EUROCONTROL

EUROCONTROL Standard Inputs for Economic Analysis

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Abstract

This document provides values for commonly used data items for economic analyses, together with details of the sources and a discussion of the applicability and use of the values. The values have been compiled from publicly available documents. They are often average values and may not be appropriate in all circumstances. This edition 10.0 takes the year 2022 as a baseline since this is the year for which most of the data values are available at the time of writing of this document. From this version onwards, the updates will be made available in the online document that can be found at https://ansperformance.eu/economics/cba/standard-inputs/.

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DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

EDITION NUMBER	EDITION DATE	REASON FOR CHANGE	PAGES AFFECTED
0.1	07/2002	Working draft	All
1.0	09/2002	Revised and upgraded to released issue	All
2.0	02/2004	Updated to 2004 values	All
3.0	06/2007	Updated to 2006 values	All
4.0	10/2009	Updated to 2009 values	All
5.0	12/2011	Updated to 2010 values	All
6.0	09/2013	Updated to 2013 values, review and replacement of some values, addition of four new values	All
7.0	11/2015	Updated to 2014 values, review and replacement of some values, addition of three new values	All
8.0	12/2017	Updated to 2016 values, review and replacement of some values, addition of new values	All
9.0	11/2020	Change of title, updated to 2019 values, review, replacement of some values, addition of new values	All
10.0	05/2024	Update the values to the year 2022, setting it as a reference year for this PDF edition. Review and replacement of some values, addition of new values to correspond to the new, online version of the document in which all the upcoming updates will be made	All

About us

The EUROCONTROL Business Cases team is a dedicated team of experts that support stakeholders who need to choose between different solutions and alternatives, using the best available data. For over 20 years, EUROCONTROL has been providing ATM decision makers with a wide range of regularly updated Standard Inputs to help them to take rational long-term investment decisions.

With the view to make this process even more efficient and ensure that the values are as up to date as possible, all the updates coming after this edition 10.0 will be published online, on the AIU Portal.

Notice and disclaimer

The EUROCONTROL Business Cases team has made every effort to ensure that the information and analysis contained in this document are as accurate as possible. Only information from quoted sources has been used and information relating to named parties has been checked with the parties concerned. Despite these precautions, should you find any errors or inconsistencies we would be grateful if you could please bring them to our attention. Our email address is Economics.Business-Cases@eurocontrol.int.

This document is published by the EUROCONTROL Business Cases team in the interest of the exchange of information.

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Foreword

The first version of the EUROCONTROL Standard Inputs for Economic Analyses series was launched in 2002 and has been kept alive for more than twenty years. This latest edition is a continuation of the work developed over all these years and aims to update the inputs that have been previously published, but also to add new inputs that are believed to be of interest for our stakeholders. In comparison with Standard Inputs for Economic Analyses Ed. 9.0, the following new values have been added in this version:

- Transit time, which shows the average time flown by aircraft controlled in a specific airspace over a year.
- Shadow cost of carbon, which is the cost of carbon required to drive the economy to meet the 1.5°C global temperature target set by the Intergovernmental Panel on Climate Change.
- Proportion of sustainable aviation fuel, showing the evolution of sustainable fuel in the total aviation fuel blend.

The previous editions of the Standard Inputs for Economic Analyses can be found in EUROCONTROL Library.

This document is intended to be the last version of Standard Inputs for Economic Analyses in a PDF format. **The document is now available in an online version on the Aviation Intelligence Portal, where all the upcoming versions and updates will be made available on regular basis.**

We, the EUROCONTROL Business Cases Team, would like to show our gratitude to the many different colleagues that have contributed to this endeavour by providing us data and helping develop the values. Trying to name them all would be impossible.

We have received valuable remarks and suggestions from all stakeholders in the aviation value chain. In particular, we have benefited from stakeholders involved in the entire development life cycle, from ideas to a working system. We strongly believe that this collaboration makes the EUROCONTROL Standard Inputs for Economic Analyses a robust product.

Readers are invited to send comments and suggestions for improvement to Economics.Business-Cases@eurocontrol.int.

CONTENTS

Introduction

This document provides a set of data commonly used in economic and financial analyses and appraisals, particularly in the field of ATM.

The aim of this document is to standardise the data used in different ATM-related assessments, to facilitate data access for the different stakeholders involved and contribute to the comparability of different analyses through relying on the same data.

In this edition (10.0) the values have been updated according to the latest available information, either by adding new data or by adjusting existing data for inflation, where relevant.

Please note that the inputs have been compiled from EUROCONTROL data and intelligence, from values provided by airspace users, ANSPs, airports, IATA, EASA, and other organisations, and from other relevant documents which are publicly available.

The inputs are average values and may not be appropriate in all circumstances. The document also gives details of the sources of information and discusses the applicability and use of the values.

2022 was taken as a baseline for this edition since this is the latest year for which most of the updates to the values are available. This edition is intended to become the last PDF publication of the Standard Inputs for Economic Analyses, and **all the upcoming updates to the values will be made available on the *AIU Portal* on a regular basis. Please refer to this online version for more recent data.**

Readers are invited to send comments and suggestions for improvement to Economics.Business-Cases@eurocontrol.int.

Details per data item

For each standard input, the following information is provided, where relevant.

Section	Description
EUROCONTROL recommended values	One or a set of recommended values put forward by EUROCONTROL for the specific indicator, including a description containing relevant information or details regarding the values
Comment	Any further comments regarding the source or derivation of the value, for example the degree of confidence in the values and sources cited
Related inputs	A link to other related standard inputs included in the document
When to use the input?	A recommendation on when and where the specific input can be beneficial is provided here

When necessary, please refer to EUROCONTROL Air Navigation Inter-Site Acronym List (AIRIAL) for more information about specific terminology.

General parameters

The sections hereafter present some key values used in the Standard Inputs that can also serve as a reference for other uses.

Inflation

The inflation levels have been calculated based on the Eurostat European Union region Harmonised Index of Consumer Prices (HICP),[1] as the yearly difference in the HICP. The HICP data was extracted from Eurostat HICP - annual data (average index and rate of change) database (prc_hicp_aind). The annual change in the index is shown in Table 1.

