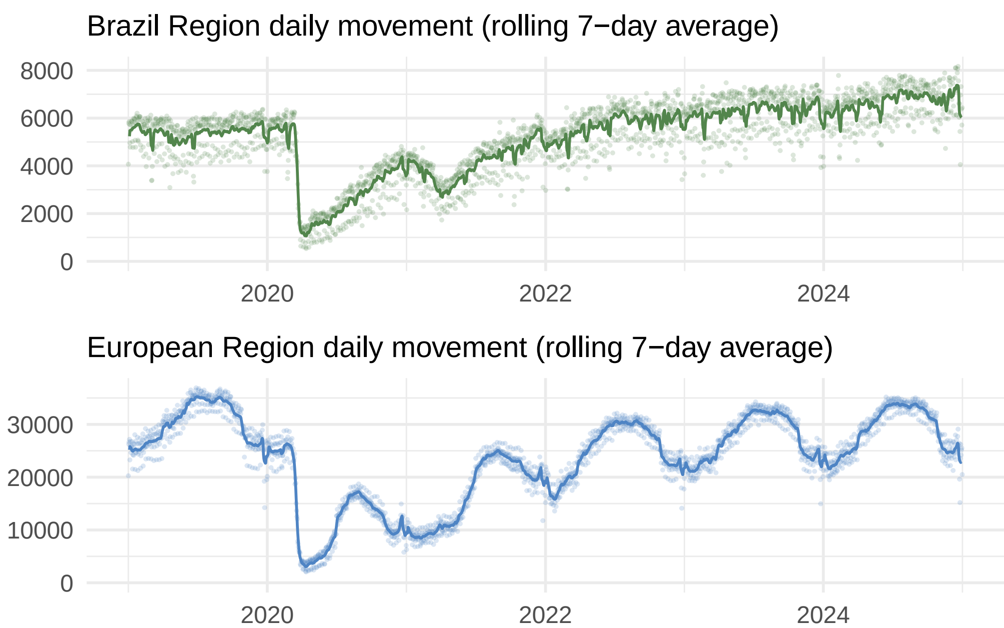


Figure 3.1: Regional daily air traffic

Brazilian air traffic continues to exceed 2019 levels, marking a phase of real growth, not just post-pandemic recovery. Since 2022, traffic has grown steadily, showing a structured recovery in demand. However, commercial aviation is still adjusting its route network in some regions to fully match 2019 levels.

Figure 3.1 shows the daily evolution of air traffic in Brazil (7-day moving average) highlights the busiest and quietest periods of recent years. Over the past three years, the day with the lowest average traffic in Brazil typically falls on the Wednesday after Carnival. Meanwhile, the annual peak usually happens in late December, close to Christmas, reinforcing a well-established seasonal pattern in the Brazilian air transport market. Overall, despite short-term fluctuations, the general trend is upward, confirming that Brazil is on a steady growth path. It is important to note that the Brazilian data only includes commercial flights (excluding general and military aviation) and is based on UTC time.

When we compare this with the European Region, a different dynamic becomes visible. In terms of total network-level air traffic, Europe still lags behind its pre-pandemic levels. However, if current trends continue, the region is expected to reach or slightly surpass 2019 traffic levels by 2025. Low-cost carriers have outperformed mainline airlines in the recovery phase. Their business model allowed for faster adjustments in staffing, crewing, and servicing. At the same time, national support programs for legacy carriers often included conditions such as slot restrictions or reduced domestic operations, which contributed to a decrease in overall network connectivity and frequency between airports.

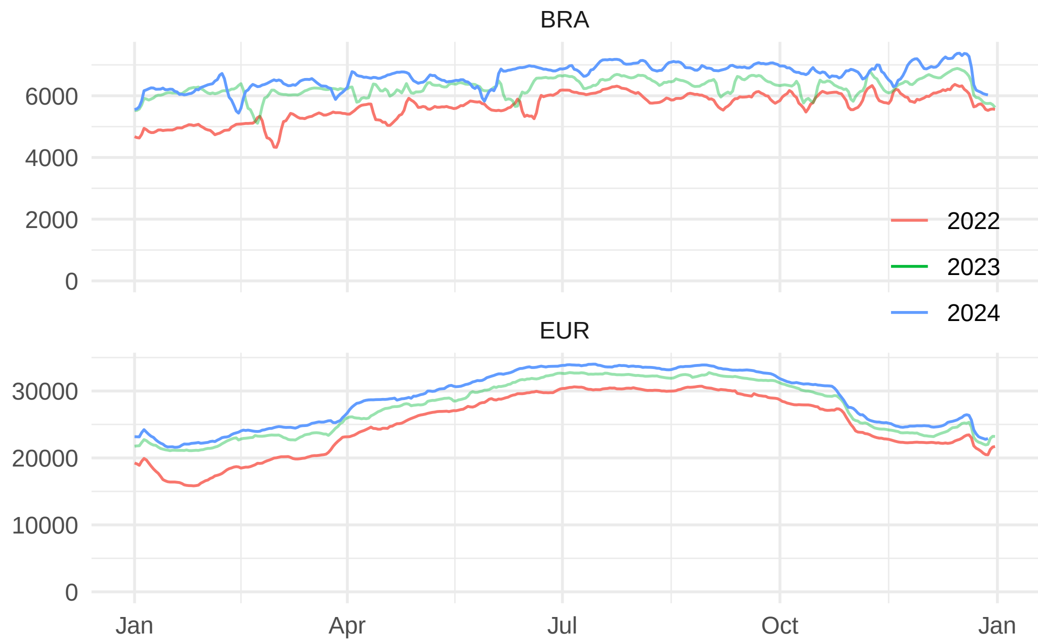


Figure 3.2: Evolution of annual network traffic

Figure 3.2 compares the evolution of daily air traffic in the Brazil and European regions across the last three years. Each line represents a 7-day moving average of flight numbers, allowing seasonal patterns and year-over-year changes to be visualised more clearly.

In the Brazilian region, the data shows a consistent upward trend, with each year positioned above the previous one, especially in the first and second quarters. This indicates that Brazil's aviation sector not only recovered from the pandemic but has entered a period of sustained organic growth. The seasonal curve in Brazil is more stable throughout the year, reflecting a demand pattern that is less affected by strong seasonal variations.

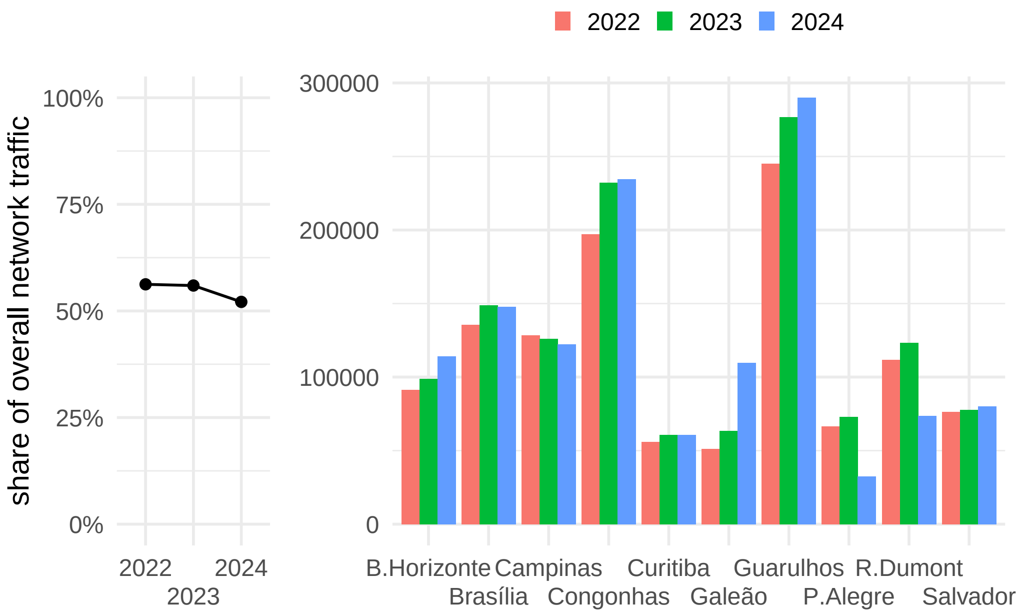
In contrast, the European region displays strong seasonality, with pronounced peaks during the summer months (June to September) and sharp drops in winter. This pattern aligns with Europe's tourism-driven traffic, where demand is concentrated in holiday periods. While there is a general growth trend during the post-pandemic phase, a clear step change took place between 2022 and 2023. Comparing 2023 to 2024 reveals a shallow, but continual, growth across the year signalling a certain level of saturation in terms of network connections.

The analysis of annual trends also reveals how regional disruptions can impact national networks. In Brazil, traffic volume dropped significantly in May 2024, due to heavy rainfall in the south starting in late April. The floods led to the prolonged closure of Salgado Filho International Airport (SBPA) in Porto Alegre, which remained out of operation until October. This disruption had a clear impact on domestic commercial aviation and reduced overall national traffic during that period.

While Brazil shows less seasonal fluctuation overall, Europe's variation in traffic volume is much more pronounced. This contrast points to the importance of adjusting capacity and optimizing airport infrastructure to better respond to periods of high demand.

3.2 Airport Level Air Traffic

The previous section showed the air traffic development on the network level. As airports represent nodes in this overall network, changes to the overall traffic situation will ripple down to the airport level. This demand on terminal and airport air navigation services forms a substantial input to understand how the operational performance measures in this report developed over time for the selected study airports. This report looks at the performance levels observed at 10 key airports in each region (c.f. scope)



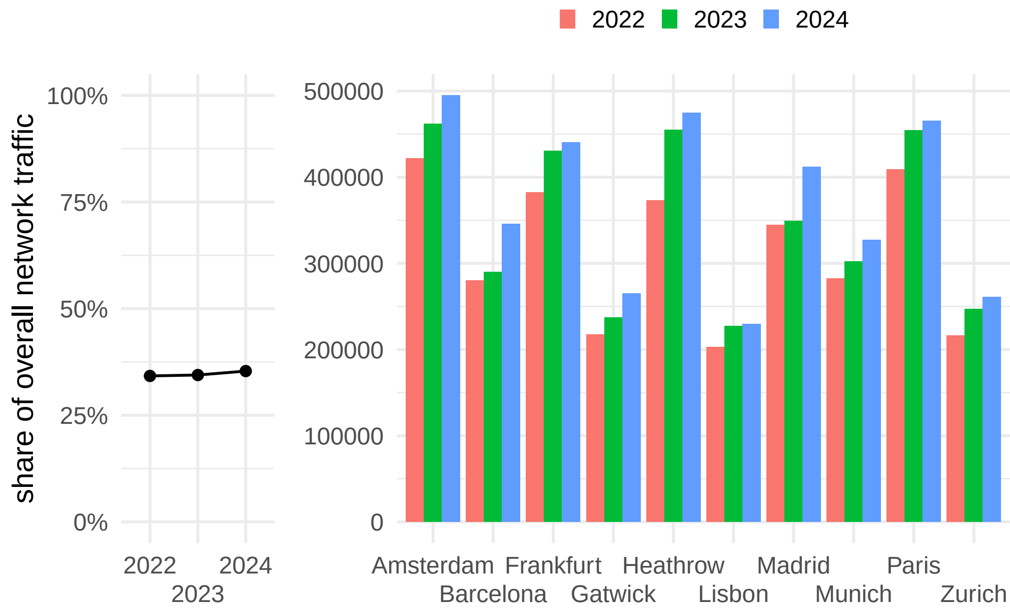


Figure 3.3: European airport level traffic

Figure 3.3 presents the airport-level traffic evolution for the study airports from 2022 to 2024. The data clearly show different dynamics between the two regions. In Europe, all airports observed increases in movement levels from 2023 to 2024, reinforcing the region's ongoing recovery trajectory.

The Brazilian scenario is more heterogeneous. While some airports, such as Galeão (SBGL) and Guarulhos (SBGR), registered increases, others—such as Santos Dumont (SBRJ) and Porto Alegre (SBPA) saw declines. Meanwhile, Congonhas (SBSP) and Brasília (SBBR) showed very little variation. This divergence highlights the uneven pace of recovery among Brazil's major airports, reflecting broader structural and operational differences in the national aviation landscape.

It is also important to emphasize that Brazil's air traffic is distributed across a much larger number of airports compared to Europe. As discussed in Chapter 2, Brazil's extensive network dilutes traffic concentration at the top airports. This is illustrated on the left side of Figure 3.3, which shows a slight decline in the share of total traffic handled by Brazil. This suggests a modest redistribution of movements across a broader set of airports, potentially due to regional market recovery, strategic airline adjustments, or temporary infrastructure constraints—factors that will be discussed in the next sections.

Europe's busiest airports have slightly increased their share of total network traffic over the same period. This upward trend reflects the growing reliance on major hubs as the region continues progressing toward pre-pandemic traffic levels, supported by more robust infrastructure and concentrated demand.

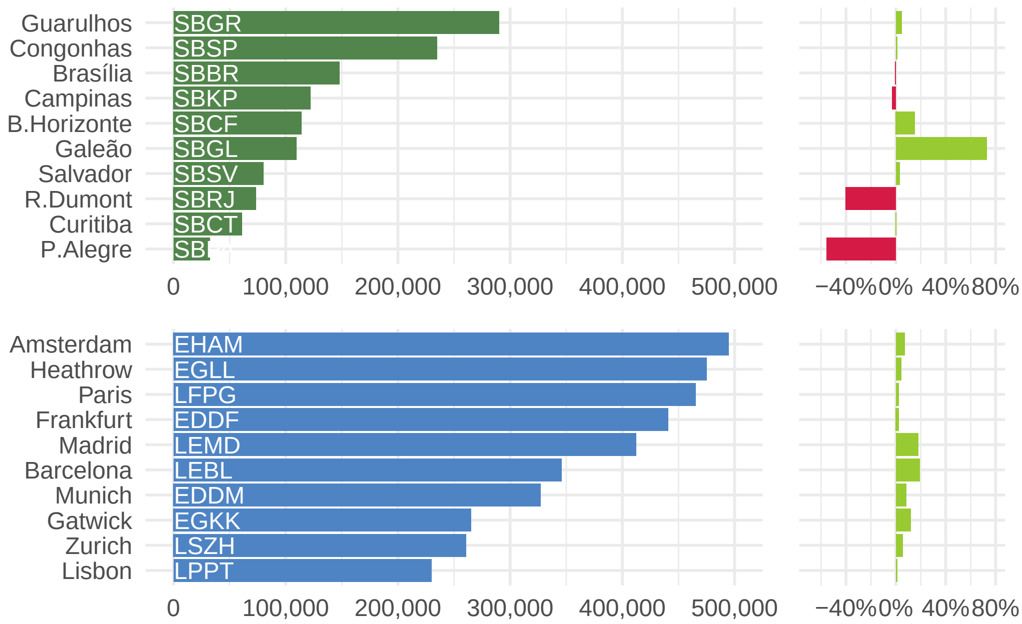


Figure 3.4: Annual traffic at study airports in 2024 and variation 2024/2023

The 2024 air traffic analysis highlights the importance of understanding the structural differences between the Brazilian and European networks. While Guarulhos (SBGR) remains the busiest airport in Brazil, its traffic volume is comparable to that of the fifth and sixth busiest airports in Europe— Munich and Gatwick. This shows that direct comparisons between the top airports in each region may not fully reflect their operational realities. Factors such as the number of runways, network architecture, and traffic density create unique operational complexities in each case.

In Brazil, the largest traffic drop in 2024 occurred at Porto Alegre Airport (SBPA), which was directly impacted by major flooding in May and remained closed until October. Many flights were redirected to nearby airports in southern Brazil, which are not included in the scope of this comparison with Europe. Another change was the increase in traffic at Galeão International Airport (SBGL), which rose to sixth place among Brazil's busiest airports. This shift was mainly driven by restrictions applied at Santos Dumont Airport (SBRJ), leading to a reallocation of flights from SBRJ to SBGL. As a result, SBRJ saw a decline, while SBGL experienced gradual growth in operations. This redistribution not only affects annual totals but will also have direct impacts on other indicators, such as the peak day of operations, which will be discussed later in this report.

The data illustrates how both the Brazilian and European air networks have adapted to their respective challenges. In Brazil, the system has shown resilience in the face of environmental events and regulatory changes, while in Europe, traffic growth is becoming more concentrated at major hubs as the region continues to recover toward pre-pandemic levels. These dynamics highlight the importance of continuous monitoring and flexible planning to ensure operational efficiency and network stability in both regions.

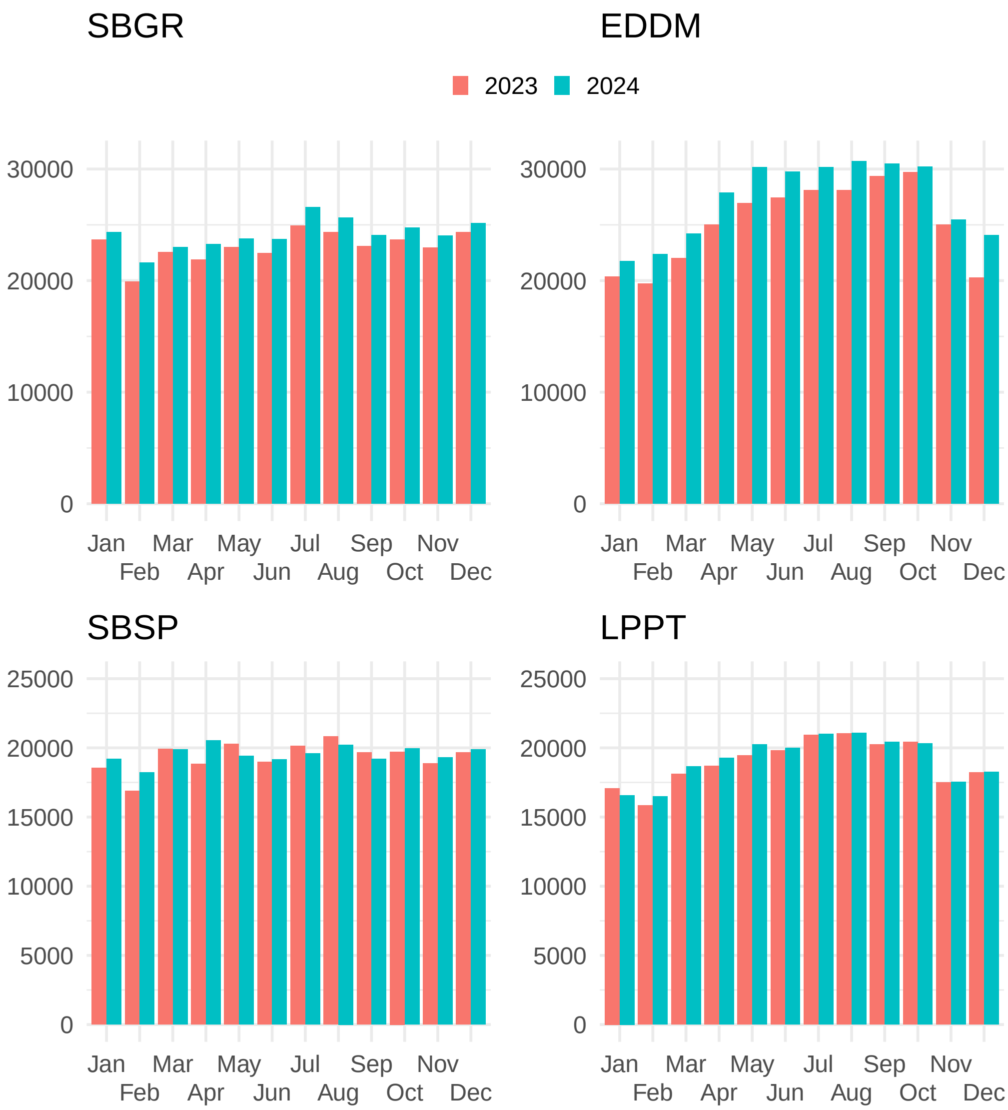


Figure 3.5: Monthly traffic evolution at SBGR, EDDM and SBSP, LPPT

Figure 3.5 shows the monthly evolution of traffic at Guarulhos International Airport (SBGR) during 2023 and 2024, which remains the top airport in Brazil, and Munich (EDDM). EDDM recorded approximately 50,000 more operations than SBGR in 2025. For SBGR, a steady increase in monthly operations can be seen throughout 2024 compared to 2023, with July standing out as the month with the highest volume during the period analysed. This trend reflects the continued strengthening of commercial aviation at Brazil's main hub. Operations at EDDM show a more pronounced seasonal pattern with traffic building up from end Spring to the peak levels during the summer months including October. Comparing traffic levels in 2023 with 2024, EDDM shows also a strong increase in demand as part of the on-going pandemic recovery.