Year	Index	Rate of change	Year	Index	Rate of change
2023	126.4	6.4%	**2011**	95.4	3.1%
2022	118.8	9.2%	**2010**	92.5	2.1%
2021	108.8	2.8%	**2009**	90.6	1.0%
2020	105.8	0.4%	**2008**	89.7	3.5%
2019	105.4	1.5%	**2007**	86.7	2.3%
2018	103.9	1.9%	**2006**	84.7	2.2%
2017	101.9	1.7%	**2005**	82.9	2.2%
2016	100.3	0.3%	**2004**	81.1	2.0%
2015	100.0	0.1%	**2003**	79.5	2.0%
2014	99.9	0.6%	**2002**	77.9	2.1%
2013	99.4	1.5%	**2001**	76.4	2.2%
2012	97.9	2.6%	**2000**	74.7	1.9%

Table 1: Annual average inflation values

Exchange rate conversion

The currency exchange rates provided in Table 2 are based on the European Central Bank (ECB) rates that are published daily.[2] The rates correspond to the average rate for the year 2022 and are used across this document for the purpose of currency conversion.

Currency	EUR/currency	Currency/EUR
USD ($)	1.05	0.95
GBP (£)	0.85	1.18

Table 2: Average euro foreign exchange rate in 2022

[1] Eurostat, 'Harmonised Indices of Consumer Prices (HICP)', accessed 26 January 2023, https://ec.europa.eu/eurostat/web/hicp

[2] European Central Bank, 'Euro Foreign Exchange Reference Rates', European Central Bank, December 2023, https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/index.en.html

Cost of fuel

The cost of fuel used in this document is based on the 2022 average jet fuel price provided by IATA,[3] unless otherwise specified. All conversions are done using the values specified in Table 4.

Currency	Price per barrel	Price per gallon	Price per kg
USD	$ 136	$ 3.2	$ 1.1
EUR	€ 129	€ 3.1	€ 1.0

Table 3: Average jet fuel price in 2022

[3] IATA, 'Jet Fuel Price Monitor', accessed 12 December 2023, https://www.iata.org/en/publications/economics/fuel-monitor/

Conversion values

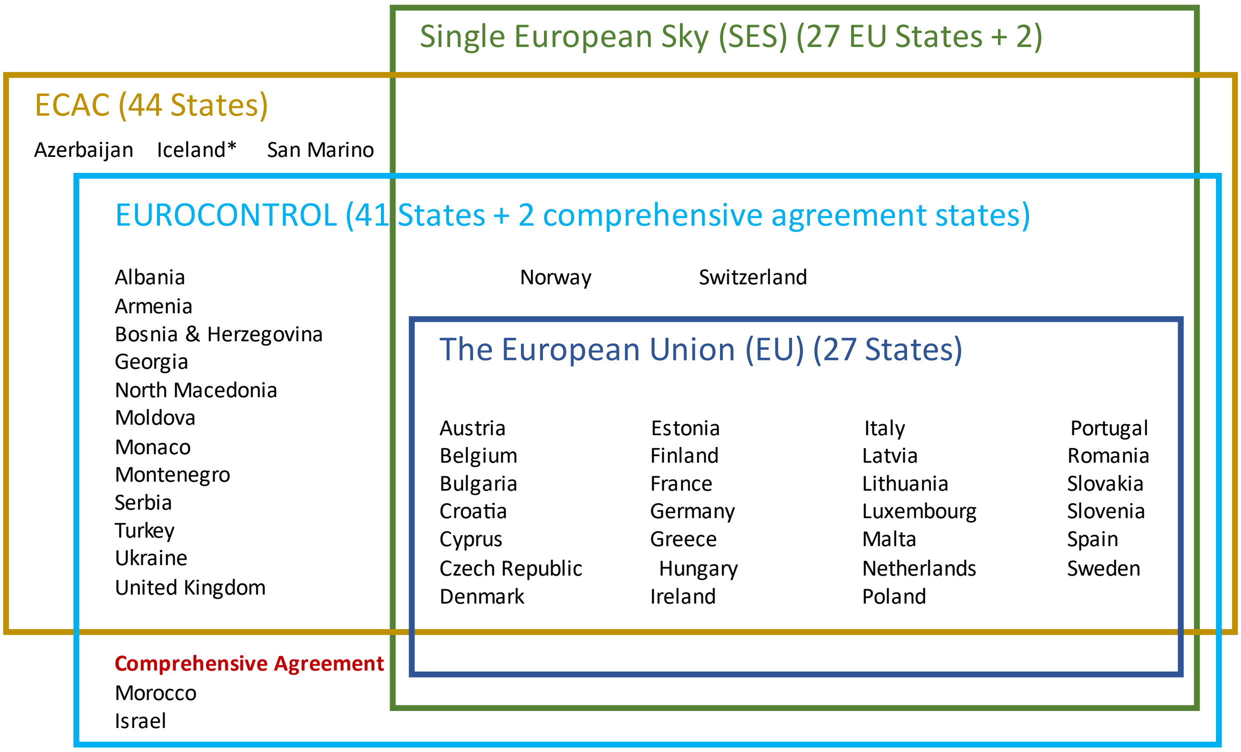
From	To
1 nautical mile (NM)	1.852 km
1 kilometre (km)	0.53996 NM
1 tonne (metric = 1 000 kg) of jet fuel	325.33 US gallons
	1 235 litres
	7.8 barrels
1 barrel (bbl) of jet fuel	42 US gallons
	158.99 litres
	0.1291 tonne = 129.10 kg
1 US gallon of jet fuel (US gal)	3.7854 litres
	3.073 kg
	6.7764 lb
Density of kerosene	0.812 kg/litre
1 litre of fuel (l)	0.26417 US gallons
1 kilogramme of fuel (kg)	2.2046 lb
1 pound of fuel (lb)	0.45359 kg
1 US ton	1.01605 tonne

Table 4: Unit conversion values

Geographical areas

Member States and geographical areas covered

The Single European Sky initiative, the European Civil Aviation Conference (ECAC) and the European Union (EU) are the different scopes that are covered in this Standard Inputs document. Figure 1 shows a summary of the States that are included in the different groupings relevant to the aviation domain, while Figure 2 shows a map of the EUROCONTROL states.



*The country is set to become a EUROCONTROL Member State in 2025

Figure 1: State groupings

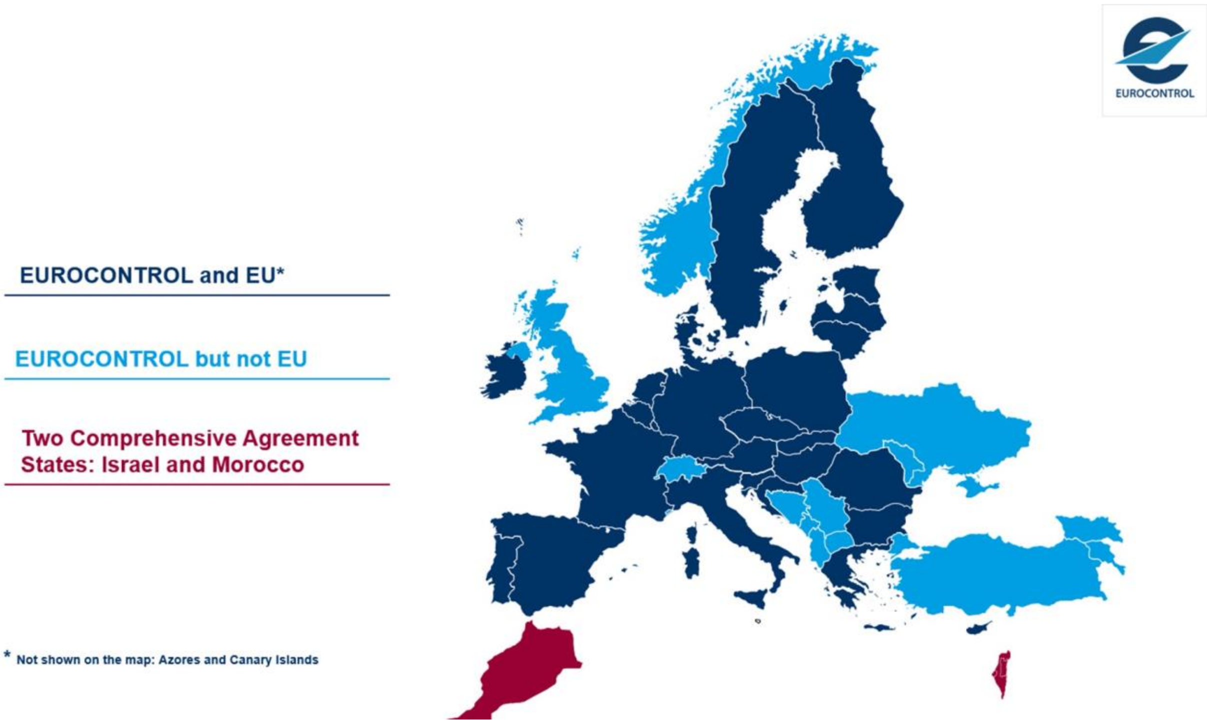


Figure 2: EUROCONTROL Member States (status: November 2020)

Airspace of the ECAC Member States

ECAC is an intergovernmental organisation that was established by ICAO and the Council of Europe. ECAC now has 44 Member States, including all 27 EU Member States, 31 of the 32 European Union Aviation Safety Agency Member States, and all 41 EUROCONTROL Member States. Figure 3 is a graphical representation of the airspace belonging to the ECAC states.

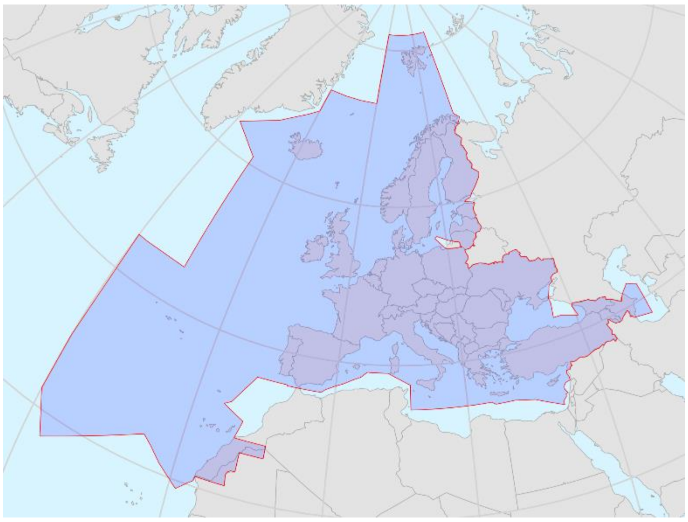


Figure 3: State flight information region for ECAC

TRAFFIC AND CAPACITY

1 Air traffic statistics and forecasts

1.1 EUROCONTROL recommended values

The EUROCONTROL Statistics and Forecast (STATFOR) service produces flight and service unit forecasts of future network traffic with a view to help planners understand and manage risks, identify bottlenecks, and anticipate the needs of airspace users.

1.2 Medium-term forecast (7-year timespan)

The medium-term forecasts give a comprehensive picture of **anticipated air traffic development in Europe (i.e. ECAC) for the next seven years.** These forecasts combine flight statistics with economic growth and models of other industry drivers, including costs, airport capacity, passenger numbers, load factors and aircraft size. Using high and low growth scenarios, they present a likely range for growth, to help planners manage risks. These forecasts are published biannually, in spring and autumn, covering flights, en-route and terminal service units.