Comparing operations at Sao Paulo Congonhas (SBSP) and Lisbon (LPPT) shows again a more seasonal pattern in Europe with the summer period representing the peak months. Traffic evolution at SBSP is more moderated. There exists variation across the year in comparison to 2023 suggesting slight modifications of the schedule. However, on average, traffic levels appear stable at SBSP servicing predominantly national and regional traffic. Lisbon (LPPT) showed also smaller variations when comparing traffic levels in 2023 vs 2024. This suggests that air transport demand has stabilised post-pandemic. It also evidences that the level of air transport recovery across Europe varies.

Guarulhos' performance becomes more relevant when compared to the busiest airports in Europe. Similar traffic levels were observed at Munich (EDDM) in Europe in 2024 highlighting the different realities of each region. This comparison helps illustrate the structural complexity and differences between the two systems. While Brazil concentrates much of its traffic in a number of key airports like SBGR, Europe sees a more varied spread of operations across a larger network of major airports. The group of latter airports often operate a more robust infrastructure (such as more runways). Therefore, a direct comparisons between the "top" airports in each region may not accurately reflect their unique operational contexts.

3.3 Peak Day Traffic

While the annual traffic provides insights in the total air traffic volume and the associated demand, it does not provide insights on the upper bound of achievable daily movement numbers. The latter depends on demand, operational procedures and/or associated constraints, and the use of the runway system infrastructure. The peak day traffic is determined as the 99th percentile of the total number of daily movements (arrivals and departures). The measure represents thus an upper bound for comparison purposes.

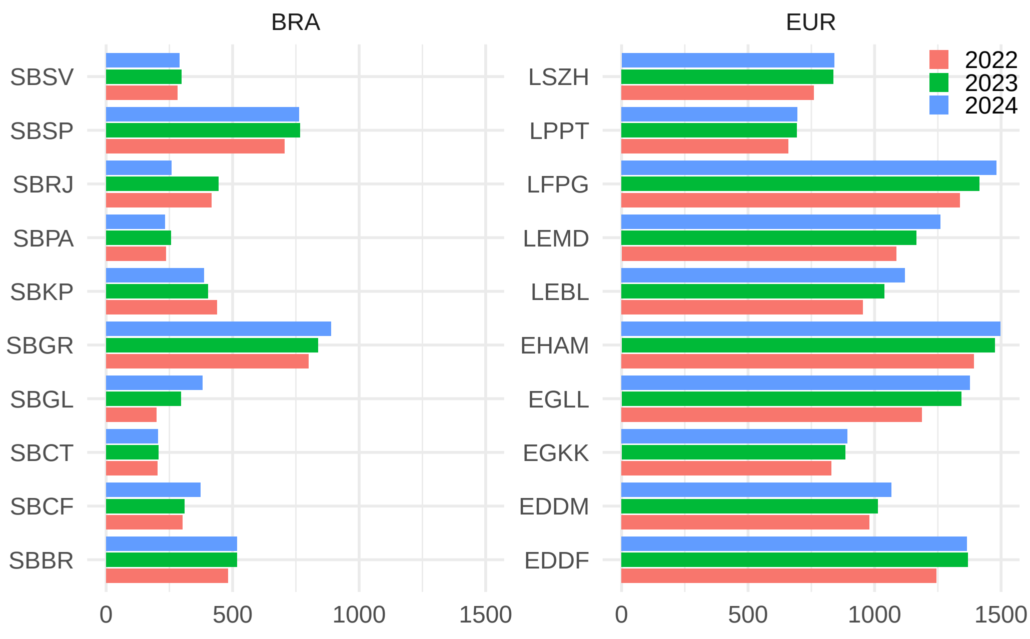


Figure 3.6: Airport peak daily traffic (2022 - 2024)

Figure 3.6 shows the evolution of peak day traffic between 2022 and 2024 across the Brazilian and European airports included in this study. The peak day measurement is as a useful complement to traffic levels and average daily movement metrics. It provides a reference to the achievable daily service rate that can highlight nuances of the operational context and constraints at comparable airports and approach areas.

Overall, the data shows a general stability in operational volumes across most major airports in Brazil. On the European side, the year-by-year comparison highlights the on-going recovery and initial consolidation effects post the pandemic. Consistent with the overall traffic increase the majority of them recorded an increase in peak day traffic, with all of them showing significantly higher values compared to 2022.

Still, some variations stand out on the Brazilian side:

- Guarulhos (SBGR), Galeão (SBGL), and Confins (SBCF) recorded increases in their peak day movements, reflecting their greater capacity to absorb traffic and some redistribution of demand within the national network.
- Santos Dumont (SBRJ), on the other hand, shows a notable drop, directly tied to the operational restrictions implemented during 2024, which limited its capacity and led to the transfer of some flights to SBGL.
- In the case of Porto Alegre (SBPA), even though it was severely affected by floods starting in May 2024, the data does not show a significant drop in its peak day value. This is likely because the peak occurred either before May or after limited operations resumed in October.

Regarding the peak day traffic at European airports:

- Paris Charles de Gaulle (LFPG) stood out with the most pronounced growth in both 2023 and 2024.
- Significant step increases were observed at London Heathrow (EGLL), Frankfurt (EDDF), and Madrid (LEMD) between 2022 and 2023. As major hubs, this also reflects the increase in international air traffic and the reactivation of network connections by the major carriers operating from/to these airports.
- Marginal to no changes between 2023 and 2024 evidence that the peak operations at Frankfurt (EDDF), Gatwick (EGKK), Lisbon (LPPT), and Zurich (LSZH) reach their daily maximum service rate.

The comparison between the Brazilian and European contexts reinforces the importance of considering each network's structure, operational model, and geographic distribution when evaluating operational performance at and around airports. It also shows how peak day traffic can offer unique insights — especially during periods of recovery or transition — by highlighting the maximum operational load airport services can sustain regardless of their average daily traffic.

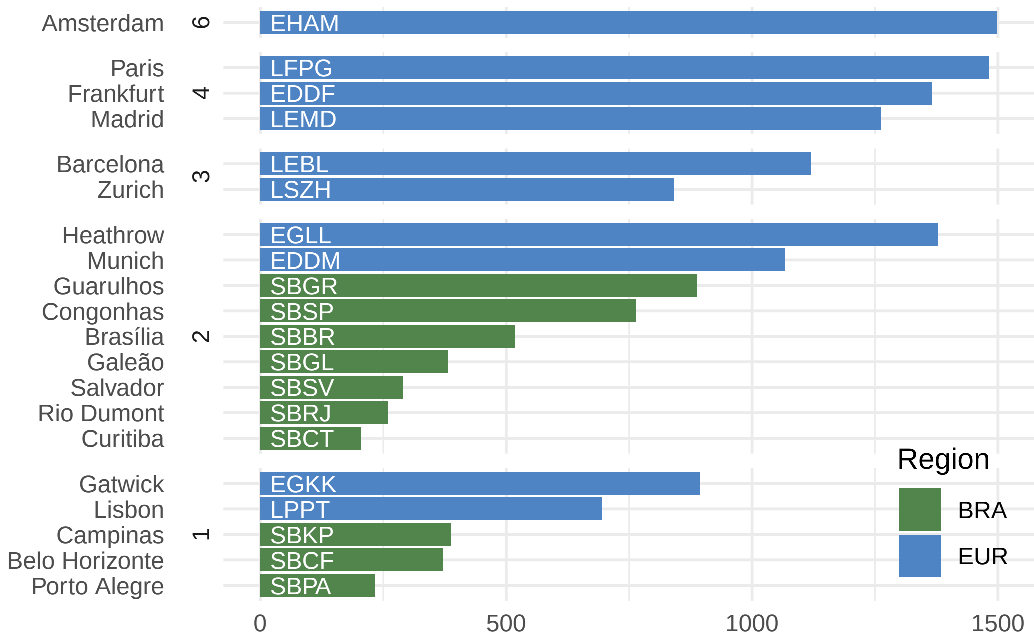


Figure 3.7: Airport peak daily service rate (99th percentile, 2024)

Analysing the 2024 peak day data, as presented in Figure 3.7, with Brazilian and European airports grouped by number of runways, we observe that six European airports operate with three or more runways and are therefore not directly comparable to Brazilian airports. However, it is important to note that in many of these cases, the runway system does not support fully independent operations on all available runways. Such constraints reduce the available runway system capacity, and thus, the serviced peak traffic is also impacted by the runway system configuration. For example, operations at Amsterdam (EHAM) cannot make use of all six runways at the same time. Operations at Zurich (LSZH, 3 interdependent runway system) range in the order of single runway operations at Gatwick (EGKK, 1 runway). As a result, peak traffic performance is also shaped by the specific runway configuration.

When focusing on airports with up to two runways, European airports still show significantly higher peak day movements compared to the Brazilian ones. This difference can be attributed to more robust infrastructure and operational systems in Europe. Additional benefits are exploited by dedicated operational concepts. For example, London Heathrow implemented time-based separation on final which adds to achieving a high level of runway system throughput even in high wind situations.

This shows the importance of analysing peak day traffic as a complementary indicator to average daily movements, especially during periods of recovery or operational adjustments. Future research may highlight the impact of the runway system configuration on the service rate under the associated runway use.

3.4 Fleet Mix

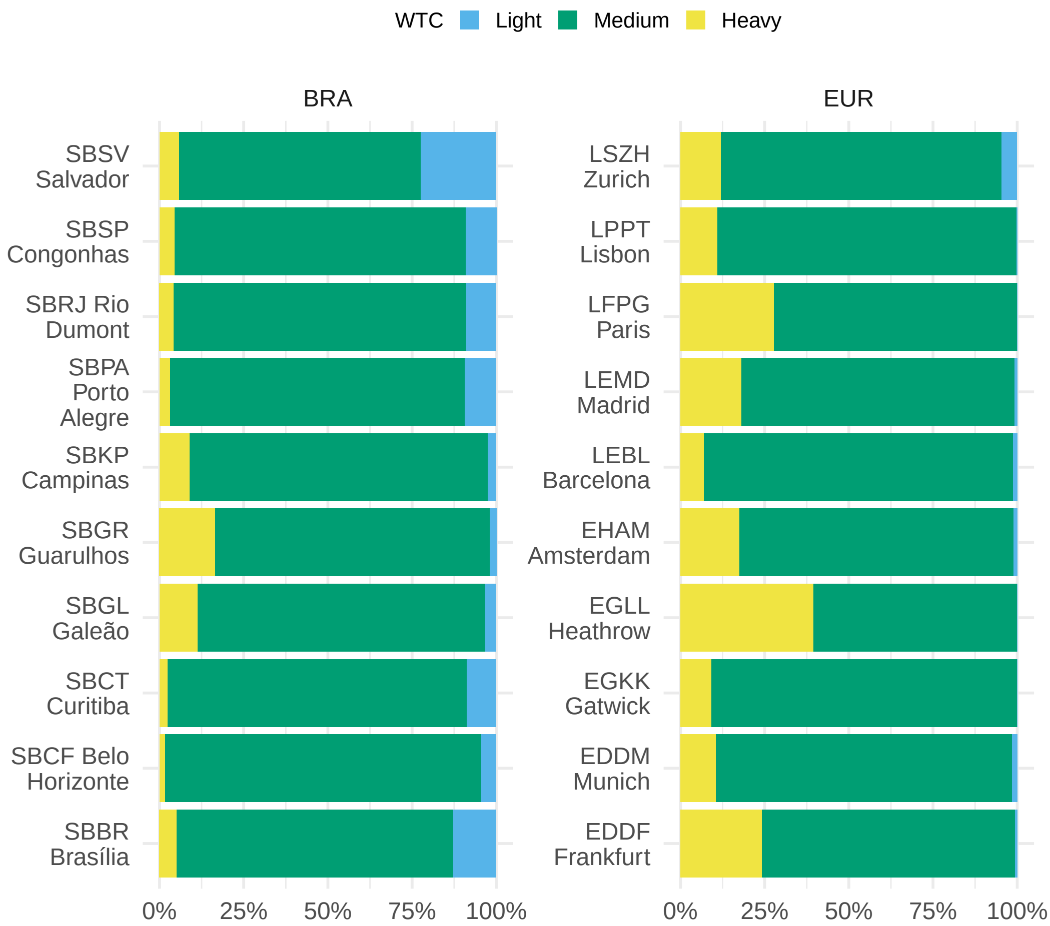


Figure 3.8: Fleet mix observed at the study airports in 2024

Figure 3.8 confirms the dominance of the "medium" aircraft category at the airports analysed in both Brazil and Europe. Fleet mix plays a key role in airport capacity, directly impacting traffic flow and operational efficiency. Generally, a higher share of "heavy" aircraft can reduce runway throughput due to wake turbulence separation requirements and longer landing and take-off times.

In Brazil, the main international hubs, Guarulhos (SBGR), Galeão (SBGL), and Campinas (SBKP), showed a 15% to 20% share of "heavy" aircraft, reinforcing their role as the country's key international gateways. Campinas, in particular, stands out as the main hub for Azul Linhas Aéreas and also handles a large volume of cargo operations, which contributes to its diverse fleet profile and operational complexity.

Some Brazilian airports such as Brasília (SBBR) and Salvador (SBSV) serviced a significant share of "light" aircraft. This category that is nearly absent among the European airports analysed. The notable exemption is Zurich (LSZH). In Salvador, light aircraft account for nearly 20% of all movements, and a similar pattern is observed in Campinas, reflecting their regional and logistical roles.

On average, the share of “heavy” aircraft is higher at the European study airports. The major European hubs like Frankfurt (EDDF), Heathrow (EGLL), and Charles de Gaulle (LFPG) operate with a higher proportion of “heavy” aircraft, in line with their function as global connection points. These structural differences reflect how each region organizes its connectivity: Brazil tends to centralize long-haul operations in a few key airports. The European network evidences the national focus on air transport development. With a significant higher number across a broader set of hubs traditionally servicing the national capitals.

Based on continuous monitoring throughout the year, this pattern has proven to be remarkably stable. The distribution of aircraft categories has remained consistent even during periods of disruption, such as extreme weather or localized infrastructure constraints. These observations suggest that the fleet mix at the analysed airports is shaped more by long-term structural factors than by short-term fluctuations, as airspace users operate and renew their fleet servicing these airports within their economic and operational context.

3.5 Summary

This chapter provided a comprehensive overview of air traffic dynamics across Brazil and Europe, covering both network-wide and airport-level perspectives.

The data confirms that Brazilian air traffic has surpassed pre-pandemic levels, reflecting a phase of real growth, while Europe continues a gradual recovery, marked by strong seasonal peaks and a more fragmented network structure. If current trends persist, Europe is expected to return to pre-pandemic traffic levels by 2025/2026, particularly driven by robust summer activity and the continued normalisation of regional and international demand. Despite these differences, both regions show signs of stability and resilience, even when affected by disruptions such as extreme weather or regulatory adjustments. Events like the prolonged closure of Porto Alegre (SBPA) and restrictions at Santos Dumont (SBRJ) highlighted the sensitivity of localized operations and the capacity of the network to adapt.

At the airport level, Brazilian traffic remains highly concentrated in a few major hubs, whereas European operations are more spread across several national gateways. There is a more pronounced seasonal pattern in Europe typically culminating during the summer holiday season.

The peak day analysis complemented the annual view by illustrating the operational limits reached under maximum demand. Although volumes remained stable overall, individual airports showed notable variations—either from growth, as in SBGL and SBCF, or contraction, as seen in SBRJ. European peak service rates show the overall recovery pattern and first signs of reaching the available capacity for the major hubs.

Finally, the fleet mix analysis reinforced the structural differences in how each region operates: Brazil shows a higher presence of light aircraft in some regional airports and a centralised model for long-haul traffic. Light-type traffic at the study airports in Europe remain the exemption. A higher share of heavy aircraft is observed at the top-European airport in this study. The wider spread of international connections across all chosen airports shows a less centralised global connectivity model.

Together, these findings establish a base to understanding the operational performance indicators in the next chapters.

4 Predictability

The preceding sections have demonstrated that both systems exhibit unique reactions to the broader developments in air transport. Predictability plays a crucial role impacting both the strategic phase, where airline schedules are formulated, and the operational phase, where Air Navigation Service Providers (ANSPs) and stakeholders manage the balance between demand and capacity. Higher levels of predictability stand to be advantageous for ANSPs, mainly when serving airspace users, as it contributes to highly efficient operations, even during periods of peak demand. This chapter focuses on arrival and departure punctuality as crucial predictability indicators.

4.1 Arrival Punctuality

The arrival punctuality shows the predictability of landing operations at airports, based on the scheduled in-block time (SIBT). It considers a 15-minute window for early or late arrivals and expresses the percentage of flights arriving at the gate within that margin.

Figure 4.1 shows the 2024 data and reaffirms key structural differences in punctuality behaviour between Brazilian and European airports. Brazilian airports continue to report a high share of early arrivals—more than 15 minutes ahead of schedule—accounting for 20% to 30% of flights. In contrast, while some buffering is discernible, most European airports show early arrival shares below 15%. This pattern, observed consistently over recent years, reflects the use of built-in buffer times in Brazil's scheduling practices. While these buffers help airlines improve on-time performance records, they can reduce predictability and complicate planning for air traffic management and airport operations.

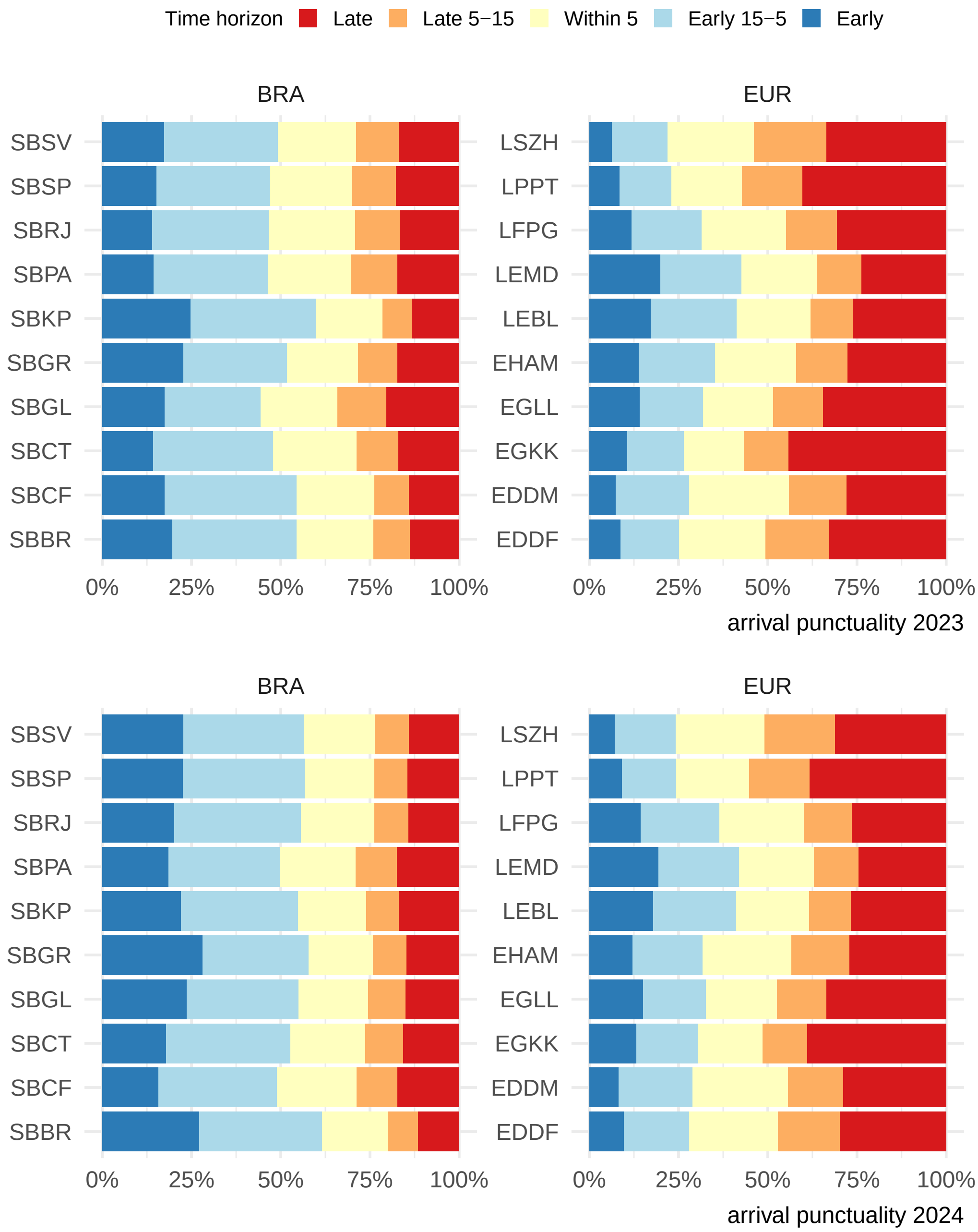


Figure 4.1: Evolution of arrival punctuality at study airports (2023 vs 2024)

Compared to Brazil, Europe observed a high level of delayed arrivals in 2023 and 2024. Across all study airports, there is a minimum of 25% of the flights arriving late, an in extreme cases ranging up to 40% at London Gatwick (EGKK) and Lisbon (LPPT). Capacity constraints on the European network level - amplified by local constraints - rippled throughout the whole network and contributed to the poor overall delay performance.

Across both regions, the share of flights arriving within the -/+ 15 minute window remains the key measure of operational predictability. European patterns remained relatively stable in 2024, while in Brazil, punctuality varied significantly among airports.

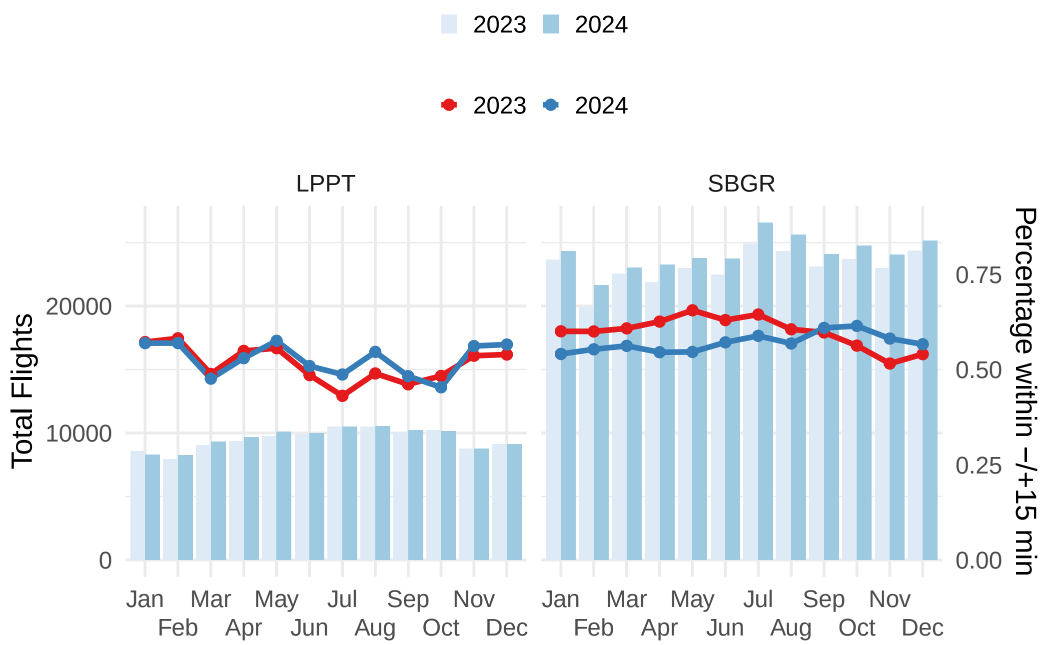


Figure 4.2: Total flights and arrival punctuality at two comparison study airports

To contextualise regional contrasts, Figure 4.2 presents a side-by-side comparison between Guarulhos (SBGR) and Lisbon (LPPT) between 2023 and 2024. Despite LPPT handling less than half the volume of flights compared to SBGR, it maintained punctuality levels close to 45% in October 2024. Overall, LPPT showed gradual improvement throughout the year. In contrast, SBGR remained below its 2023 performance until September, after which punctuality slightly improved. This late-year improvement indicates a potential shift but also highlights ongoing challenges.

Compared to Figure 4.1 it is interesting to note - broadly assuming an average annual arrival punctuality of 50% of flights arriving between -/+15 minutes of their scheduled time - that the share of early and late arrivals is more balanced at SBGR, while LPPT observed an extreme high share of late arrivals.

This comparison underscores how operational structure, traffic complexity, and scheduling strategies directly influence punctuality outcomes. In Brazil, concentrated demand at a few major hubs—especially SBGR, the country's busiest airport—makes it harder to sustain performance within the target window. The higher level of traffic can amplify network disruptions leading to high share of delay across all airports and ripple effects propagate through the network.

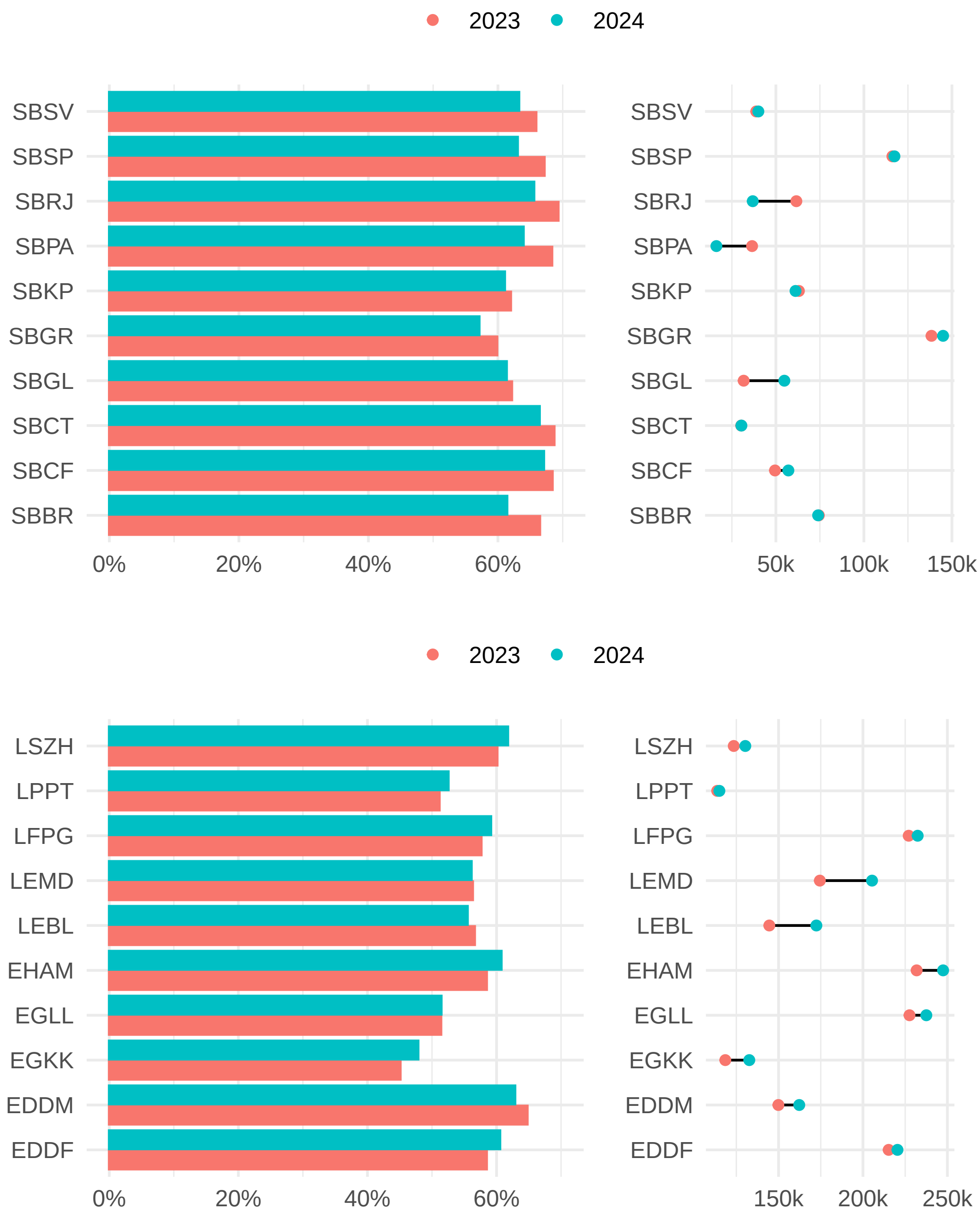


Figure 4.3: Evolution of arrival punctuality -/+15 min vs arrival traffic

Figure 4.3 presents a side-by-side view of airport-level arrival punctuality and movement evolution between 2023 and 2024.

As presented above, while differences exist in the share of early and late arrivals, the number of flights arriving within -/+15 minutes of their scheduled time ranged higher in Brazil than in Europe. For 2023 and 2024, a 60% share of operations serves as a useful threshold. The majority of European arrival operations at the study airports failed to meet this threshold with the highest offset observed at London Gatwick (EGKK), Heathrow (EGLL), and Lisbon (LPPT). This is contrasted by the success rate observed across the Brazilian study airports. Virtually all arrival operations ranged above this threshold.

Overall, a majority of European airports demonstrated small improvements in arrival punctuality comparing the 2023 levels with 2024. The strong traffic growth at Spanish airports, Madrid (LEMD) and Barcelona (LEBL), is not negatively impacting the overall achieved performance. At Amsterdam (EHAM) and London Gatwick (EGKK) a notable improvement in arrival punctuality was achieved despite a discernible increase in traffic among all airports in the study. On the other side, Munich (EDDM) registered a drop in punctuality, despite an increase in flight movements. This reinforces two critical operational dynamics:
First, the cumulative nature of delays, which highlights the limited resilience of the flight network — when a single flight is delayed, subsequent flights tend to be impacted due to tight scheduling and lack of flexibility. Second, increasing demand often exacerbates existing local resource constraints, especially in areas like passenger processing and turnaround operations. As a result, reactionary delays accumulate and propagate throughout the system, further reducing predictability and punctuality.

The previous section highlighted the overall arrival punctuality observed at the study airports. Lower levels of punctuality can negatively impact predictability of operations and thus put a stronger strain on resources managing the arrival flow. Next to the arrival airspace capacity, stronger variations of the scheduled arrival times pose challenges for the surface management, as taxi operations, including stand allocation and availability, might result in changes of the taxi patterns, queuing within the taxiway and apron/stand system.

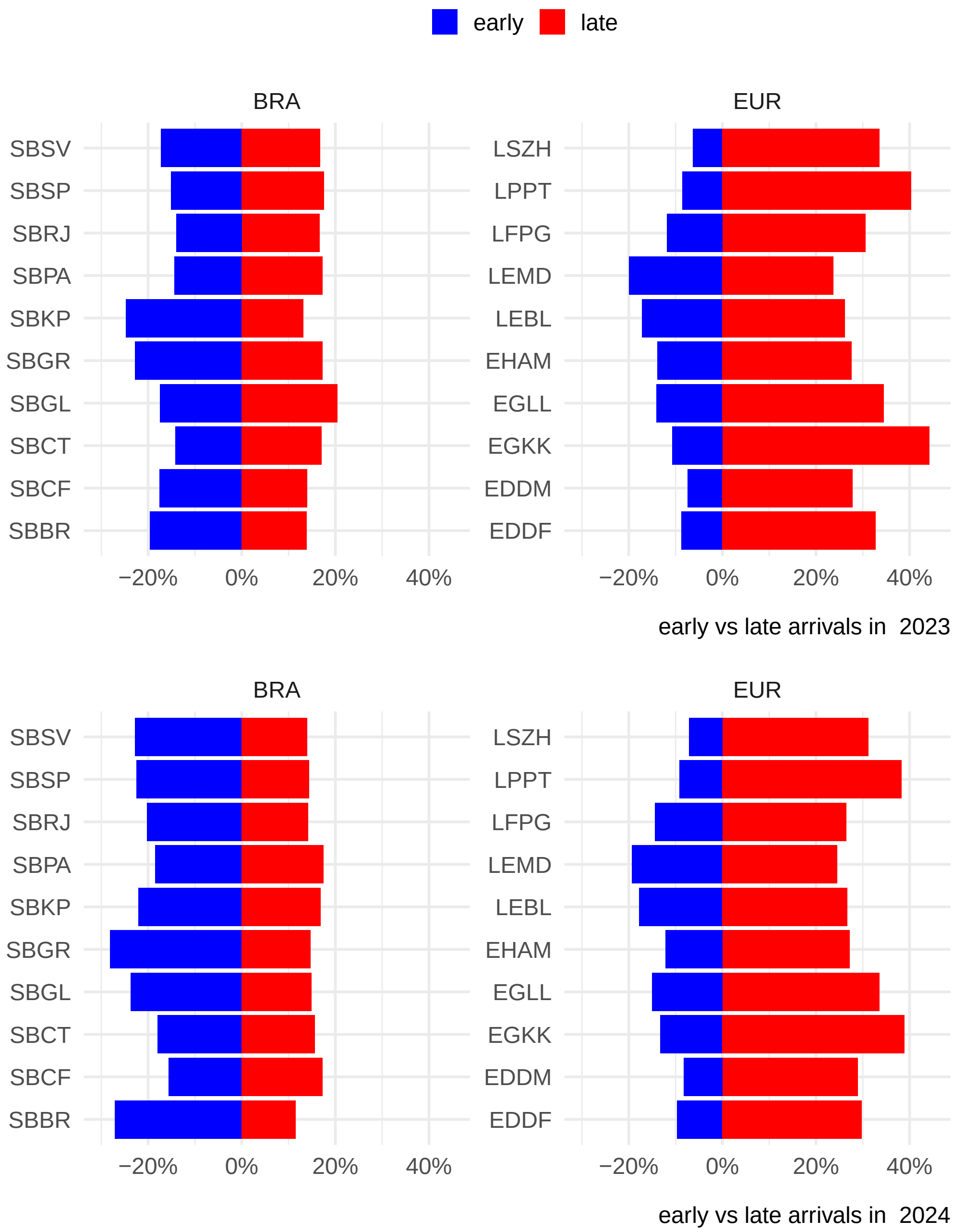


Figure 4.4: Change of share of early and late arrivals (2023 vs 2024)

Figure 4.4 compares the share of early and late arrivals at each study airport, considering arrivals more than 15 minutes ahead of or behind schedule (-15 min or +15 min) in 2023 and 2024. From a broader perspective, air traffic in Brazil continues to show a tendency toward early arrivals, while in Europe, delayed arrivals are more prevalent. Thus, it appears that Brazilian operators tend to a conservative buffering of their arrival schedules. The network level implications on the arrival punctuality in Europe throughout 2023 and 2024 can be clearly seen.

Guarulhos (SBGR) remained the Brazilian airport with the highest share of early arrivals in 2024, followed by Campinas (SBKP), both with more than 30% of flights landing ahead of schedule. As key hubs in Brazil's network, this may reflect a deliberate strategy by airlines to better manage connections and mitigate delays within their own schedules. However, from a flow management perspective, this lack of precision poses operational challenges, as it complicates the allocation of resources and the sequencing of arrivals within controlled airspace and on the ground.

In Europe, Madrid (LEMD) recorded the highest share of early arrivals in 2024, reaching nearly 20%, followed by the other Spanish airport Barcelona (LEBL). Still, this figure remains below the levels seen in Brazil, reinforcing the structural and strategic differences in scheduling practices and performance expectations between the two regions. There is a varied explanation of the overall poor arrival punctuality performance across the airports. It is important to understand that disruptions stemming from the transition from pandemic to post-pandemic, and the overall network capacity constraints amplified each other. Airport operators were identified as the major contributors to primary delays (ground handling, staff shortage) followed by ATFM delays. However, the aforementioned reactionary effect was the main driver of knock-on delays (EUROCONTROL Central Office of Delay Analysis 2023) [1].

4.2 Departure Punctuality

The departure punctuality reflects the predictability of take-off operations at monitored airports. It is based on the comparison between the scheduled off-block time (SOBT) and the actual off-block time (AOBT), using a 15-minute tolerance window for early or late departures. The indicator expresses the percentage of flights that leave the gate within this time margin.

[1] See CODA report at https://www.eurocontrol.int/publication/all-causes-delays-air-transport-europe-annual-2022.

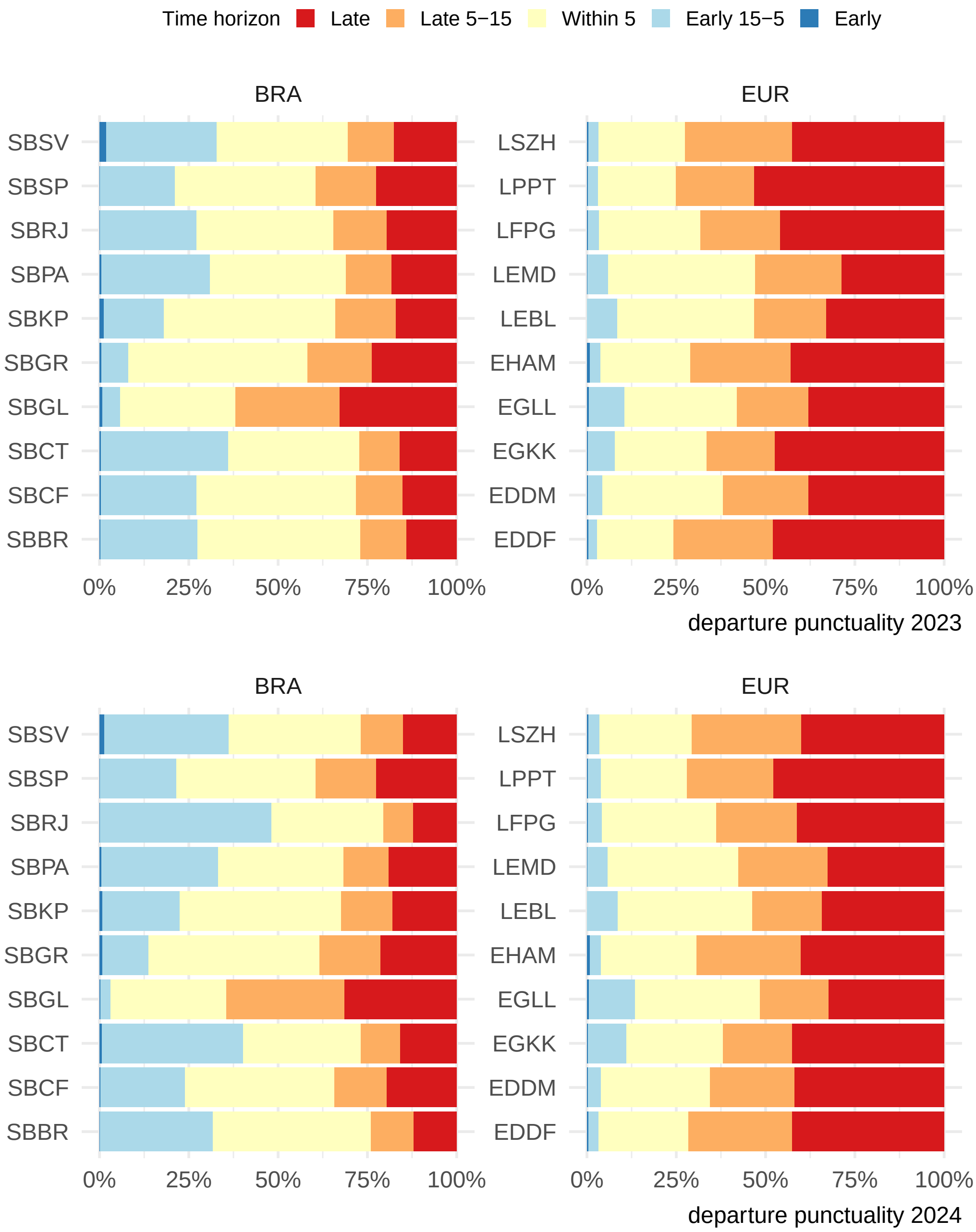


Figure 4.5: Evolution of departure punctuality at study airports (2023 vs 2024)

Figure 4.5 presents the departure punctuality results for the study airports. The 2024 data show that, overall, airports perform better in managing outbound traffic, although challenges remain. Different from arrival punctuality, where Brazilian airports showed a high share of early arrivals and wide variability across the network—departure punctuality metrics appear comparatively stronger, especially in terms of flights departing within the punctuality (-/+ 15 min) time window.

One example is Santos Dumont Airport (SBRJ), where near to 50% of departures occurred 5 to 15 minutes ahead of schedule, reinforcing a consistent tendency toward early operations.

On the other hand, Galeão Airport (SBGL) was one of the highest shares of delayed departures of flights leaving more than 15 minutes behind schedule. These two airports operate in close proximity and have undergone significant operational changes in recent years, which likely contribute to the contrasting performance.

Moreover, seasonal weather conditions—such as summer thunderstorms, wind gusts, and windshear, especially in Brazil's South-east region, can disrupt operations, increase runway occupancy time, or require frequent runway changes, further affecting predictability.

In summary, while departure punctuality shows a slightly more favourable scenario compared to arrival operations, maintaining high performance levels still demands continuous improvements—especially at high-density airports. Operational planning, weather adaptation, and runway configuration remain key factors for enhancing outbound flight reliability.