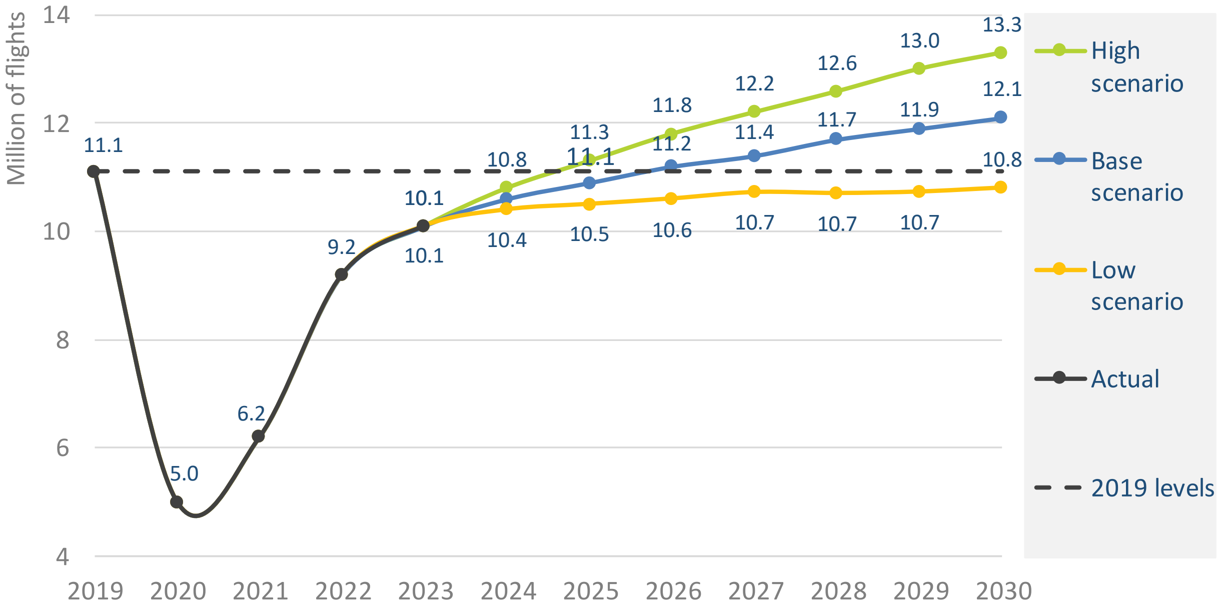


Figure 4: EUROCONTROL 7-year forecast 2024-2030 (Spring 2024 release)[4]

The above graph shows the traffic forecast taking account of the impact of the COVID-19 pandemic. In the base scenario, IFR flights are expected to be back to 2019 levels by 2026. Traffic statistics and forecasts can be obtained directly from the STATFOR Interactive Dashboard (SID).[5]

1.3 Long-term forecast (20 to 30-year timespan)

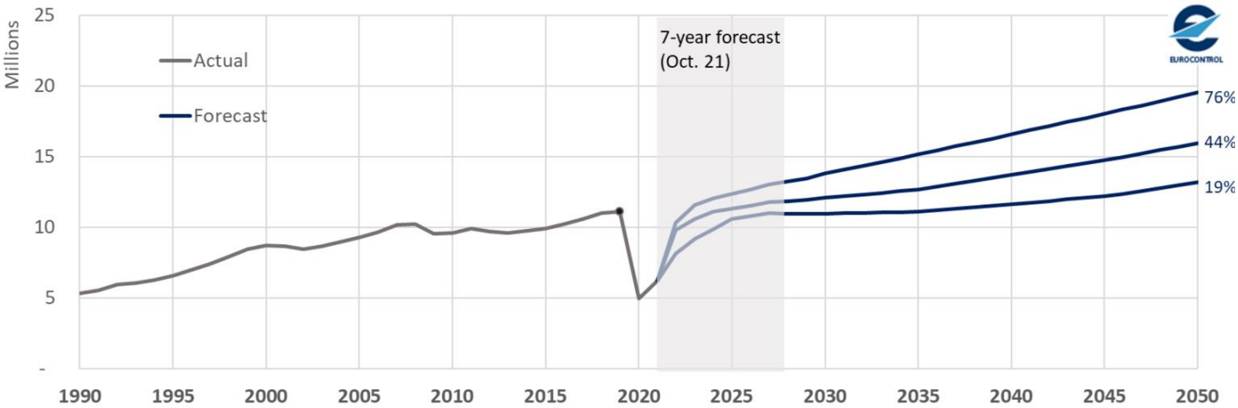
Twenty to thirty-year forecasts look at a range of distinct possible scenarios for how the air traffic industry might look in 20-30 years' time.

[4] EUROCONTROL STATFOR, 'EUROCONTROL Forecast Update 2024-2030', 26 February 2024, https://www.eurocontrol.int/publication/eurocontrol-forecast-2024-2030

[5] EUROCONTROL STATFOR, 'STATFOR Interactive Dashboard', n.d., https://www.eurocontrol.int/dashboard/statfor-interactive-dashboard

This allows a range of "*what if?*" questions to be explored, for factors inside the industry (e.g. the growth of small business jets, or of point-to-point traffic) or outside the industry (e.g. the price of oil or environmental constraints).

Twenty to thirty-year forecasts are usually published every two to three years. In April 2022, EUROCONTROL published its first EUROCONTROL Aviation Outlook (EAO) looking out to 2050, much further than previous forecasts. This forecast estimates a future number of flights and CO_2 emissions per scenario, in line with aviation's objective of achieving net-zero CO_2 emissions by that date.



ECAC	2019		2050			2050/2019	
	Total (million)	Avg. daily (thousands)	Total (million)	Avg. daily (thousands)	Extra flights/day (thousands)	Total growth	AAGR
High scenario			19.6	53.6	23.2	+76%	+1.8%
Base scenario	11.1	30.4	16.0	43.7	13.4	+44%	+1.2%
Low scenario			13.2	36.2	5.8	+19%	+0.6%

Figure 5: Flight forecast for Europe, with total growth between 2019 and 2050

In the most-likely Base scenario, the forecast is for 16 million flights in Europe in 2050, 44% more than in 2019 – average growth of 1.2% per year.

Furthermore, Figure 6 shows the estimated evolution of CO_2 emissions between 2005 and 2050. According to this data, by 2050, CO_2 emissions, net of sustainable aviation fuel (SAF), fleet and operational improvements, will be reduced by about 41% compared to 2005 in the Base scenario.

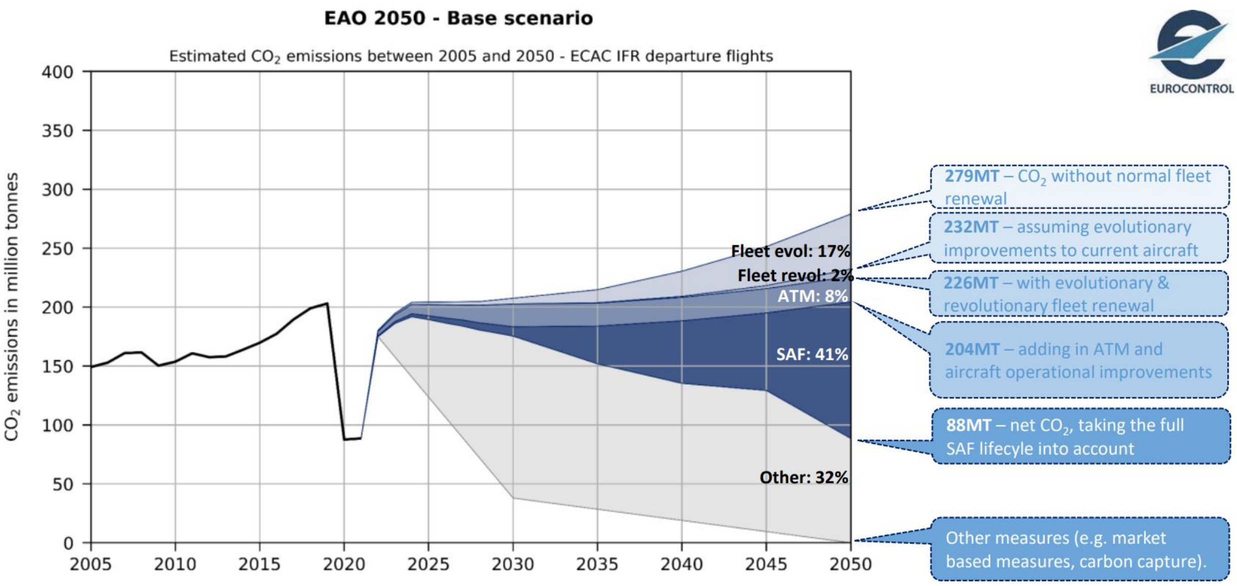


Figure 6: Estimated CO_2 emissions between 2005 and 2050[6]

1.4 Service units forecast

Service Units are billed to airlines for the provision of air-traffic services. They are of two types:

- En-route Traffic Service Units (TSU) that are taxed for the provision of en-route air traffic control and are a function of the weight and the distance flown within each state over which the concerned aircraft flies.
- Terminal Navigation Service Units (TNSU) are taxed for the provision of ground services to the airlines for each departure at a given airport. They are a function of the weight of the considered aircraft.

EUROCONTROL produces a 7-year forecast of Service Units that builds on the 7-year IFR movements forecast, by adding forecasts of the aircraft weights and distances. This Service Units forecast is provided to states that are part of the Central Route Charges Office (CRCO) to help them set-up their en-route unit rates, if needed. The Forecast of Service Units in general serves also as a benchmark for the European Commission to assess the financial aspects of the performance plans of the states that are bound by the Performance and Charging Schemes according to EU regulations (EU) N°2019/317.

[6] EUROCONTROL, 'EUROCONTROL Aviation Outlook 2050', 13 April 2022, https://www.eurocontrol.int/publication/eurocontrol-aviation-outlook-2050

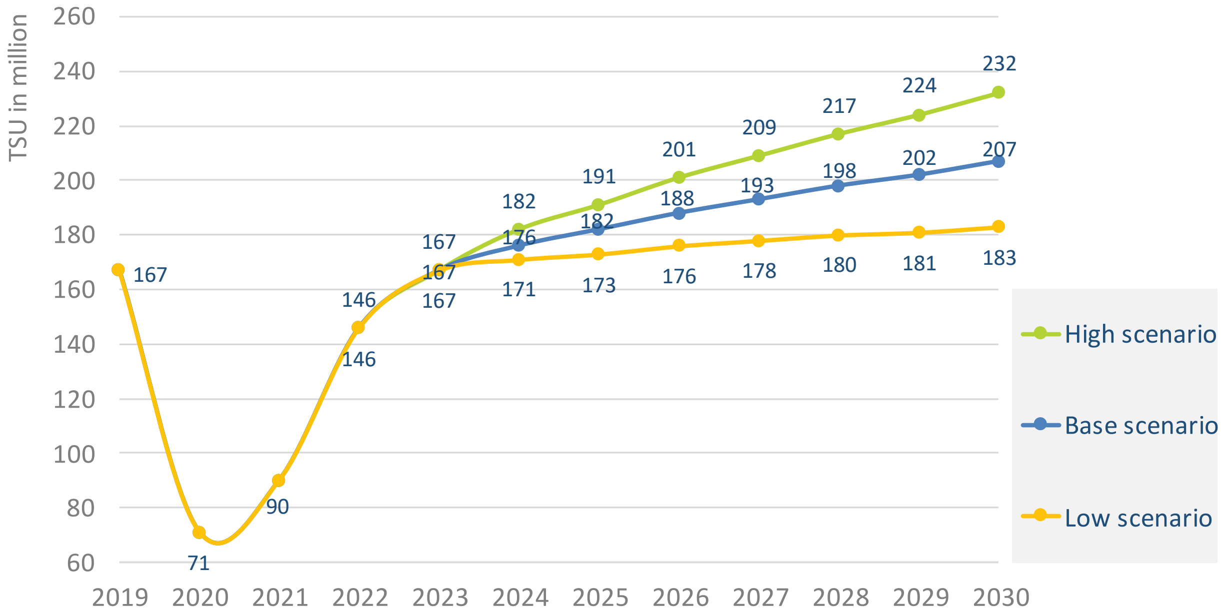


Figure 7: En-route Service Units 7-year Forecast 2024-2030 (Spring 2024 release)[7]

The above graph shows the en-route service units forecast taking account of the impact of COVID-19.