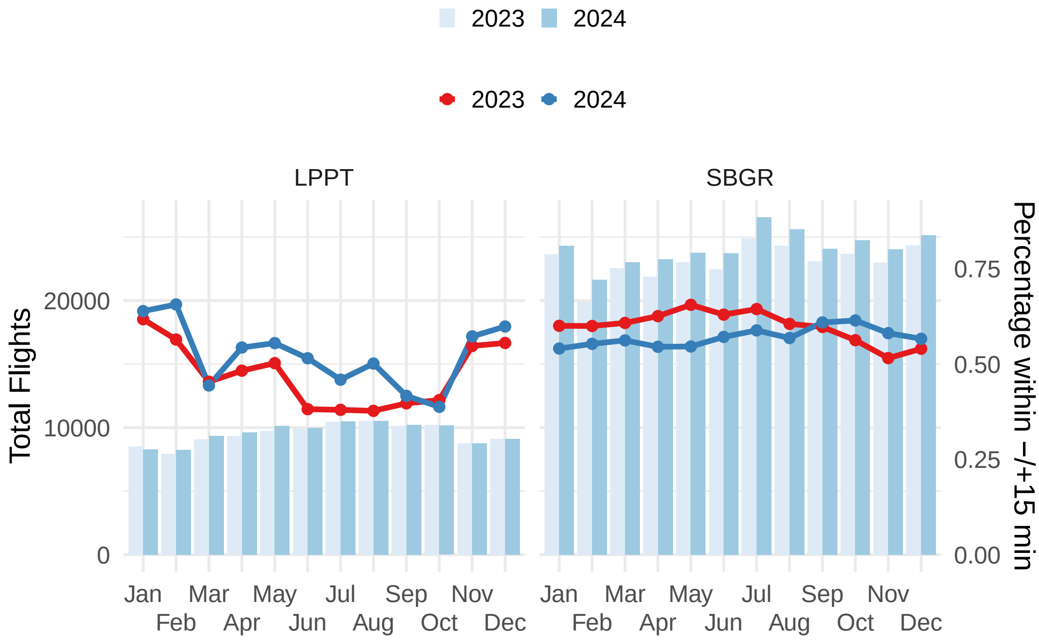


Figure 4.6: Departure Punctuality at two comparison study airports

Comparing the observed punctuality performance for departures at Lisbon (LPPT) and Guarulhos (SBGR), c.f. Figure 4.6, depicts the lower level of departure punctuality at LPPT. It appears that the punctuality performance followed broadly the seasonal development. This is in line with the earlier commentary on the network level effects impacting the overall delay situation through increased reactionary delays driven by significant ATFM delay constraints. The departure performance observed at Guarulhos is in line with the arrival punctuality pattern showing the same behaviour across 2023 and 2024.

The preceding section highlighted how the general traffic conditions in the previous years influenced the dependability of arrival schedules. In this section, we assess the degree of departure punctuality measured as the difference between the scheduled (i.e. planned) departure versus the observed actual off-block time. Figure 4.5 shows the overall departure punctuality at Brazilian and European airports in 2023 and 2024.

Departure punctuality appeared slightly higher in Brazil in 2024 in comparison to 2023 and outperforms the punctuality levels observed in Europe. It is also noteworthy, that in Brazil there is a higher share of flights blocking off between 15 to 5 minutes before their scheduled time. Further research may help to clarify the factors driving this phenomenon.

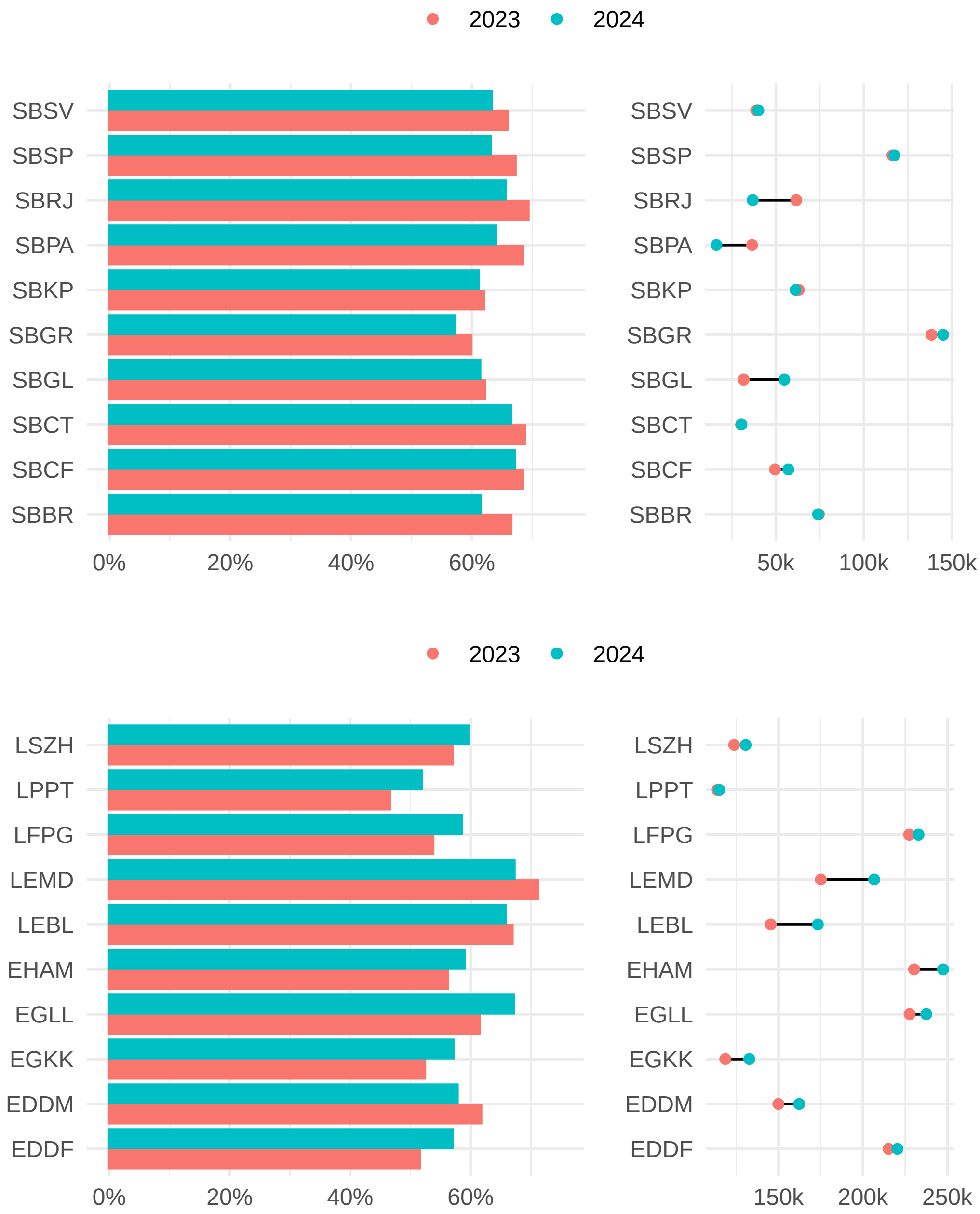


Figure 4.7: Evolution of departure punctuality -/+15 min vs departure traffic

In analogy to the previous section, Figure 4.7 shows a side-by-side view of departure punctuality and movement evolution between 2023 and 2024 for each of the study airports.

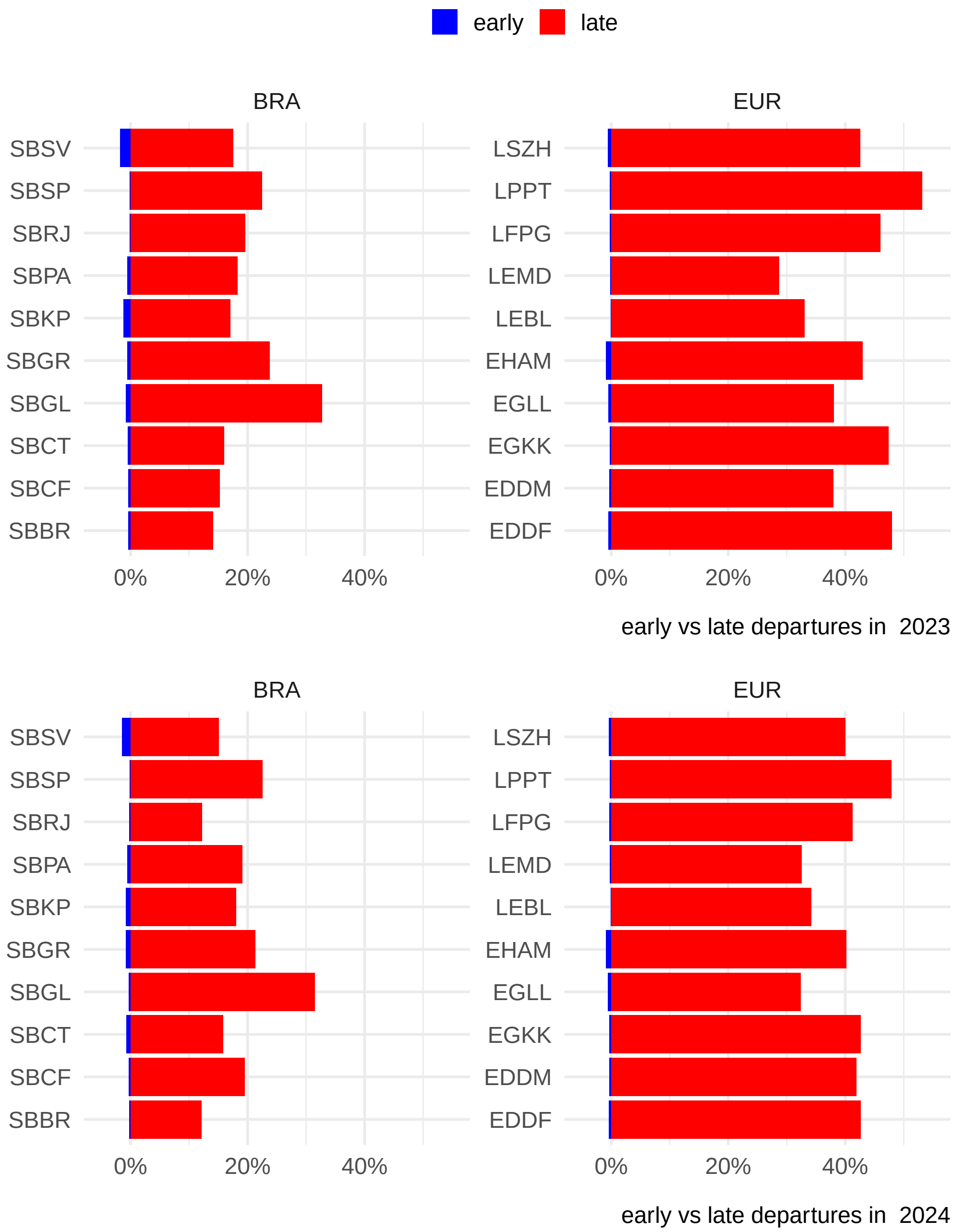


Figure 4.8: Change of share of early and late departures (2023 vs 2024)

The change of the share of early and late departures in 2023 and 2024 is shown in Figure 4.8.

The observed departure punctuality at Brazilian and European airports demonstrates a positive operational behaviour: early departures (before scheduled time) are relatively small in both regions, which is favourable for maintaining schedule stability.

In Brazil, the patterns observed in 2023 and 2024 are notably similar across the study airports, indicating consistent operational practices. Galeão (SBGL) was the airport with the highest share of late departures, reaching approximately 30% in both years. Despite this, most Brazilian airports maintained a balanced distribution, with a large proportion of flights departing within the -/+ 15-minute window.

There is stark contrast in terms of overall departure punctuality between Brazil and Europe. On average, the number of delayed departures ranged about twice as high as in Brazil. In Europe, while the general behaviour remains similar, some airports experienced a deterioration in departure punctuality. Munich (EDDM) saw an increase in late departures, with the share rising above 40% in 2024. The amplification effect is evident. Delayed departures for regional flights will ultimately cause downstream delays. Disrupted schedules pose challenges to the local capacity management and surface operations. However, they also contribute to challenges of flow control on the network level. The associated imbalances influenced negatively the overall network sequencing/flow management.

While surface movement operations appear stable at most airports, the growing share of late departures at specific locations signals the need for continuous monitoring and management interventions to assure the predictability of operations.

4.3 Summary

Arrival and departure punctuality play an important role in terms of balancing demand and capacity.

Arrival punctuality revealed distinct regional patterns. Brazilian airports continued to show a high share of early arrivals, largely due to the use of built-in buffer times in flight schedules. While this improves on-time performance metrics, it complicates air traffic management by reducing predictability. In contrast, European airports generally maintained lower shares of early arrivals and more stable punctuality performance across the study period. A closer operational comparison of the behaviour at Guarulhos (SBGR) and Lisbon (LPPT) highlighted the challenges faced by large, high-density hubs in sustaining punctuality under growing demand.

Departure punctuality showed a distinct difference between both regions and when compared to the wider spread of the arrival punctuality. Early departures remained relatively rare, supporting schedule stability. However, challenges persisted, particularly at airports like Galeão (SBGL) in Brazil and Munich (EDDM) in Europe, where late departures increased. Overall, the departure punctuality in Europe was poor compared to Brazil. On average, the share of departures departing late were twice as high as in Brazil. These patterns emphasize how local operational and network constraints, weather disruptions, and surface management practices directly influence performance.

In both regions, maintaining high predictability levels remains critical to support efficient surface operations, arrival sequencing, and passenger experience. Continuous adaptation, proactive operational planning, and effective resource management are essential to sustain and improve predictability, especially as traffic demand continues to grow. As both regions are committed to move toward trajectory-based operations, the management of highly predictable air traffic flows will require attention.

5 Capacity and Throughput

Maintaining an optimal network flow necessitates an equilibrium between airport capacity and flight demand. This section delves into assessing capacity and throughput using various key performance indicators (KPIs) at the airport level. Airspace users expect sufficient capacity provision addressing the levels of demand. With higher levels of capacity utilisation, airspace users will experience congestion and constraints (e.g. higher inefficiency, increased delay/lower punctuality and predictability). However, planning and staffing for peak situations may come at significant costs to airspace user as well. In that respect it is essential to understand the trade-off between capacity provision and capacity consumption (i.e. traffic demand) as it impacts the overall system performance. Capacity and throughput analyses are therefore showing to what extent air navigation services are capable to accommodate the demand. The previous sections showed the level of overall traffic recovery in both regions. The increasing demand put strain on the systems and local knock-on effects amplified the uncertainty and variability of the expected traffic levels. This chapter may therefore also highlight the flexibility of air navigation services to accommodate such distortions of the schedule.

5.1 Peak Declared Capacity

Peak Declared Capacity refers to the highest movement rate (arrivals and landings) at an airport using the most favourable runway configuration under optimal conditions. The capacity value might be subject to local or national decision-making processes. The indicator represents the highest number of landings an airport can accept in a one-hour period.

In both regions, peak capacity is declared by the respective authority. In Brazil, this function is performed by DECEA. Within the European region, the airport peak capacity is determined on a local or national level. The processes consider local operational constraints (e.g. political caps, noise quota and abatement procedures) and infrastructure related limitations (e.g. apron/stand availability, passenger facilities).

Figure 5.1 shows the evolution of the declared capacity for the airport services in this comparison report. Throughout the last years, no substantial change in the peak declared capacity was observed at European airports. In Brazil, on the other hand, 2019 and 2020 showed a revised capacity declaration at most of the Brazilian airports. In 2018 CGNA had developed a refined method for the determination of the runway system capacity.

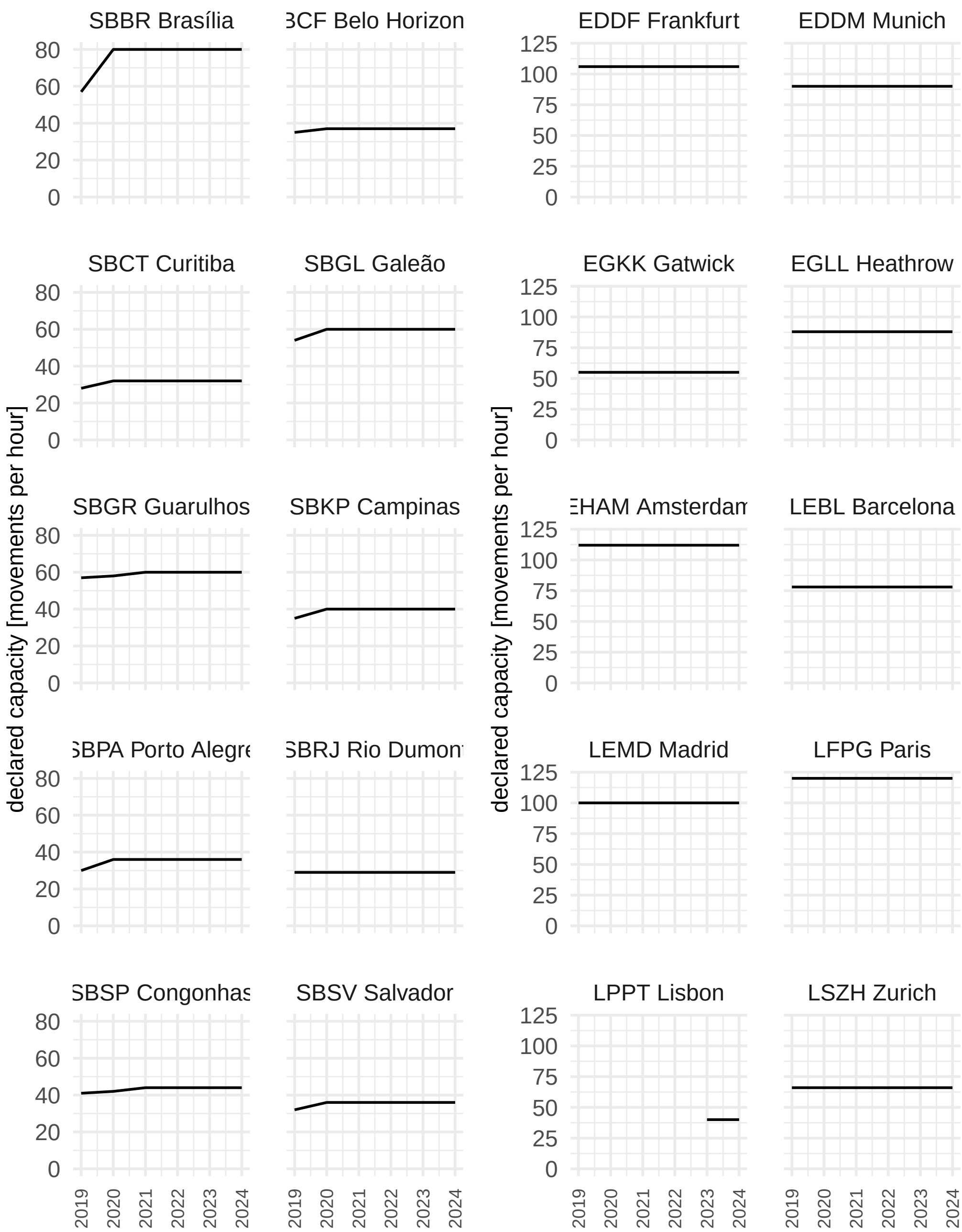


Figure 5.1: Evolution of Declared Capacities at study airports.

The capacity of airports (and the associated runway system) is predominantly influenced by their infrastructure. The existence of independent parallel runways, e.g. Brasilia (SBBR) and Munich (EDDM), can support decisively the resulting capacity. Furthermore, operational procedures can lead to an increase in airport capacity. London Heathrow (EGLL), in the past, and Guarulhos (SBGR) in recent years show that changes in operational procedures can help the airport absorb significant traffic increases or reduce the additional sequencing time in the terminal airspace. Guarulhos, for example, benefited from the implementation of segregated operations under VMC conditions, and Heathrow increased its capacity through the introduction of time-based separation on final.

In this context, Figure 5.2 shows the declared peak capacity for the study airports. As observable in the case of Amsterdam Schiphol (EHAM, 6 runways), the number of runways is not a direct indication of the maximum capacity. For example, the two-runway airports Brasilia (SBBR), London Heathrow (EGLL), and Munich (EDDM) share a similar runway system layout and range above the 3-runway systems of Barcelona (LEBL) and Zurich (LSZH). London Gatwick (EGKK) is renowned for its maximisation of its single-runway throughput. Please note that Lisbon (LPPT) was added to this comparison report and capacity values for earlier years were not available at the time of writing.