Related inputs

Medium-term capacity planning

Air traffic delay

Cost of delay

When to use the input?

The objective of STATFOR is to provide statistics and forecasts on IFR flight movements and service units in Europe (ECAC) and to monitor and analyse the evolution of the air transport industry.

[7] EUROCONTROL STATFOR, 'EUROCONTROL Forecast Update 2024-2030'.

2 Medium-term capacity planning

2.1 EUROCONTROL recommended sources

Capacity planning represents the systematic determination of resource requirements for the projected output over a specific period of time. It is a dynamic activity that relies on constantly changing data on the ATM network use, capacity forecasts, etc.

Given this, it is recommended to consult the sources below to obtain relevant up-to-date information on capacity planning.

- *EUROCONTROL NMD (2023), European Network Operations Plan 2023-2027*[8]

  The document constitutes a short- to medium-term outlook of the expected ATM network operations and performance at network and local level. It provides a detailed overview of capacity and flight efficiency enhancement measures planned at network level and by each Area Control Centre (ACC), a description of the airport performance assessment and improvement measures planned at airports generating a high level of delay. It also describes operational actions planned to be taken by the Network Manager (NM) and other stakeholders that would respond to the performance targets. Furthermore, it provides an assessment of the expected impact from these measures on the network.

- *EUROCONTROL NMD (2024), European Network Operations Plan (NOP) – 2024 Rolling Seasonal Plan*[9]

  The European NOP Rolling Seasonal Plan focuses on the planning of the next six weeks and on the management of the execution and implementation of the 5-year NOP. Its aim is to facilitate ANSP and airport planning to match traffic demand in a safe, efficient, and coordinated manner by providing them with a consolidated European network view of the evolution of air traffic. More information about network performance (and access to dashboards and the archive) can be found on the Network Performance page.

- *European ATM Master Plan - implementation plan – level 3*[10] *and European ATM Master Plan – implementation report – level 3*[11]

  The European ATM Master Plan Level 3 (MPL3) implementation plan brings together the framework for the commonly agreed actions that ECAC Stakeholders should take in the context of the implementation of SESAR. In this respect, it addresses:

  - V3 validated SESAR Solutions
  - Common Project 1 (CP1) ATM Functionalities (AF), based on Commission IR (EU) 2021/116 on Common Project One

[8] EUROCONTROL NMD, 'European Network Operations Plan 2023-2027', 13 July 2023, https://www.eurocontrol.int/publication/european-network-operations-plan-2023-2027
[9] EUROCONTROL NMD, 'European Network Operations Plan 2024 Rolling Seasonal Plan', 19 January 2024, https://www.eurocontrol.int/publication/european-network-operations-plan-2024-rolling-seasonal-plan
[10] EUROCONTROL, 'European ATM Master Plan - Implementation Plan - Level 3', 10 July 2023, https://www.eurocontrol.int/publication/european-atm-master-plan-implementation-plan-level-3
[11] EUROCONTROL, 'European ATM Master Plan - Implementation Report- Level 3', 10 July 2023, https://www.eurocontrol.int/publication/european-atm-master-plan-implementation-report-level-3

  - SESAR Baseline elements, validated or under deployment at the beginning of the SESAR Deployment phase
  - SES and ICAO requirements

Updated yearly, the Plan covers a short to medium-term horizon of around 5 years. It is based on the ATM MP L1 and L2,[12] the SESAR Deployment Programme (SDP), the Network Strategy Plan (NSP), and the SES Interoperability Regulations. The MPL3 Implementation Plan feeds the LSSIP+ monitoring mechanism as well as the reporting process through the yearly elaboration of the MPL3 Implementation Report, which provides a holistic view of the implementation of commonly agreed actions to be taken by ECAC States, in the context of the implementation of SESAR. These actions are consolidated in the form of "Implementation Objectives" that set out the operational, technical, and institutional improvements that have to be applied to the European ATM network to meet the performance requirements for the key ATM performance areas defined in the MP Level 1 – safety, capacity, operational efficiency, cost efficiency, environment, and security.

The MPL3 Plan 2023 edition mirrors the content of the SESAR Deployment Programme (SDP) edition 2022 for what concerns the IR (EU) 2021/116 on the Common Project 1 (CP1). It also features the following changes in the Implementation Objectives: Implementation Objectives changed in status, from Initial to Active (Local); Implementation Objectives changed in status, from Active to Achieved. They are both linked to the CP1 Regulation.

The Implementation Report 2023 maps the evolution of the Master Plan implementation on the four progressive Phases of the SESAR vision (Phase A to D), as defined in the 2020 edition of the Executive view of the Master Plan, for the delivery of a Digital European Sky (DES).

- *Local Single Sky ImPlementation (LSSIP) documents*[13]

  The Local Single Sky ImPlementation (LSSIP) documents give a comprehensive overview of all ATM information for each of the ECAC Member States. They also show the ATM capacity forecasts and planning targets from the NOP. The documents reflect progress made and detail the plans for each State for the next five to seven years. LSSIP documents, one for each State, are derived from the Master Plan Level 3 (previously known as European Single Sky Implementation (ESSIP)) objectives, and stakeholder lines of action cascade down to the States.

Related inputs

[Air traffic statistics and forecasts](#)

[Air traffic delay](#)

[12] There are three levels of the ATM Master Plan 2020: Level 1 - Executive view; Level 2 - Planning and architecture view; Level 3 - Implementation view.

[13] EUROCONTROL, 'Local Single Sky Implementation Monitoring', n.d., https://www.eurocontrol.int/service/local-single-sky-implementation-monitoring

3 Number of IFR flights

3.1 EUROCONTROL recommended values

This section presents the evolution of flight movements in Europe (ECAC area) by flight flow, market segment[14] and aircraft type.

3.2 Evolution of flights per flow in Europe (ECAC) in 2022 compared to 2019

	DAIO				Total		Change
Month	Departure	Arrival	Internal	Overflight	2022	2019	2019-2022
January	55,404	55,146	414,063	14,966	539,579	787,503	69%
February	50,790	50,617	408,170	12,509	522,086	737,763	71%
March	59,201	59,017	515,945	12,293	646,456	846,442	76%
April	63,347	63,158	604,074	11,410	741,989	906,539	82%
May	71,101	70,824	695,949	13,273	851,147	985,862	86%
June	77,150	76,794	725,748	13,977	893,669	1,038,128	86%
July	87,541	87,643	759,745	15,615	950,544	1,092,562	87%
August	88,379	88,363	755,485	15,897	948,124	1,080,554	88%
September	81,577	81,483	721,100	15,117	899,277	1,034,322	87%
October	79,570	80,012	684,229	15,033	858,844	980,049	88%
November	70,868	70,939	536,747	14,772	693,326	801,961	86%
December	74,021	74,221	527,941	16,469	692,652	793,617	87%
Total	**858,949**	**858,217**	**7,349,196**	**171,331**	**9,237,693**	**11,085,302**	**83%**

Table 5: Evolution of IFR flights in Europe (ECAC) 2019 vs 2022[15]

Please note that the comparison between 2022 and 2019 in Table 5 is due to the fact that 2019 is the last year where the traffic levels were not affected by the COVID-19 pandemic, allowing for a more realistic comparison of the flight levels.

[14] The market segments are defined according to EUROCONTROL STATFOR Market Segment Rules. Please refer to the 2022 document for further details on what each segment comprises.

[15] EUROCONTROL STATFOR, 'STATFOR Interactive Dashboard'.

3.3 Flights by market segment in Europe (ECAC) in 2022 compared to 2019

Market segment	2019	As % of total	2021	As % of total	2022	As % of total
Mainline	3,991,685	36%	1,816,909	29%	2,981,880	32%
Low-cost	3,493,913	32%	1,610,239	26%	2,984,376	32%
Regional	1,643,854	15%	861,587	14%	1,219,685	13%
Business Aviation	683,473	6%	709,398	11%	791,909	9%
All-Cargo	368,362	3%	419,824	7%	389,611	4%
Other[16]	372,796	3%	363,712	6%	389,396	4%
Charter	382,218	4%	303,384	5%	324,824	4%
Military	149,001	1%	145,699	2%	156,012	2%
Total	**11,085,302**	**100%**	**6,230,752**	**100%**	**9,237,693**	**100%**

Table 6: Flights by market segment in Europe (ECAC) - years 2019, 2021 and 2022[17]

In 2022 the total number of flights went up by 48% compared to 2021 but was at 83% of 2019 flight levels (pre-COVID-19). Compared with 2019, two segments increased in 2022, All-Cargo (+6%) and Business Aviation (+16%). The Mainline (-25%), Low-Cost (-15%) and Regional (-26%) segments were the most affected, along with the Charter segment which went down by -15% in 2022 (vs 2019).

3.4 Top 20 number of flights by civil aviation aircraft in Europe (ECAC) in 2022

Aircraft type	Flights	Proportion	Cumulative[1]
B738	1,717,381	20%	20%
A320	1,417,930	16%	36%
A319	513,699	6%	42%
A20N	462,294	5%	47%
A321	371,456	4%	51%
A21N	296,722	3%	55%
B38M	270,614	3%	58%
AT76	210,778	2%	60%
E190	210,022	2%	63%
B77W	163,600	2%	64%
B789	135,989	2%	66%
A333	128,892	1%	67%
E195	124,823	1%	69%

[16] The “Other” market segment contains flights that do not fall in any of the remaining segments mentioned in the table, such as helicopter flights, etc.
[17] EUROCONTROL STATFOR, ‘STATFOR Interactive Dashboard’.

Aircraft type	Flights	Proportion	Cumulative[1]
CRJ9	112,652	1%	70%
AT75	100,619	1%	71%
DH8D	93,110	1%	72%
BCS3	90,613	1%	73%
A332	86,165	1%	74%
B788	80,654	1%	75%
A359	78,200	1%	76%
Other types	2,073,792	24%	100%
Total	**8,740,005**	**100%**	

[1]Please note that the percentages in "Proportion" column are rounded, which results in cumulative values that may differ from the expectations.

Table 7: Top 20 flights by aircraft type in Europe (ECAC) in 2022[18]

In 2022, about 76% of all IFR flights in Europe were carried out by the 20 aircraft types listed in Table 7. Please note that the values presented in Table 7 focus on the civil aviation flights (i.e. excluding the military and other categories), resulting in a difference in the total flights as compared with Table 6 and Table 5.

[18] EUROCONTROL STATFOR.

3.5 Daily average of IFR flights, 2016 to 2022

Figure 8 shows the daily average number of IFR flights EU-wide between 2016 and 2022.