As mentioned above, the capacity declaration/determination process takes into account the varying local conditions and constraints. It balances the need to accommodate growth vs policy priorities and public interests. A potential area for further research could be a closer investigation of the operational concepts deployed and the variations of the declared capacity with the local runway system characteristics.

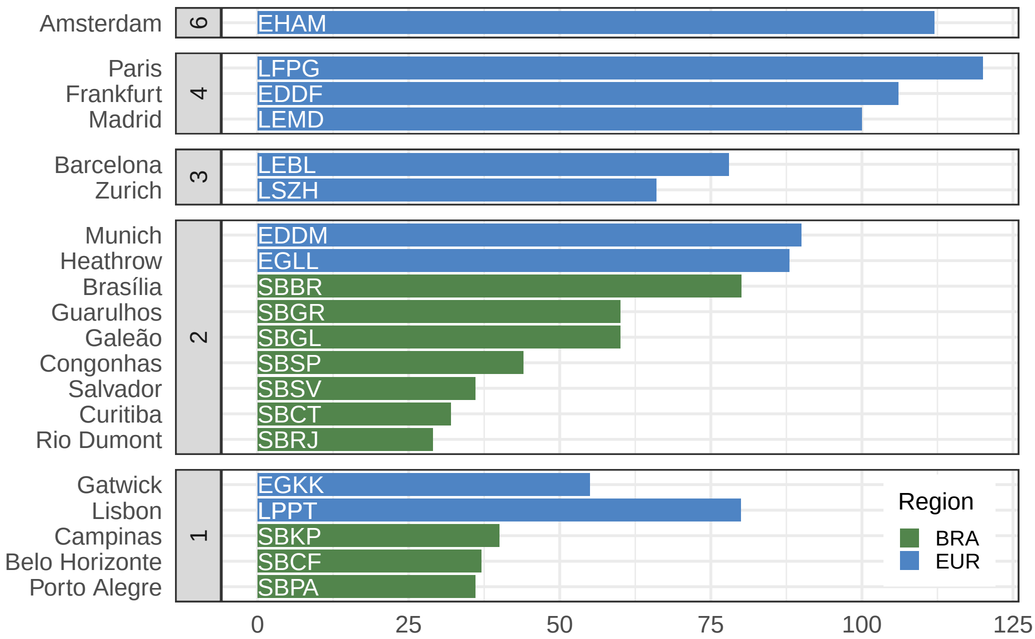


Figure 5.2: Peak declared capacity 2024 [flights/hour]

5.2 Peak Arrival Throughput

This comparison report uses the GANP KPI to measure the peak arrival throughput as the 95th percentile of the hourly number of landings observed at an airport (ICAO 2019a). The measure gives an indication of the achievable landing rates during "busy-hours". It is an indication to what extent arrival traffic can be accommodated at an airport. For congested airports, the throughput provides a measure of the effectively realized capacity. Throughput is a measure of demand and therefore comprises already air traffic flow or sequencing measures applied by ATM or ATC in the en-route and terminal phase. For non-congested airports, throughput serves as a measure of showing the level of (peak) demand at this airport.

Figure 5.3 compares the observed annual peak arrival throughput at the study airports in Brazil and Europe. On average, the busiest hour of the Brazilian airports under study did not suffer a significant reduction. This signals that peak arrival demand remained fairly constant during the pandemic. An increased arrival peak throughput was serviced at Brasilia (SBBR), Campinas (SBKP), Rio de Janeiro (SBRJ), and Confins (SBCF). Services at Galeão (SBGL) observed a significant shift in the traffic pattern. The peak arrival throughput fell sharply with the pandemic and has not yet recovered. This overall picture is contrasted by the pandemic related drop of overall traffic at European airports. The overall reduction resulted in significantly lower peak hours. The recovery pattern is also visible in the peak arrival throughput behaviour.

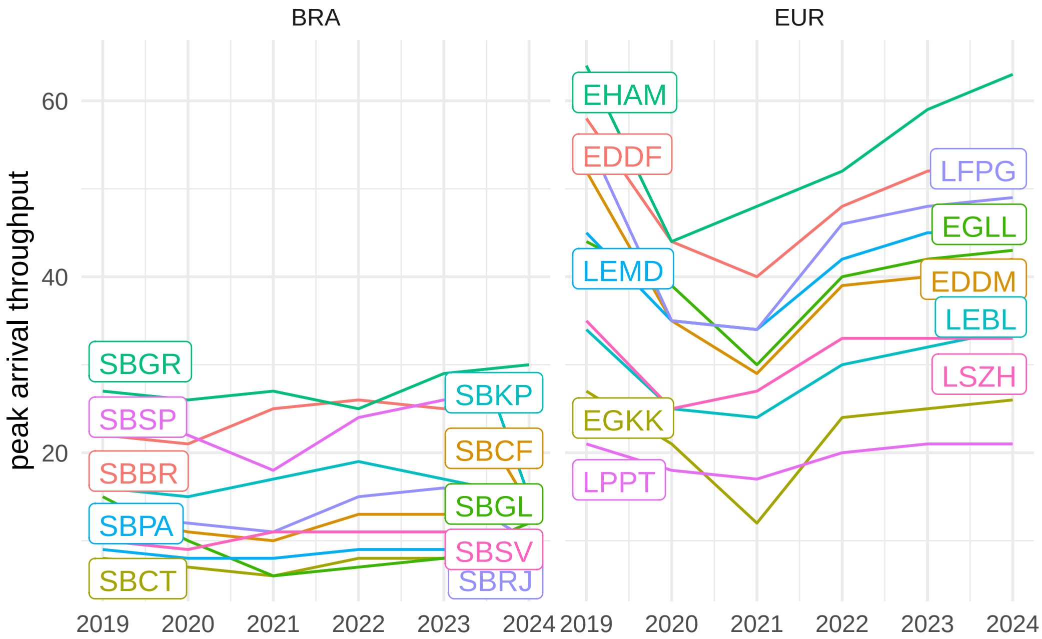


Figure 5.3: Evolution of annual arrival throughput at study airports

With Figure 5.3, a further difference between both regions becomes apparent. The peak arrival throughput represents the achieved peak service rate utilising the available arrival runway system capacity. On average, the peak arrival throughput is higher in Europe than in Brazil based on the available infrastructure. It is interesting to see that arrival operations at SBGR, SBSP, and Brasilia (SBBR) range at the level of Gatwick (EGKK) and above Lisbon (LPPT). At the same time, it offers growth potential when these airports are compared to the achievable arrival throughput at dual independent runway operations at Munich (EDDM) or even Heathrow (EGLL).

While the peak arrival throughout varied in Brazil over the past 6 years, the pattern is more homogeneous. Larger variations are explainable with local demand changes. However, compared to Europe, Brazil did not show the scale effects of lower air traffic demand during the pandemic phase. In light with the overall traffic recovery also the pressure on the arrival runway system increased at the European airports. Lisbon (LPPT) shows a level of variation. This suggests that even during the pandemic, operational peaks were serviced consistently at the same level.

5.3 Peak Departure Throughput

In analogy to the previous section, Figure 5.4 shows the peak departure throughput. The latter is determined as the 95th percentile of the hourly number of departures.

A similar picture emerges for the peak departure throughput in both regions. In Brazil, Campinas , Brasilia and Santos Dumont reduced the peak departure in comparison with 2023. Only Curitiba and Porto Alegre maintained the same level as 2023. For the other Brazilian airports, the peak departure throughput increased. A continual increase of the peak departure throughput is observed at SBGR exceeding in 2024 the pre-pandemic 2019 level. This suggests a concerted effort and more efficient use of the runway system for the departure phase.

The pattern in Europe is characterised by the continual air traffic recovery for the majority of the airports. A lesser pronounced variation is observed at Lisbon (LPPT) for which the peak departure rate remained fairly stable over the past years.

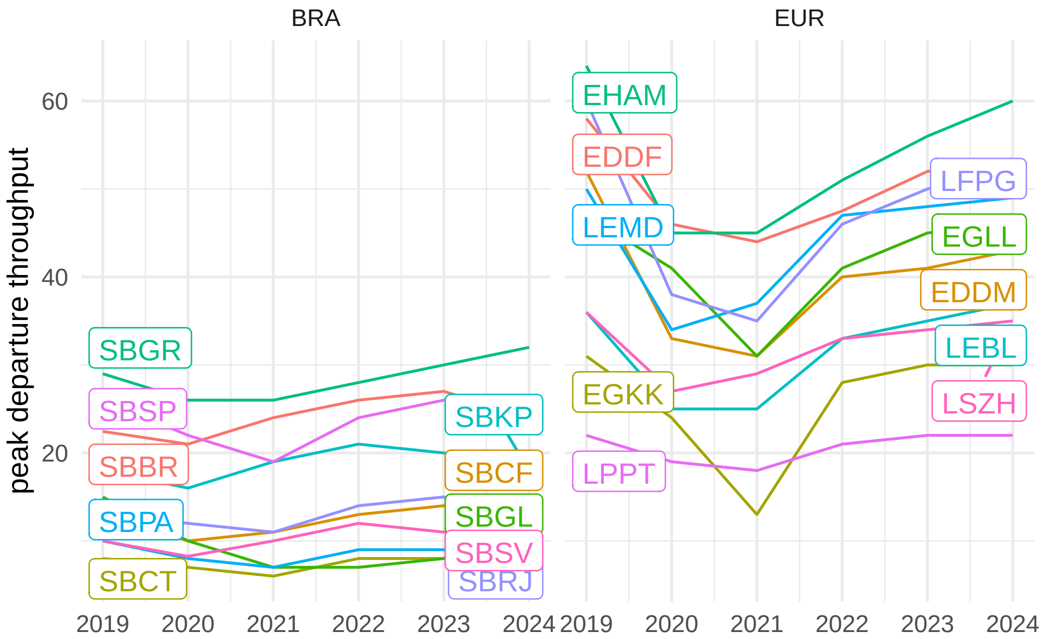


Figure 5.4: Evolution of departure throughput at study airports

5.4 Declared Capacity and Peak Throughput

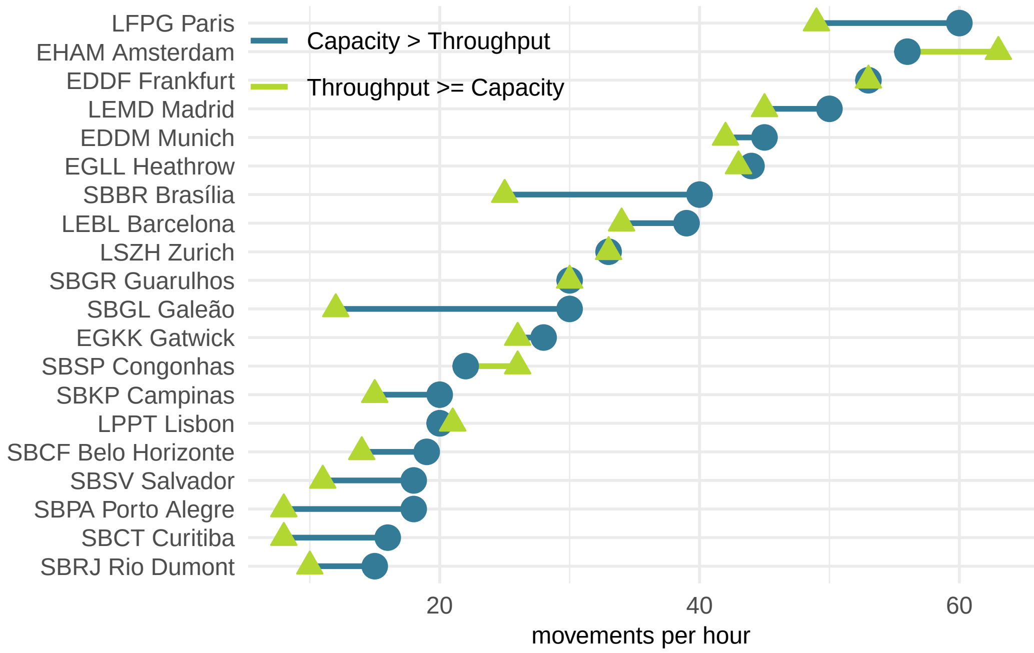


Figure 5.5: Comparison of declared capacity and throughput for arrival phase.

Comparing the peak declared (arrival) capacity and throughput serviced at the different airports reveals a varying picture. On average, Figure 5.5 evidences that operations at the majority of the airports do not yet observe capacity constraints. In many instances, the achieved throughput ranges about 10 flights per hour below the maximum declared capacity. In 2024, a low utilisation was observed at Galeão (SBGL), Brasilia (SBBR), and Paris Charles de Gaule (LFPG). Here the observed the spread between declared capacity and peak throughput exceeds 15 flights per hour. It is also noteworthy, that a subset of airport services operate at their maximum declared capacity (e.g. SBGR, LSZH, EDDF). These airports are also characterised by a combination of complexity of the aerodrome layout and operational context. It will be interesting to study how these airports facilitate higher levels of demand. Higher peak throughput rates than the declared capacity were observed at Amsterdam (EHAM), Congonhas (SBSP), and marginally at Lisbon (LPPT). The offset at EHAM and SBSP suggest that declared capacity might be too conservative. In the case of Amsterdam (EHAM) there is a political cap on the number of operations per year. This may result in a determined (and declared) hourly rate that does strictly speaking not apply to the operational peak situations.

The analysis of the spread of the declared capacity versus the achieved throughput is useful. However, it provides no indication on how often the demand reaches the declared capacity level. For this purpose, this report determines two characteristics points, i.e., the *BLI* base load index, and the peak load index *PLI*.

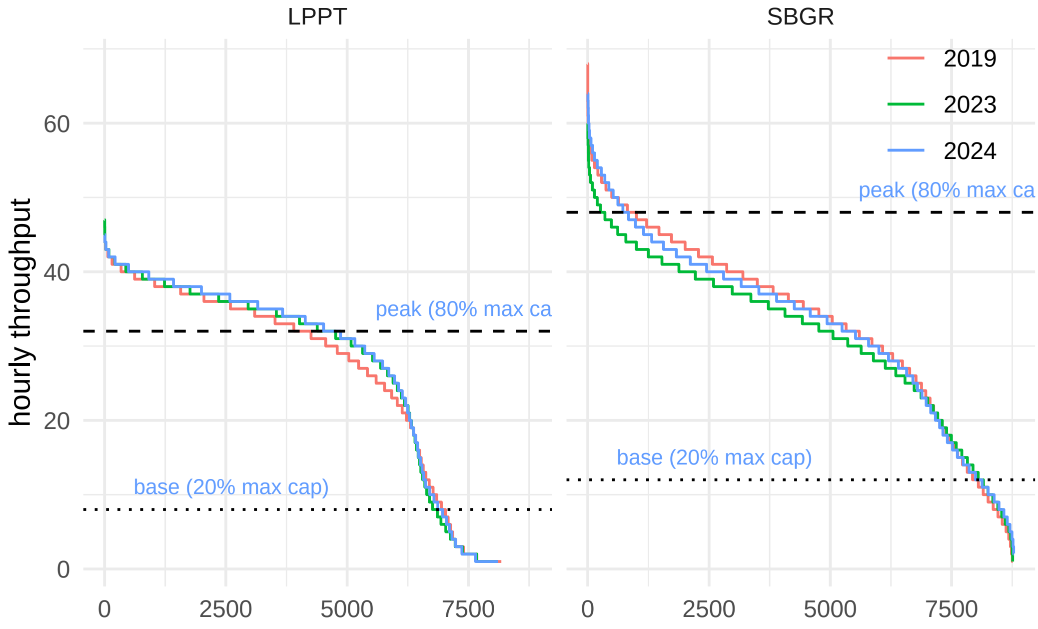


Figure 5.6: Ranked hourly throughput at LPPT and SBGR

Comparing the achieved hourly throughput at Guarulhos (SBGR) and Lisbon (LPPT), Figure 5.6 depicts a higher level of peak throughput traffic numbers at SBGR. The overall patterns are similar across the studied years. Lisbon (LPPT) observed an increase in its overall traffic throughputs as the hourly throughputs for 2023 and 2024 exceed the pre-pandemic levels of 2019. Guarulhos (SBGR) experienced a bounce-back with the continual increase in its hourly throughput between 2023 and 2024 catching up with the pre-COVID levels.

In terms of demand pressure, Lisbon observed for a higher share of hours with throughputs above 80% of its declared capacity than SBGR. As the overall ordered throughput shows a gradual reduction gradient Guarulhos (SBGR) combined with a large spread of the peak and base level, there exists available capacity at the airport. Lisbon shows a narrower spread. On top, the existence of night flying restrictions is clearly visible for LPPT with its distribution tail.

Figure 5.6 shows that multiple factors influence the interplay between the declared capacity and observed throughputs. Similar to comparing only the number of runways and not the runway system utilisation, focussing on the difference between declared capacities, demand periods and operating conditions does not readily allow to compare operations at different airports. For this report, we define peak operating conditions, if the total hourly throughput reaches or exceeds 80% of the declared capacity levels, and accordingly, base load levels, if 20% of more are observed. The peak load index (PLI) accounts then for the number of operating hours at or above the peak level, and respectively, the base load index (BLI) for hours at or above the 20% base traffic level.

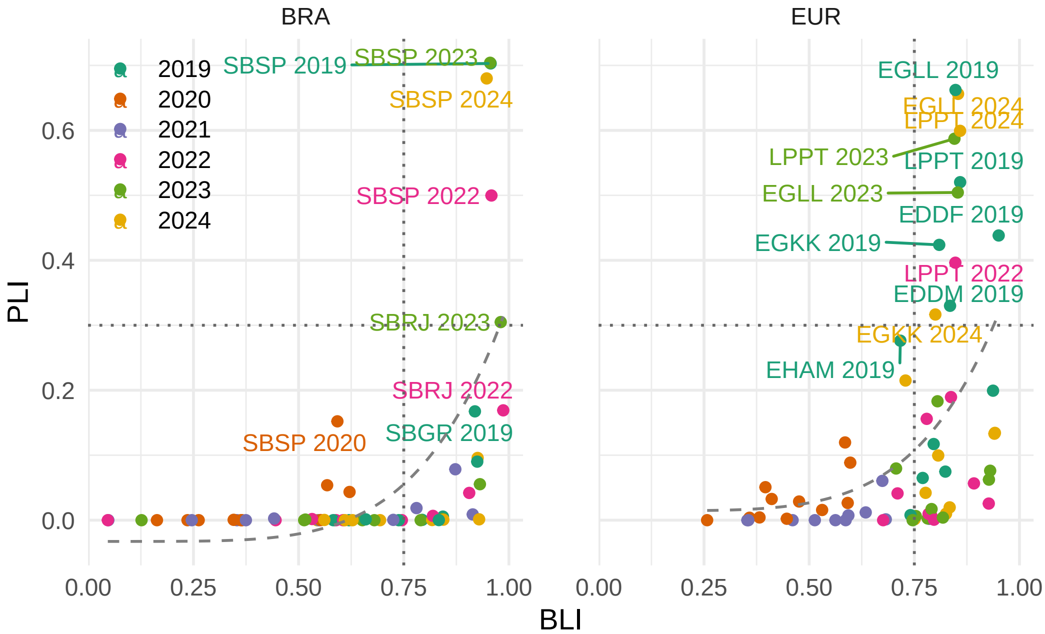


Figure 5.7: Capacity utilisation (base load index vs peak load index)

Figure 5.7 summarises the observed utilisation of the available (i.e., declared) capacity at the study airports in the different regions. Based on this report, it appears that airports showing a BLI of higher than 0.75 observe a consistent level of demand across the operating hours, congestion due to peak operating conditions kick in with a PLI of 0.3. The lower range suggesting a strong banks, while higher levels of the PLI demonstrating a consistent use of the available capacity. In Brazil, we observe a high utilisation of the capacity at Sao Paulo (SBSP) in 2023 and 2024 comparable to pre-COVID levels in 2019. For a majority of the airport across the years, no substantial peak loads were measured. This suggests that there is substantial capacity to sustain future growth of air traffic. Rio de Janeiro observed moderate loads confirming the role of the airport within the Brazilian system. that both aerodromes are characterised by a relatively conservative and low capacity declaration. The major hub in Brazil, SBGR shows a relatively high base-load-index (BLI), however rarely observed peak loads back in 2019. Within the European context, a high utilisation of the available system capacity was observed for London Heathrow, Frankfurt, Gatwick, and Lisbon in 2019, 2023, and 2024 with a BLI above 0.8 and the associated PLI above 0.3 (top right quadrant). This suggests that for many of these airports the daily traffic loads returned to similar levels of capacity utilisation than pre-COVID. For the majority of European airports, the peak load index ranges relatively low. This suggests that most of the airports operate currently concentrated short peaks or having growth potential available in terms of traffic load.

Using a regression analysis, we can also see a difference in the trend in Europe in comparison to Brazil. Amongst the study airports, there is a higher share of European airports with more peak operating hours than in Brazil. This might be related to the overall role of the airports and underlying connectivity structure and demand levels already described in earlier chapters. Future work on understanding the drivers between operational concepts and demand may reveal further characteristics of the service provision in both systems.

5.5 Summary

This chapter analysed the relationship between airport capacity, throughput, and demand management across Brazilian and European airports.

On average, declared peak capacities at Brazilian airports tend to be lower than in Europe, suggesting greater flexibility to accommodate future traffic growth at major Brazilian hubs. In contrast, many European airports will increasingly depend on novel operational concepts to achieve further gains, as their existing runway infrastructure and separation standards already impose operational limits.

Comparing the utilisation of capacity based on a new indicator revealed interesting patterns. Most airports currently operate with a margin between declared capacity and observed peak throughput, suggesting that, at present, runway system capacities are not a limiting factor in either region.

Notably, in 2024, low utilisation was observed at Galeão (SBGL), Brasília (SBBR), Rome Fiumicino (LIRF), and Paris Charles de Gaulle (LFPG), where the spread between capacity and peak throughput exceeded 15 flights per hour. Conversely, São Paulo Congonhas (SBSP) emerged as one of the most constrained facilities, servicing peak arrival rates close to or slightly above its declared capacity.

Overall, the findings highlight that while current capacities are sufficient, maintaining system performance amid projected air traffic growth will increasingly depend on operational innovations and efficient management strategies in both regions.

6 Efficiency

Operational efficiency is a critical component in assessing the management and execution of operations. It provides insights in the management of arrival and departure flows and the associated separation and synchronisation activities. Inefficiencies can have an impact on user operations in terms of delays or excessive fuel burn. In light of the previous chapters, it is therefore interesting to study how the available capacity was utilised to service demand during the different flight phases.

The measures reported in this comparison report are based on the observed travel time for surface operations (i.e. taxi-in and taxi-out) and during the arrival phase. These travel times are compared with an associated reference time for a group of flights showing similar operational characteristics. The determined difference (i.e. additional time) measures the level of inefficiency. It must be noted that high performance operations will still yield a certain share of measured additional times. Operational efficiency is therefore aiming at minimising rather than eliminating these additional times as they cannot be zero.

6.1 Additional Taxi-In Time

The additional taxi-in time measures the travel time of an arriving aircraft from its touch-down, i.e. the actual landing time, to its stand/gate position, i.e. actual in-block time). This elapsed taxi-in time is compared to an anticipated reference time for aircraft arriving at the same runway and taxiing to the same (group of) stand/gate position(s). Research showed that the taxi-times are not dependent on the type of aircraft. The additional taxi-in time indicator provides a measure of the management of inbound surface traffic.

This report utilises another source for the movement times at Brazilian airports. Next to the actual taxi-times, the new data source provides also gate/stand information. Accordingly, additional taxi-times can be now determined on a per-gate basis. Previous studies did not support this higher level of granularity. The reader needs therefore to bear in mind that the reported results and trends differ from previous reports which were based on an airport-wide aggregation. The latter may be influenced by the predominant runway system configuration and frequently used stand/parking positions.

6.1.1 Annual Evolution of Additional Taxi-in Times

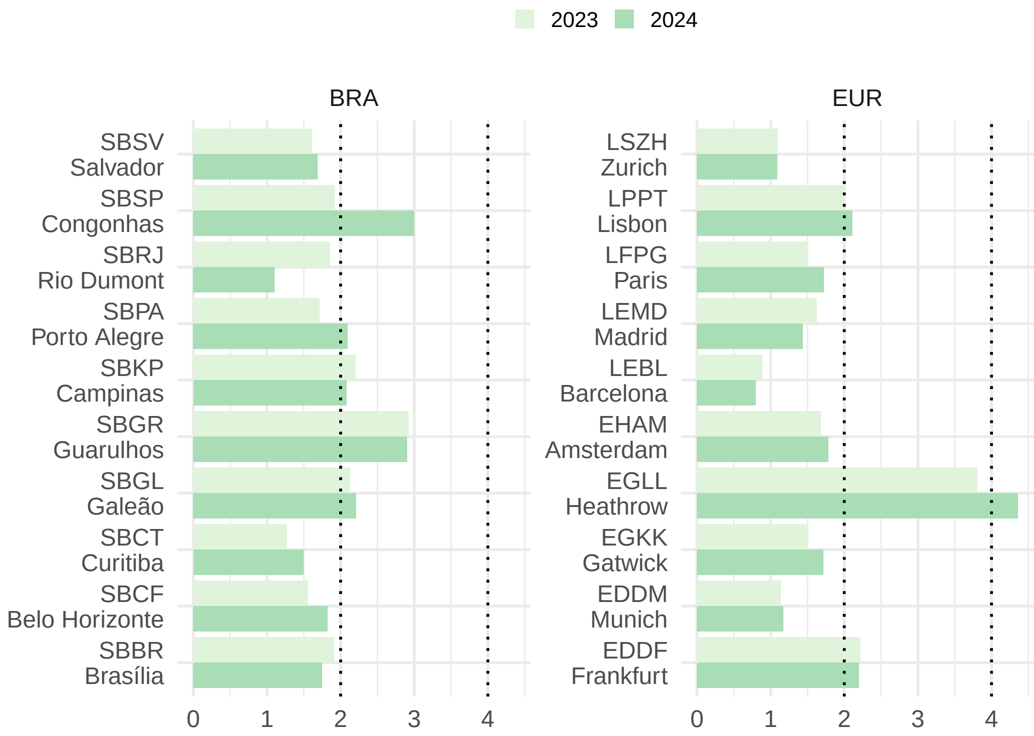


Figure 6.1: Additional taxi-in time [min/arr] (2023-2024)

The annual development of the average additional taxi-in times at the study airports is depicted by Figure 6.1.

The 2-minute threshold per arrival continues to serve as a practical reference point for evaluating taxi-in efficiency.

In Brazil, taxi-in performance in 2024 remained generally good, with most airports maintaining values close to or below 2 minutes. Notable exceptions were Congonhas (SBSP), which recorded the highest average additional taxi-in time, reaching approximately 3 minutes per arrival, followed closely by Guarulhos (SBGR), also nearing 3 minutes. Outside these two major hubs, all other studied Brazilian airports displayed taxi-in times well controlled around or below the 2-minute threshold. A particular highlight was Santos Dumont (SBRJ), which achieved a significant reduction in taxi-in times compared to the previous year.

In Europe, the patterns were slightly more varied. London Heathrow (EGLL) remained the airport with the highest additional taxi-in time, approaching 4 minutes per arrival in 2024, underlining persistent surface congestion challenges. Lisbon (LPPT) and Frankfurt (EDDF) also surpassed the 2-minute threshold, though only slightly. All other European airports maintained taxi-in times below 2 minutes. A remarkable highlight was Barcelona (LEBL), where taxi-in efficiency improved notably, with average additional taxi-in times dropping to below 1 minute per arrival.

Compared to 2023, taxi-in times remained relatively stable in both regions, although slight deteriorations were observed at some of the busiest hubs. These results emphasize the continued importance of optimizing surface management procedures to maintain overall predictability, particularly as traffic volumes increase at major airports.

6.1.2 Monthly Variation of Additional Taxi-in Times

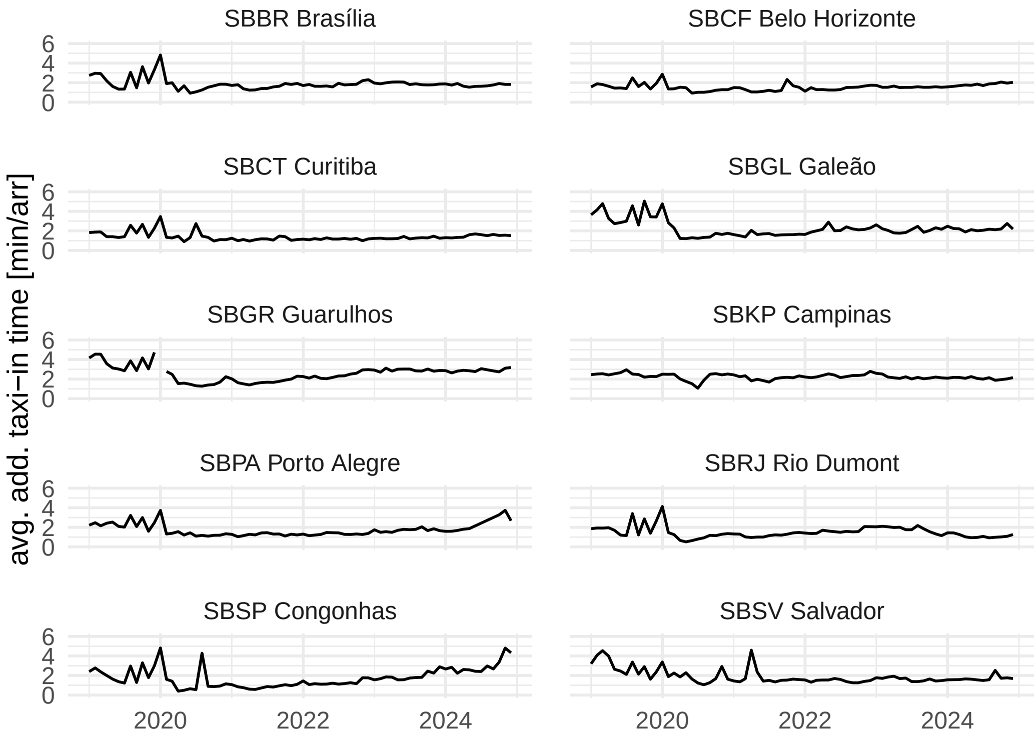


Figure 6.2: Evolution of average additional taxi-in time at Brazilian airports

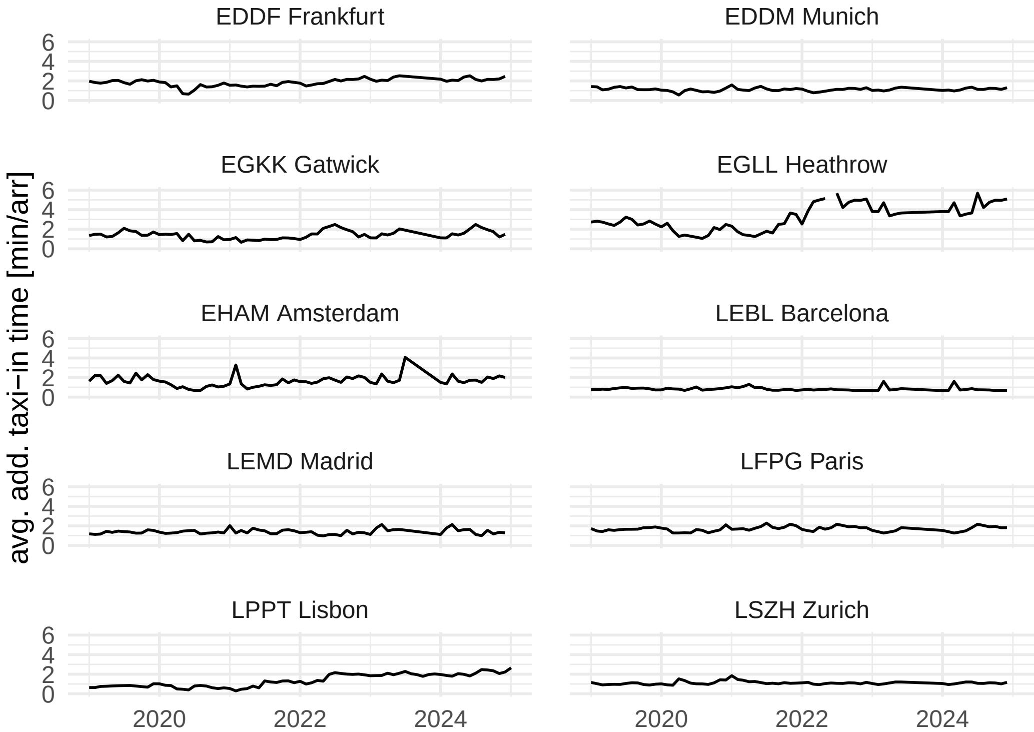


Figure 6.3: Evolution of average additional taxi-in time at European airports

The evolution of the taxi-in time at the study airports, shown in Figure 6.2 and Figure 6.3, reinforces the findings presented in the previous analysis. In Brazil, the figures clearly illustrate the increase in average taxi-in times at Porto Alegre (SBPA), Congonhas (SBSP), Salvador (SBSV), and Galeão (SBGL) throughout 2024. Congonhas and Guarulhos consistently maintained the highest levels within the Brazilian group, while Santos Dumont (SBRJ) stands out with a significant improvement, reducing its taxi-in times compared to previous years.

In Europe, the data reveal a relatively stable pattern over the two-year period. Most airports maintained consistent taxi-in times, with minor variations. Lisbon (LPPT) showed a slight upward trend, while Barcelona (LEBL) remained a highlight, sustaining very low taxi-in times, well below 1 minute per arrival.

These trends emphasize the importance of continuous monitoring of ground operations efficiency, especially as traffic demand grows.

6.2 Taxi-Out Times

6.2.1 Annual Evolution of Additional Taxi-out Times

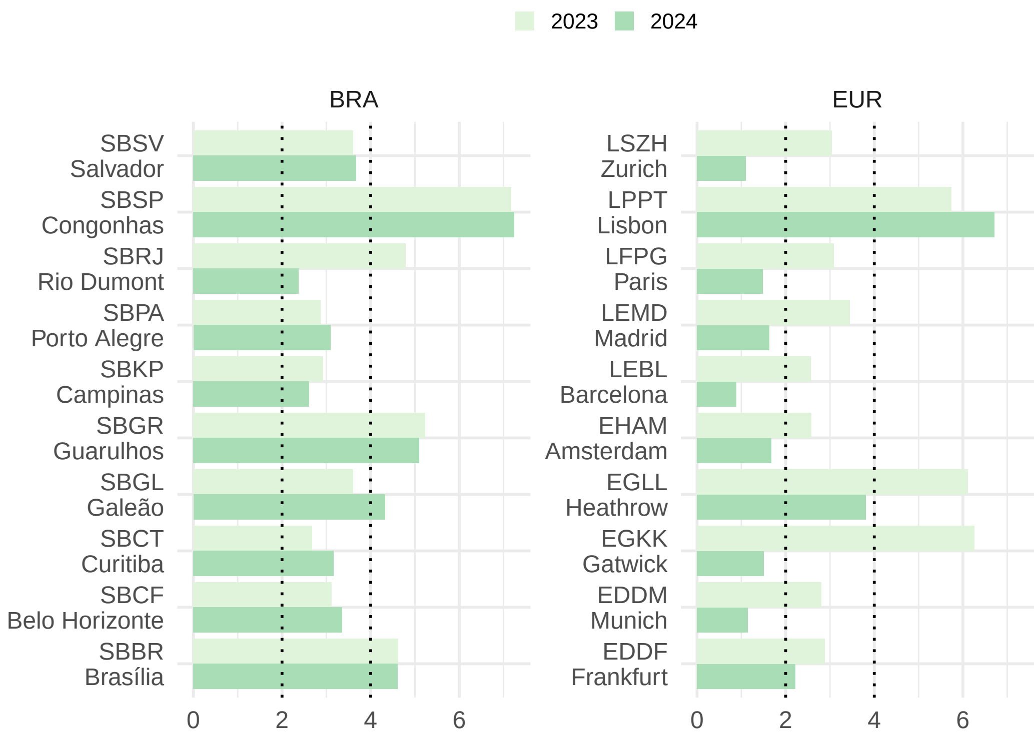


Figure 6.4: Average additional taxi-out time [min/dep] (2023-2024)

On average, higher additional times for taxi-out are observed across all airports (c.f. Figure 6.4).

In Brazil, Santos Dumont (SBRJ) showed a notable improvement, with a reduction of more than 2 minutes compared to 2023. For the remaining airports, only minor variations were observed, including slight increases at Curitiba (SBCT) and Galeão (SBGL). Congonhas (SBSP) continues to record the highest additional taxi-out times among Brazilian airports, reaching approximately 7 minutes.

In Europe, a significant reduction in taxi-out times was observed across most airports. Zurich (LSZH) particularly stands out, achieving a reduction of about 2 minutes. Lisbon (LPPT) registered the highest taxi-out time among the European airports, nearing 7 minutes. Except for Lisbon, which saw a slight increase, all other European airports improved their taxi-out performance between 2023 and 2024.

6.2.2 Monthly Variation of Additional Taxi-out Times

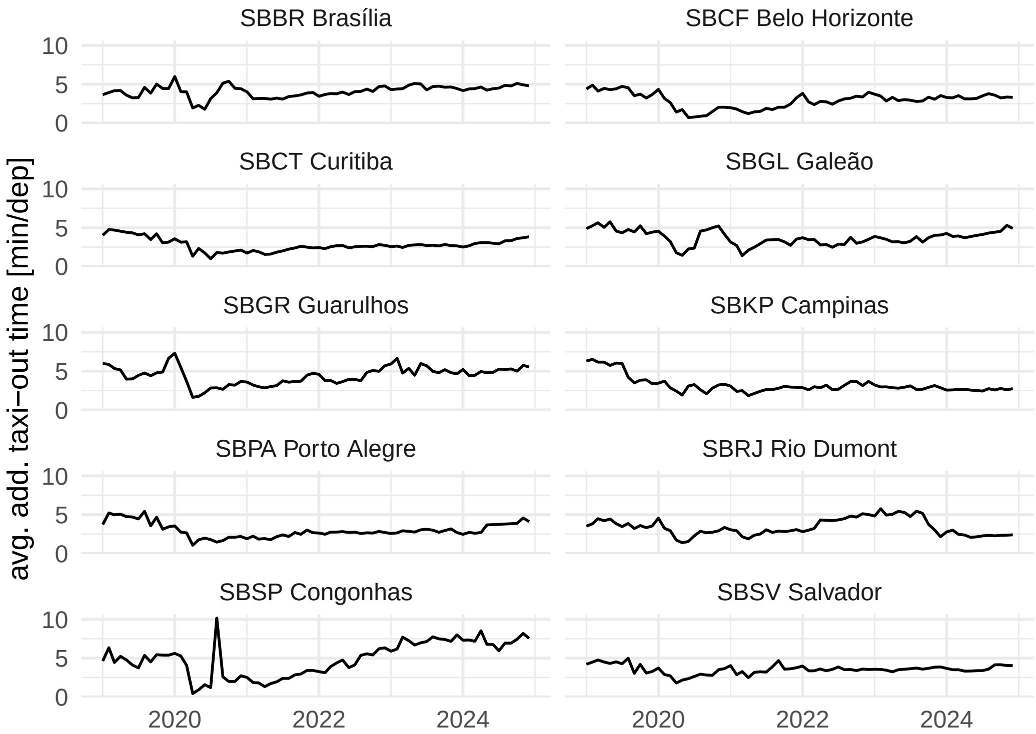


Figure 6.5: Brazil - Monthly Evolution of taxi-out times

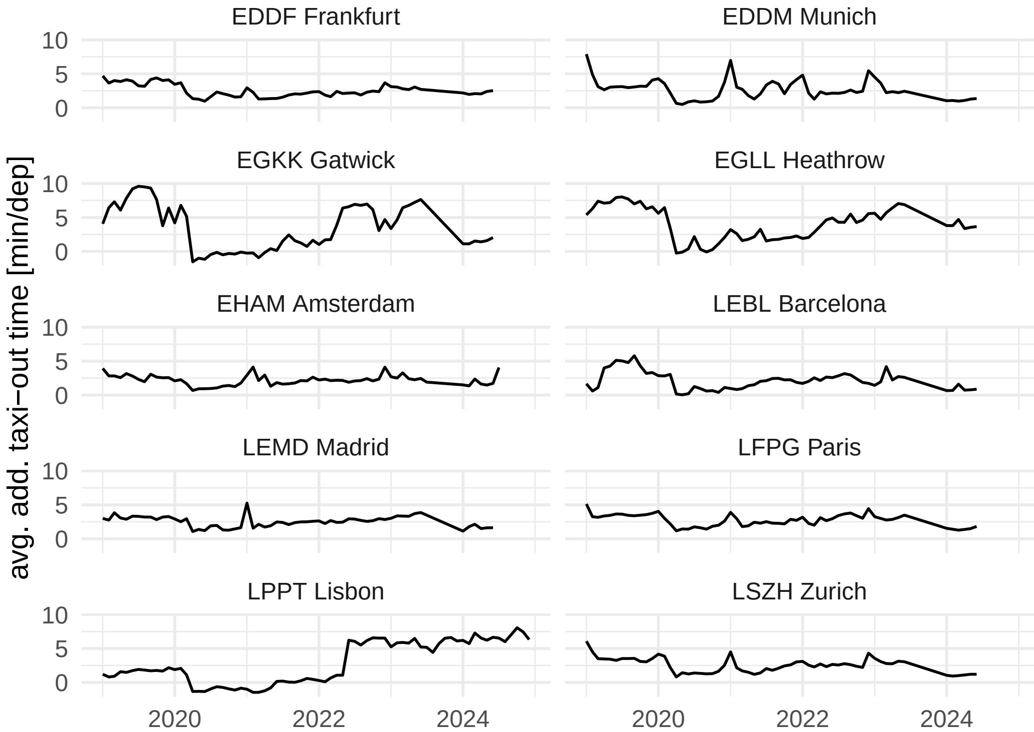


Figure 6.6: Europe - Monthly Evolution of taxi-out times

The trends reinforce the observations from the annual figures.

In Brazil, Santos Dumont (SBRJ) showed a significant improvement in 2024, with taxi-out times decreasing by more than two minutes. For the other airports, monthly variations were relatively small, although a gradual increase can be seen at Curitiba (SBCT) and Galeão (SBGL). Congonhas (SBSP) continues to register the highest additional taxi-out times among Brazilian airports, reaching nearly 7 minutes in 2024.

In Europe, the overall trend is one of improvement, with most airports reducing their taxi-out times between 2023 and 2024. Zurich (LSZH) achieved a notable reduction of about two minutes. Lisbon (LPPT) stands out with the highest taxi-out time, close to 7 minutes. Except for Lisbon, which saw a slight increase, all other European study airports experienced reductions in taxi-out times, confirming a broad regional effort to improve surface efficiency.

6.3 Mapping Additional Taxi-in and Taxi-out Times

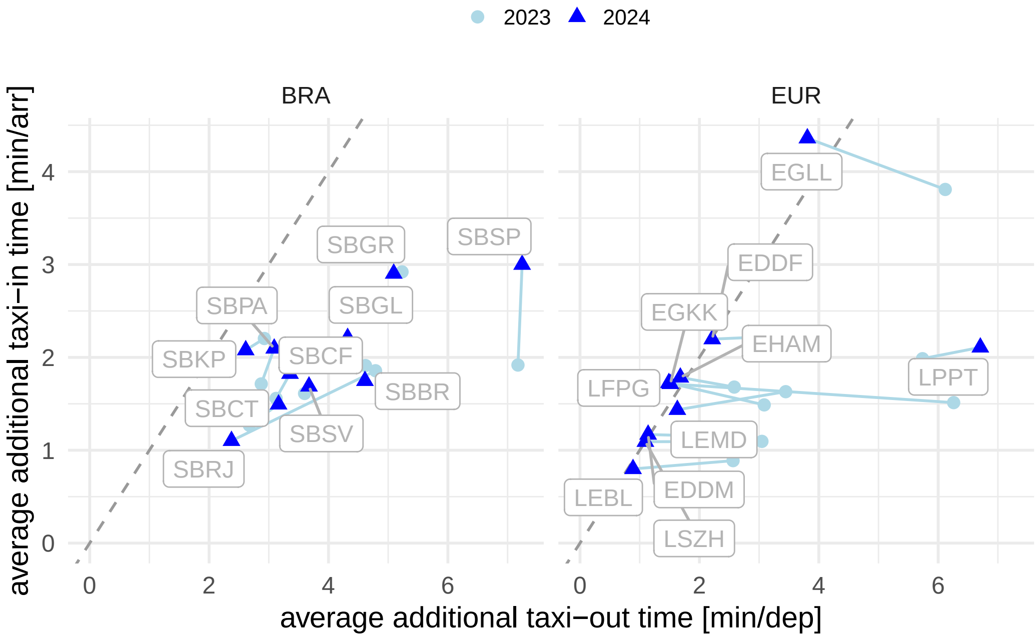


Figure 6.7: Mapping of additional taxi-in and taxi-out times

This analysis builds on the previous sections. Figure 6.7 compares the relationship between the taxi-in and taxi-out performance observed. It also shows that on average taxi-out operations accrued more additional time than taxi-in operations (data points range below the dotted unit line, and as shown in the previous sections).

For most of the European airports, the overall performance shows a reduction in additional taxi-out times (i.e., characterised by a left-shift along the x-axis). The notable exemption is Lisbon (LPPT) that observed an increase in taxi-out time in 2024. A varied picture of taxi-in performance can be observed in Brazil across all study airports (c.f. varying trend along y-axis). This is contrasted by the behaviour in Europe. The majority of European airports observed no significant change in their taxi-in performance (i.e. no vertical trend). Movements at London Heathrow (EGLL) saw a change of about one additional minute per arrival when comparing the change from 2023 to 2024 The changes in performance in terms of taxi-in is observed in Figure 6.2 and Figure 6.3 which show some increases in the second half of 2023 and 2024. Figure 6.7 also shows that the overall taxi-performance in Europe tends to show lower levels of variation between pre-pandemic and post-pandemic. On average the observed level of additional taxi-in time appeared to be similar in Brazil and Europe with the exemption of the constrained hubs.

6.4 Additional Time in Terminal Airspace

The additional time in terminal airspace is calculated as the difference of the actual flying time from entering the sequencing area (i.e. 100NM radius around the airport) to the actual landing time. Previous research and guidance suggest that reference time can be built for flights sharing similar operational characteristics (entry sector, aircraft class, and landing runway).

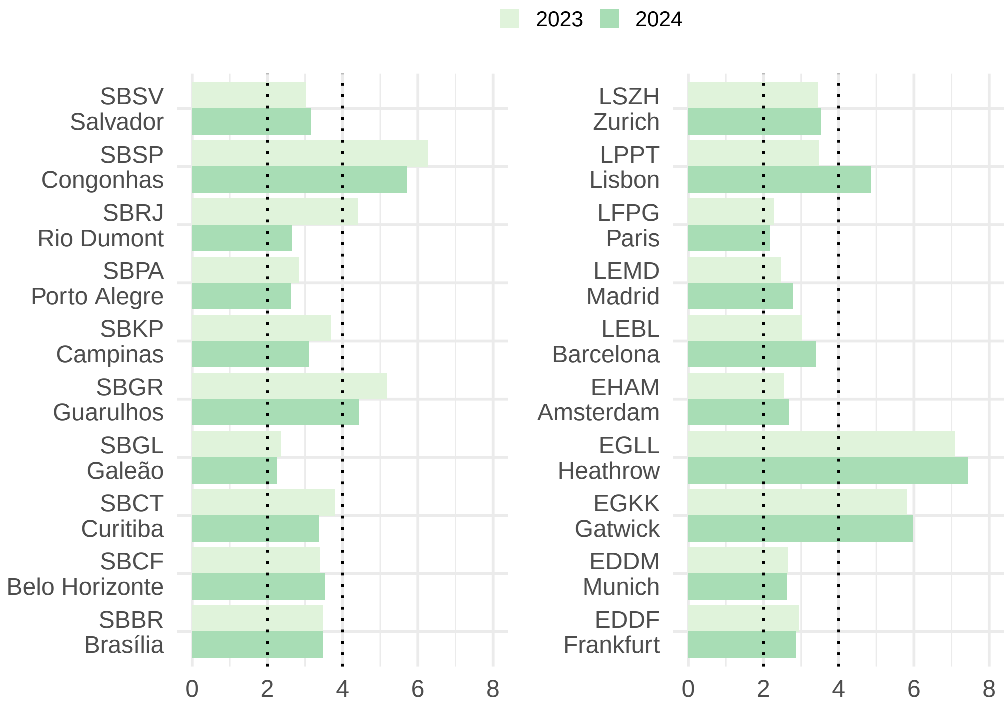


Figure 6.8: Additional time in terminal airspace

Figure 6.8 compares the annual average of additional times in terminal airspace across the study airports. On average, the arrival flows in Brazil appear to be less constraint than in Europe.

For most Brazilian airports, a reduction in additional times in the terminal airspace was observed, which is a positive development. A particular highlight is Santos Dumont (SBRJ), where the average additional time decreased by more than one minute compared to the previous year.

In contrast, European airports generally experienced a slight increase in their additional times in the terminal airspace between 2023 and 2024. This appears to be related to the on-going increase in traffic numbers that put pressure on the arrival management. With observing record years of ATFM delay, flows were generally impacted across the European network in 2023 and 2024. This may have amplified the arrival flow as flows generally were disrupted in light of the constraints.

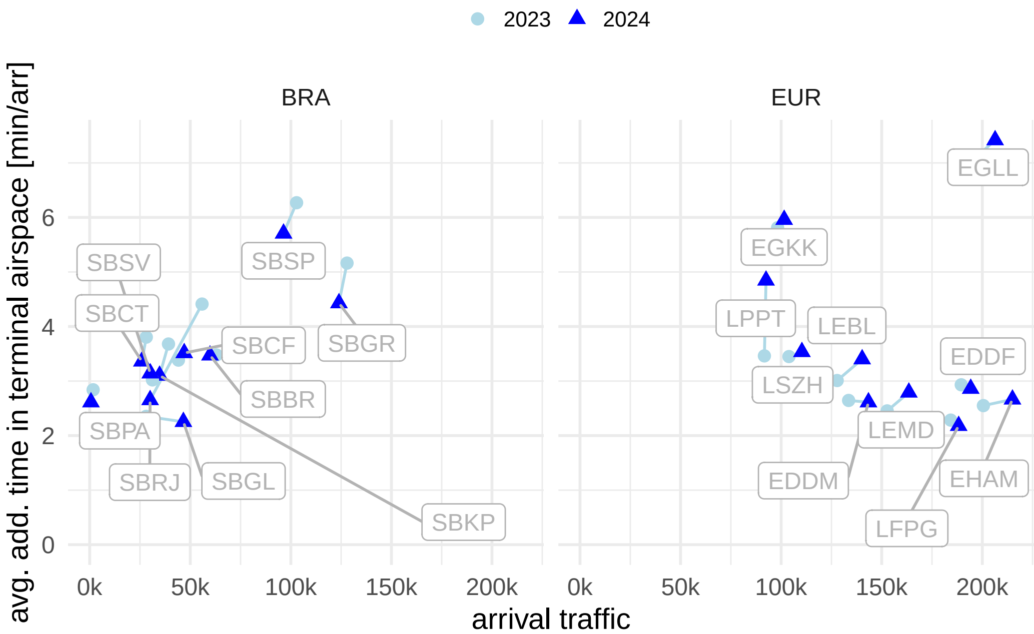


Figure 6.9: Comparison of additional time in terminal airspace

Figure 6.9 depicts the change in terms of the average additional time in terminal airspace comparing 2023 and 2024.

The comparison shows the effect of the variation of air traffic on the performance in both regions. In general Brazil observed an increase in arrival efficiency evidenced by the lower observed additional times accrued by the arriving traffic. For some airports in the Brazil region, it can be observed how procedural aspects influence the additional time in terminal airspace. For example, despite the variation of the traffic levels considered, the additional time remained fairly stable at SBGR comparing pre- and post-pandemic years.

The European region shows saturation effects characterised by the increasing number of flights. On average a shallow increase was observed from 2023 to 2024. This requires attention as future traffic demand will increase the pressure on the constraint arrival management processes.

6.5 Summary

This chapter analysed operational efficiency through the assessment of additional taxi-in and taxi-out times, as well as additional time in terminal airspace. These indicators provide important insights into how air traffic management systems handle surface and arrival flow operations in the face of increasing demand.

The 2-minute threshold remains a useful reference for taxi-in performance. In 2024, Brazilian airports generally maintained good levels of taxi-in efficiency, with most airports close to or below this threshold, except for Congonhas (SBSP) and Guarulhos (SBGR). Santos Dumont (SBRJ) notably improved its taxi-in performance. In Europe, while most airports kept taxi-in times under control, challenges persisted at London Heathrow (EGLL) and Lisbon (LPPT).

Regarding taxi-out times, Brazilian airports showed a mixed trend. While Santos Dumont (SBRJ) registered a remarkable improvement, other airports such as Congonhas (SBSP) continued to experience high taxi-out times. In Europe, most airports achieved reductions in taxi-out times, except Lisbon (LPPT), where a slight increase was observed.

The mapping of taxi-in and taxi-out times confirmed that overall taxi-out inefficiencies remain more significant than taxi-in inefficiencies. Improvements were more pronounced in Brazil for taxi-in operations, whereas Europe showed stability with exceptions like Heathrow (EGLL), which still faced increased inefficiencies.

The analysis of additional time in terminal airspace further indicated that European arrivals at European airports observe a slightly higher additional time. Less constraint European arrival sectors manage their arrivals with slightly less delay compared to Brazilian airports. However, Brazilian airports showed positive trends, with reductions observed at most locations—highlighted again by the strong improvement at Santos Dumont.

These findings underscore the ongoing need for continuous monitoring and improvements in ground and arrival management, especially in the context of increasing air traffic demand.

7 Studies

Throughout 2024, joint work between DECEA and EUROCONTROL involved the preparatory action for assessing the operational performance benefits of point-merge operations and comparing service provision within two units. This chapter provides a first summary of the work to help refine the future work.

7.1 Point-Merge Operations

Point Merge System (PMS) is an innovative air traffic sequencing technique designed to optimise aircraft arrival sequences, and enhance operational safety and workload. PMS operates efficiently under high traffic loads without the need for radar vectoring. It relies on a specific Precision-Area Navigation (P-RNAV) route structure, comprising a merge point and equidistant pre-defined sequencing legs. Traffic sequencing is achieved through a "direct-to" instruction to the merge point at the appropriate time. The sequencing legs are used to extend the flight path of an aircraft along the leg only when necessary. The length of these legs reflects the required delay absorption capacity, ensuring a streamlined and predictable arrival flow. This method simplifies controller tasks, reduces communication and workload, enhances pilot situational awareness, and improves the predictability and efficiency of flight trajectories. Figure 7.1 illustrates the Point Merge system and its components.

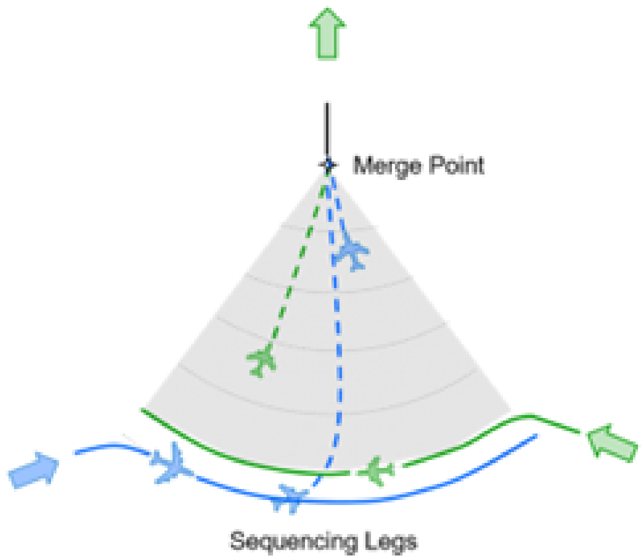


Figure 7.1: Point-merge overview

The Point Merge System has been successfully implemented at various airports worldwide, demonstrating its effectiveness in enhancing airspace efficiency and reducing the environmental impact of fuel consumption. In Brazil, Guarulhos International Airport (SBGR) — one of the busiest hubs in Latin America — faces daily challenges related to high traffic density. To address these issues, PMS was implemented for arrival procedures at SBGR in May 2021. With a recent deployment in 2024, PMS was introduced at Lisbon Airport (LPPT). The following is an illustration of flight trajectories at SBGR and LPPT during periods before and after the implementation of the Point Merge System (PMS).

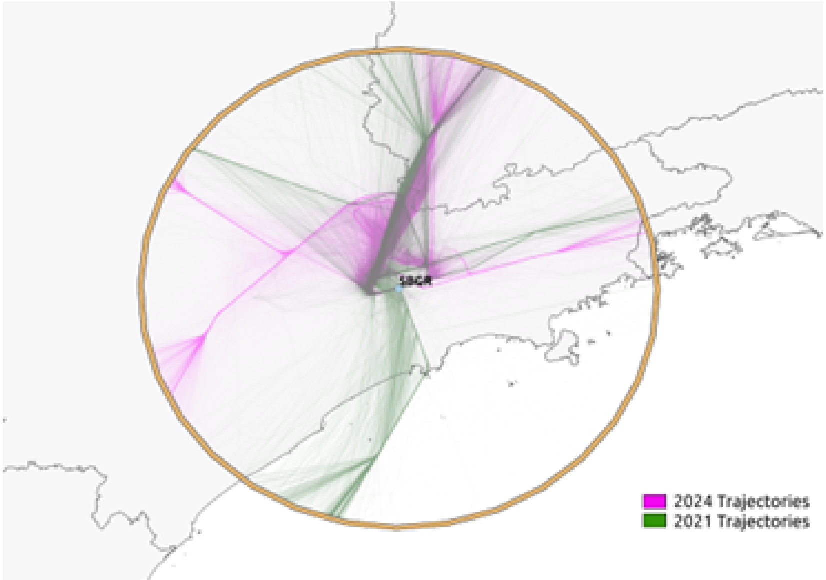
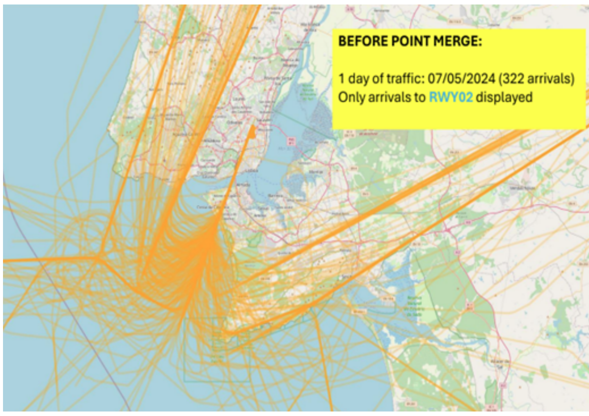
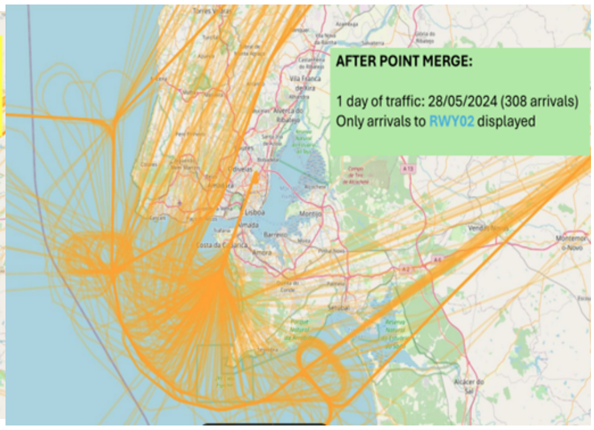


Figure 7.2: Point-merge operations at Guarulhos (SBGR) (2019 vs 2024)

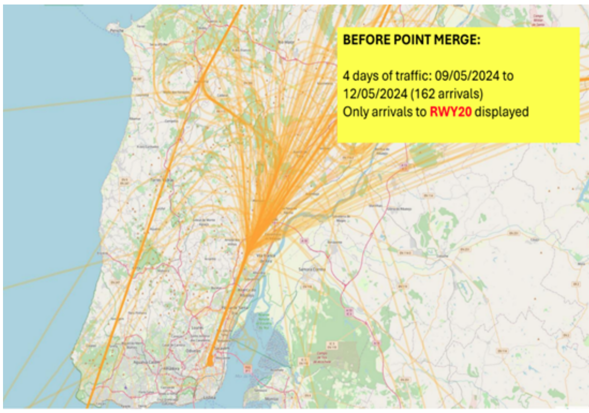
Monitoring Additional Time in TMA is valuable for assessing the impact of the Point Merge System (PMS) implementation on airspace operational performance. This indicator reflects the extra time an aircraft spends in the TMA compared to an ideal flight profile. A comparison of KPI08 values was conducted for periods before and after the implementation of PMS. For SBGR, the analysis covered the years 2019 (pre-PMS) and 2024 (post-PMS). These periods were chosen to avoid analytical bias, since PMS implementation at Guarulhos took place during the COVID-19 pandemic. The analysis period for LPPT spanned from March 2023 to July 2024. The following graph presents the results obtained. Reference times and additional times were calculated on a monthly basis.



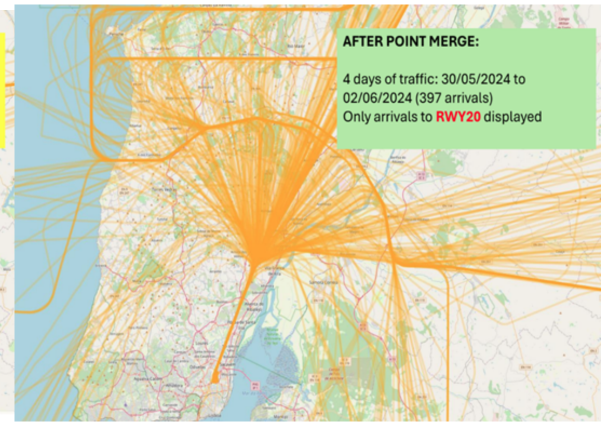
(a) LPPT runway 02 - before point-merge



(b) - post point-merge deployment



(c) LPPT runway 20 - before point-merge



(d) - post point-merge deployment

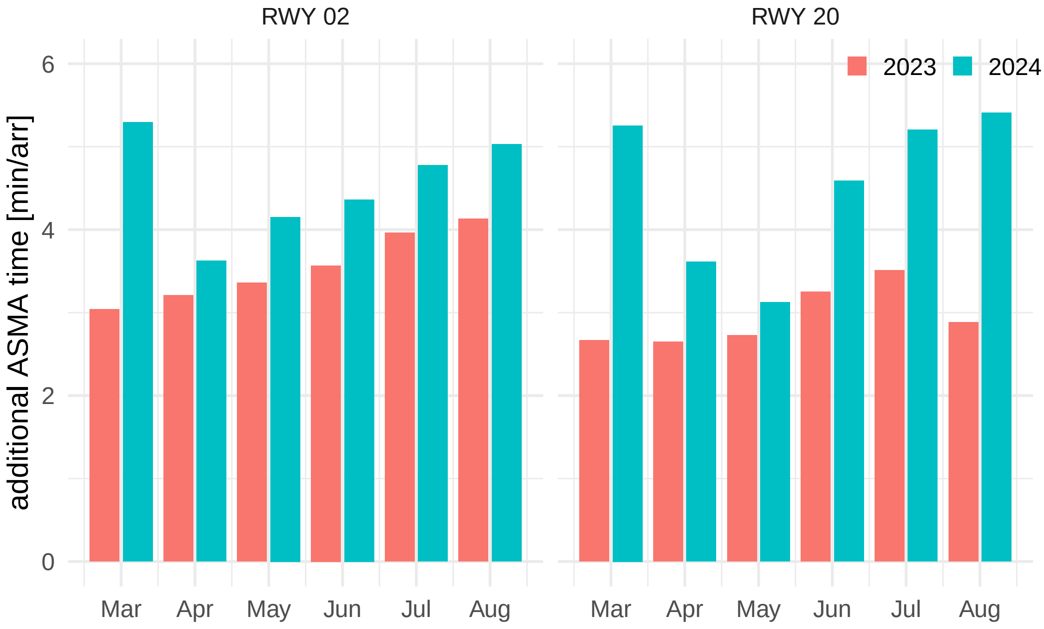


Figure 7.4: Monthly evolution of the additional time in terminal airspace in LPPT

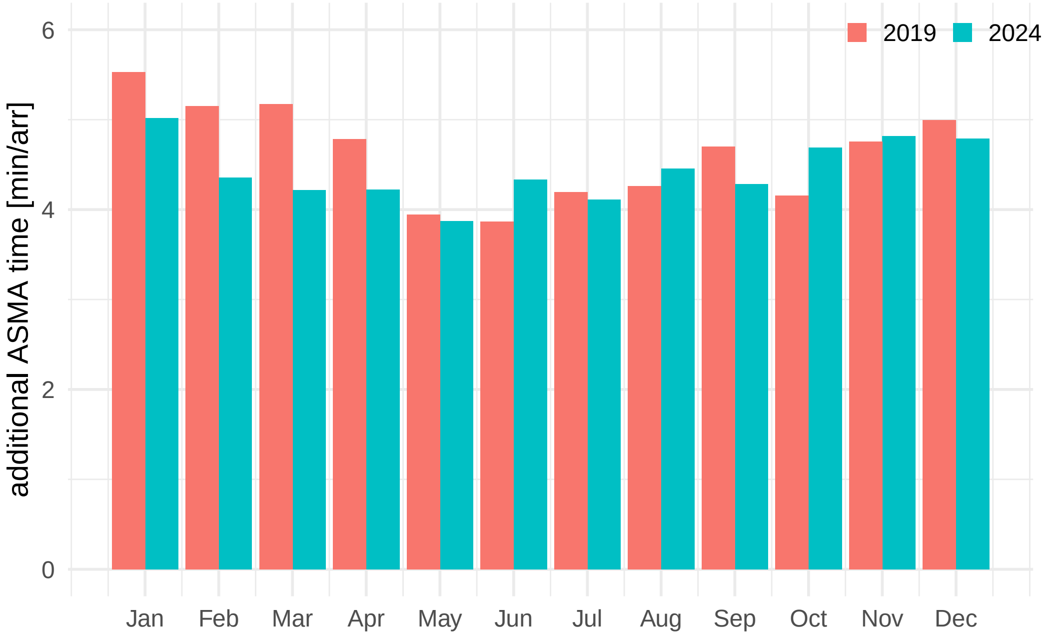


Figure 7.5: Monthly evolution of the additional time in terminal airspace in SBGR

The results presented in Figure 7.4 indicate an increase in additional time in the arrival airspace at LPPT. The additional time is shown for the period following the deployment of the point merge operations covering March through August focussing on the last 40NM around Lisbon. The results are also broken out to showcase the behaviour for both landing directions at Lisbon, i.e., runway 02 and runway 20. For both runways, an increase in the additional time can be observed. Aside the results for March that represents the transition to point merge operations, the observed additional time increased on average by about a minute when compared to the pre-deployment year 2023. It must be noted that the results for LPPT are point-in-time snapshots and influenced by the start of operations. There might be additional flow control measures in place to support the transition, including additional buffers or alignment patterns. Future work could explore how the actual arrival routes changed based on the newly arrival management technique.

The operations at SBGR show a clear trend when comparing pre-pandemic traffic levels to the current arrival flows, c.f. Figure 7.5. A mild seasonal pattern is observable, with the monthly average additional time in terminal airspace ranging post the point-merge implementation lower than in 2019. With the summer months a more varied behaviour is observed seen a fluctuation of the observed additional times.

For the implementation of the PMS, the following observations can be made. Operationally, the PMS enabled a higher occupancy rate within the terminal airspace. By design, the PMS enhances the terminal's capacity to manage and organise inbound traffic more efficiently. However, the runway throughput remained unchanged, as increasing runway capacity would require physical infrastructure modifications or change of the operational concept (i.e., separation minima). Consequently, although the terminal airspace can now accommodate a greater number of approaches simultaneously, the airport's ground infrastructure cannot absorb this increased demand at the same pace. This mismatch leads to longer dwell times within the terminal area as aircraft await clearance to land.

7.2 Air Traffic Services at Curitiba and Lisbon Continental

7.2.1 Overview Curitiba ACC

The Curitiba Area Control Center (ACC-CW) is one of four Area Control Centers strategically distributed across Brazil. Located in the city of Curitiba, in the state of Paraná, ACC-CW plays a crucial role in controlling the airspace of the southern region of the country, ensuring safe and efficient operations for both civil and military aircraft.

ACC-CW's jurisdiction covers the entire portion of the Curitiba Flight Information Region (FIR-CW), excluding the airspace delegated to the South-east Regional Airspace Control Center (CRCEA-SE). This jurisdiction totals approximately 1.7 million km^2, representing 7.7% of the airspace delegated to Brazil. Within this airspace, the Air Traffic Control Service, Flight Information Service, and Alert Service are provided.

The Air Traffic Control Service is provided to all aircraft flying above FL 150. Additionally, this service is exclusively provided to aircraft flying above FL 120 in CTA 2 (departures and arrivals for Viracopos Airport in Campinas-SP) and CTA 4 (departures and arrivals for Vitória Airport in Espírito Santo).

In 2024, traffic within FIR-CW exceeded 492,000 flights, representing a 25% increase compared to 2023 (394,000 flights). Notably, 11 of the 30 busiest aerodromes in Brazil in 2024 are located within FIR-CW (c.f. Figure 7.6).

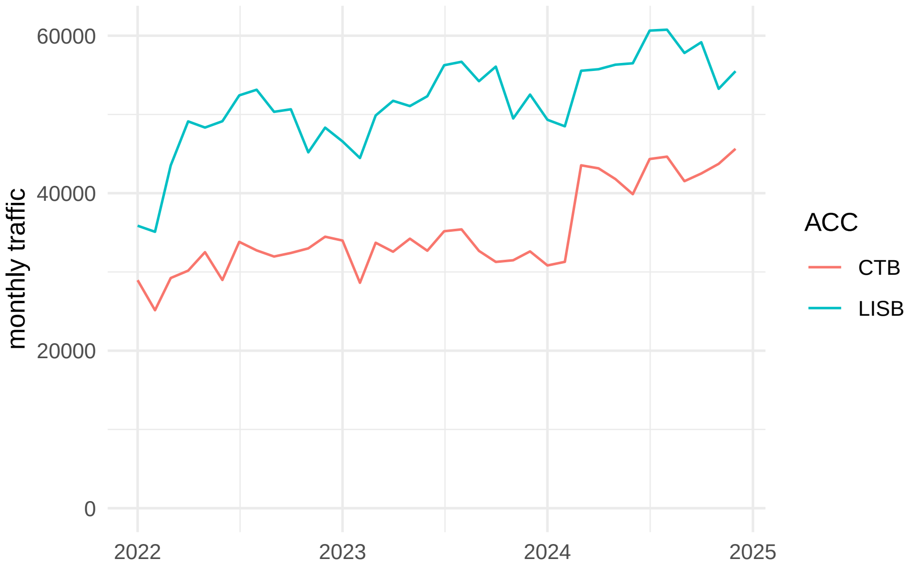


Figure 7.6: Traffic figures for Brazilian ACCs

The FIR-CW encompasses the Terminal Control Areas (TMA) of São Paulo, Rio de Janeiro, Curitiba, Florianópolis, Porto Alegre, Foz do Iguaçu, Campo Grande, Santa Maria, Macaé, Londrina, and Presidente Prudente. One of the objectives of the cooperation agreement established between DECEA and MUAC—the Rostering Philosophies and Tools Agreement—is to support the implementation of the TOTAL ATM philosophy. ACC-CW was selected to be the first operational unit in Brazil to implement changes related to new philosophies and methodologies for operational staff rostering. It was also chosen to develop and implement, with the support of MUAC, the Air Traffic Support System for the Use of Human Resources in Operational Needs, known as SATURNO.

The implementation of SATURNO began in March 2025 and is being carried out in phases, with completion expected by the end of the year. To improve planning for operational position configurations and the allocation of air traffic controllers during shifts, the ACC-CW airspace, currently, is divided into 18 sectors and two regions: North and South.

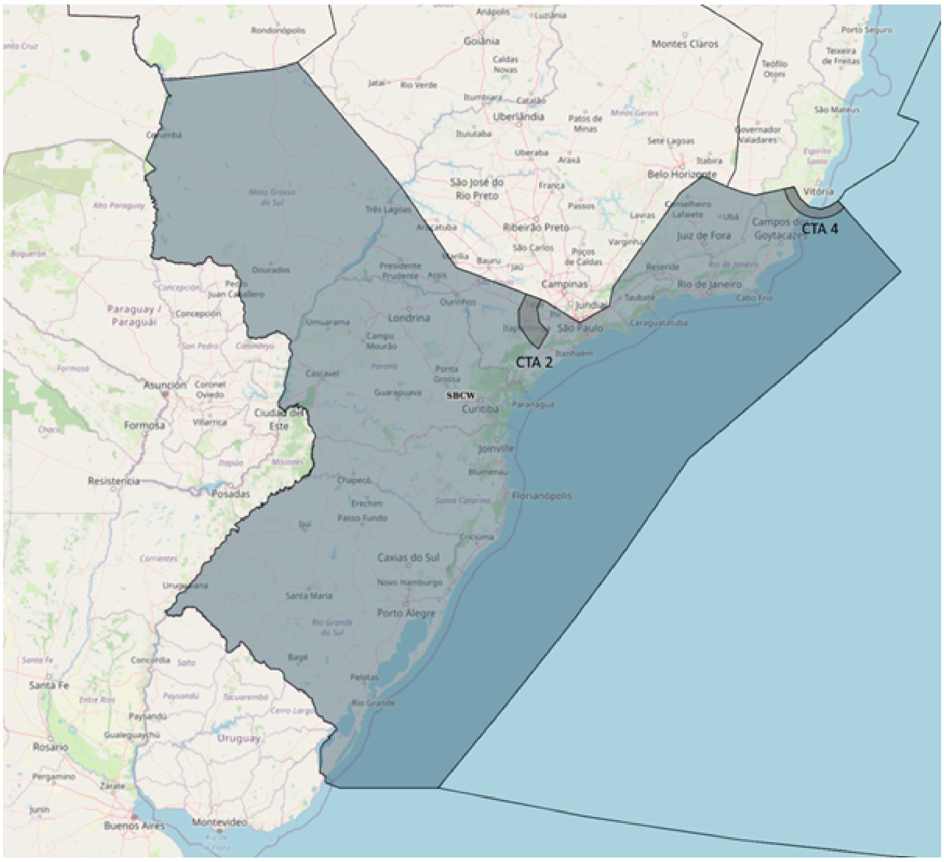


Figure 7.7: ACC-CW area of responsibility

7.2.2 Center-level comparison Curitiba ACC and Lisbon Continental

ANSP	ACC Name	Flight-hours controlled	Average transit time (min)	IFR ACC Movements	Size of the controlled area (million km^2)	ATCOs in OPS	Size of OPS room area (m^2)	Number of sectors open at maximum configuration	Sum of sector-hours
DECEA	Curitiba	462.470	18,1	492.870	1,7	208	405	13	45.606
NAV Portugal (Continental)	Lisbon	345.602	37	560.992	0,671	71	663	9	47.147

Figure 7.8: High-level comparison ACC Curitiba and Lisbon

In light of this report Figure 7.8 provides an initial side-by-side comparison between DECEA and NAV Portugal (Continental) regarding selected operational characteristics of their Area Control Centers (ACCs). While each organisation operates within its own regional and structural context, some key characteristics are worth highlighting.

Despite operating within a smaller controlled airspace, NAV Portugal managed a higher volume of IFR ACC movements than DECEA during the same period while handling nearly 25% fewer flight hours. This points to a denser and more concentrated traffic environment, likely driven by Portugal's geographical location within Europe and the structure of its flight corridors.

Another relevant aspect is the number of air traffic controllers (ATCOs) assigned to the operations room. NAV Portugal handles its operational workload in a larger OPS room with only 71 ATCOs, highlighting distinct differences in operational concepts, levels of automation, and staffing philosophies between the two organizations.

In terms of sector configuration, Curitiba operated up to 13 sectors at the end of 2024, compared to a maximum of 9 sectors in Portugal. For the year as a whole, the total number of sector hours was similar, with Portugal recording approximately 2,000 more hours.

This characterisation underscores the importance of accounting for regional characteristics and operational context when interpreting air navigation service metrics or designing systems such as staffing models or control room layouts. It will be interesting to expand this initial topic study by addressing the traffic characteristics on the basis of trajectory, flow and sequencing measures applied to handle the traffic within the respective areas of responsibility. This will support a refined assessment of the performance benefits from the implemented concept of operations.

7.3 Summary

This chapter highlighted two topics of interest for both parties. It offers a first insight into operational concepts, their implementation, and observed performance benefits.

Point merge is a sequencing technique that gained higher visibility over the past years. This initial comparison comprises a snapshot at the system deployed at SBGR and - a recent implementation at - LPPT.

Both groups are interested in advancing the state-of-the-art in assessing network- and center-level aspects. To move towards a more granular comparison, this report showcases two broadly comparable air traffic service units in Brazil and Europe. The comparison allowed for a high-level comparison on a set of harmonised indicators suitable to describe the scope of the service provision. This was useful to characterise the similarities and differences between both units. Future work will revolve around addressing the operational aspects within the respective areas of responsibility and deployed operational flow and sequencing concepts.

8 Conclusions

This fourth edition of the Brazil-Europe operational ANS performance comparison report builds on the joint project between the Performance Section of DECEA and the Performance Review Unit of EUROCONTROL. The collaboration aims at fostering the understanding and support the further development of approaches to measure operational performance in both regions. This report builds on a subset of indicators and metrics established under the umbrella of ICAO's Global Air Navigation Plan ICAO (2019b). The work is also used to showcase the application of the GANP indicators within a bi-regional and multi-regional project. DECEA and EUROCONTROL engage actively within the international community and share their findings of their joint bi-regional work.

This iteration also comprised the integration of additional data source and topics. A first characterisation of the different networks was introduced, and two additional topics studied. The new data sources offer to perform more fine-grained analyses of the observed operational efficiency performance. This will allow to further develop and complement the framework. The report also identified several observations and ideas for future research which pave the way ahead for augmenting the associated set of comparison analyses.

This report kicked off by examining the commonalities and differences in terms of the organisation of air navigation services in both regions. This was complemented by investigating the air traffic demand to better understand the factors influencing operational performance. The air navigation service provision is less fragmented in Brazil than in Europe. This plays out in the total number of air traffic service units. Both regions operate a central flow management function to ensure network wide flow management.

In terms of air traffic demand, both regions were impacted by the unprecedented decline of air traffic. Regional and global traffic restrictions resulted in different patterns. With Europe zooming in on pre-pandemic traffic levels and Brazil consistently ranging above the pre-pandemic traffic, this report also marks the new reference for future iterations. Both regions - while having their separate challenges - have certainly completed the pandemic phase. The traffic situation is also reflected by the demand at the study airports. There is also a higher level of diversity in terms of air traffic evidenced by the share of light types serviced at the comparison airports. International traffic is more centralised in Brazil than in Europe.

The observed punctuality in both regions was strongly influenced by the prevailing network effects. Particularly, Europe suffered strongly from the impact of two years of record ATFM delays that further rippled down and amplified local constraint issues. This is evidenced by the high share of departure delays. The reactionary knock-on effect amplified further the overall punctuality performance.

The utilisation of available runway system capacities is a fundamental enabler for high levels of operational performance. This report showed that associated capacities are commensurate with the current traffic levels. For the majority of airports, the realised throughput ranges still below the maximum declared capacities.

Operational efficiency is measured in this report in the form of the additional time during the surface movement phases and the terminal arrival phase. On average, taxi-in operations are less constrained than taxi-out operations. The observed performance varies across the airports and timeframe. In terms of arrival management, air traffic in Brazil observed higher additional times in the terminal airspace. This report showed that the scale effect of lower air traffic is potentially masked by the effects of airspace redesign in Brazil. In the European region, it appears that the higher level of air traffic demand puts pressure on the arrival management and sequencing, and 2022 marks a return to higher additional times within the terminal airspace. Further research can help to identify drivers and performance enablers.

The joint work also helped to promote the approach and state-of-the-art with the international community. Both groups are contributing to the ICAO GANP Performance Expert Group and the multi-national Performance Benchmarking Working Group. The wider harmonisation of performance related data and joint refinement of the guidance material and application of the performance framework start paying dividends. For example, PBWG concluded in its most recent meeting to collaborate on topics of mutual interest for which this report supported the initial research and validation.

A further outcome of the project is the close technical collaboration. It is planned to augment the report and its future editions with a rolling web-based monitoring, including regular updates of the underlying data. This and future reports will help to complement the time series of the measures tracked.

References

EUROCONTROL. 2019. "Eurocontrol Specification for Operational ANS Performance Monitoring - Airport Operator Data Flow." https://www.eurocontrol.int/publication/eurocontrol-specification-operational-ans-performance-monitoring.

EUROCONTROL Central Office of Delay Analysis. 2023. "All-Causes Delays to Air Transport in Europe, Annual 2022." https://www.eurocontrol.int/publication/all-causes-delays-air-transport-europe-annual-2022.

ICAO. 2019b. *Doc 9750, Capacity & Efficiency, Global Air Navigation Plan 2016-2030.* Sixth Edition. Montreal, Canada: International Civil Aviation Organization.

ICAO. 2019a. *Doc 9750, Capacity & Efficiency, Global Air Navigation Plan 2016-2030.* Sixth Edition. Montreal, Canada: International Civil Aviation Organization.

Eurocontrol. (2014). Point Merge: Integration of Arrival Flows Enabling Extensive RNAV Application and Continuous Descent. Eurocontrol Experimental Centre.

FRANZINI, Bruno Monteiro et al. (2024). Analysis of Guarulhos Point Merge Adherence Based On Additional Time In Tma And Trajectory Clustering.. In: Anais do XXI Simpósio de Transporte Aéreo - SITRAER 2024.

ICAO. (2016). Continuous Descent Operations (CDO) Manual. International Civil Aviation Organization.