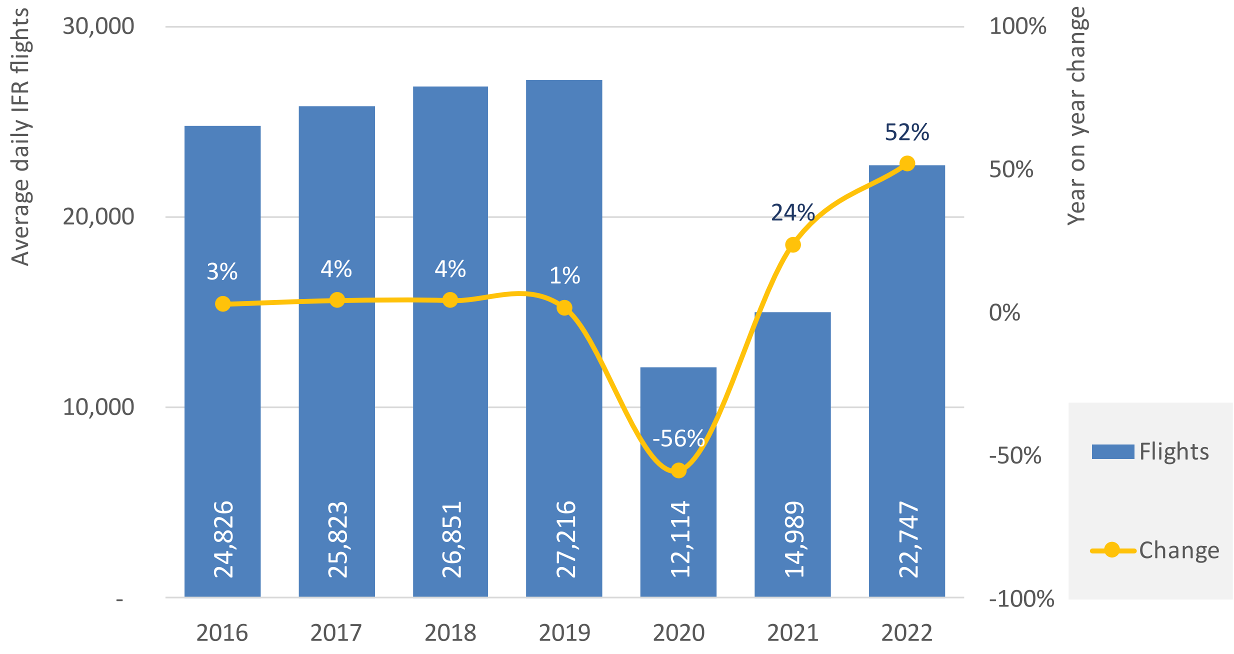


Figure 8: Daily average number of IFR flights[19]

Related inputs

IFR flight information per operator segment

Fleet age

Fleet size

Fleet CNS capability

When to use the input?

This input is recommended to be used in situations where an overview of the historical evolution in the number of flights is required, namely grouped according to different criteria.

[19] 'Reporting Period 3 - 2022 Dashboard', n.d., https://www.eurocontrol.int/prudata/dashboard/vis/2022/

4 Air traffic delay

4.1 EUROCONTROL recommended values

The sections below present the evolution in reported delays taking two perspectives:

1. The view of airlines and passengers considering all causes of delay
2. A zoom-in to the view of the Network Manager focusing on Air Traffic Flow Management (ATFM) delays

4.2 All causes of delay

Figure 9 presents an overview of all causes of delay reported by the airlines in 2021 and 2022. The figures presented are estimated by the EUROCONTROL Central Office of Delay Analysis (CODA) and are calculated based on the comparison of the scheduled and actual flight timings. They can be used in studies that look into the different causes of flight delay experienced by passengers and airlines.

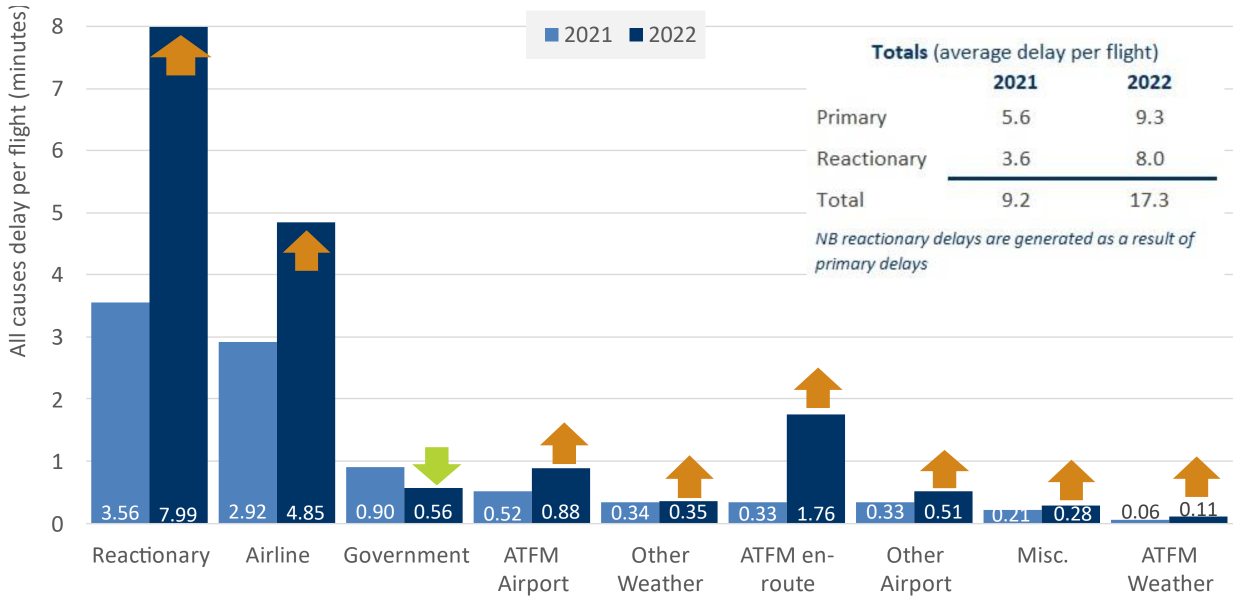


Figure 9: Breakdown of the network average delay per flight on departure: 2021 vs 2022[20]

The ATFM delay (en-route, airport and weather) constitutes only a fraction of primary delay from all causes, and around half of all delay is reactionary (i.e. delay caused by late arrival of aircraft, crew, passengers, or baggage from previous journeys) rather than primary (i.e. delay other than reactionary).

[20] C. Walker, 'All-Causes Delays to Air Transport in Europe - Annual 2022', 21 March 2023, https://www.eurocontrol.int/publication/all-causes-delays-air-transport-europe-annual-2022

4.3 ATFM delay

Looking specifically into ATFM delay, Figure 10 shows the average daily traffic and average ATFM delay per flight (en-route and at airport) for the period 2012-2022. The figures presented are calculated by the Network Manager based on the flight plans and include the planned ATFM delays due to restrictions that may be applied in the airspace.

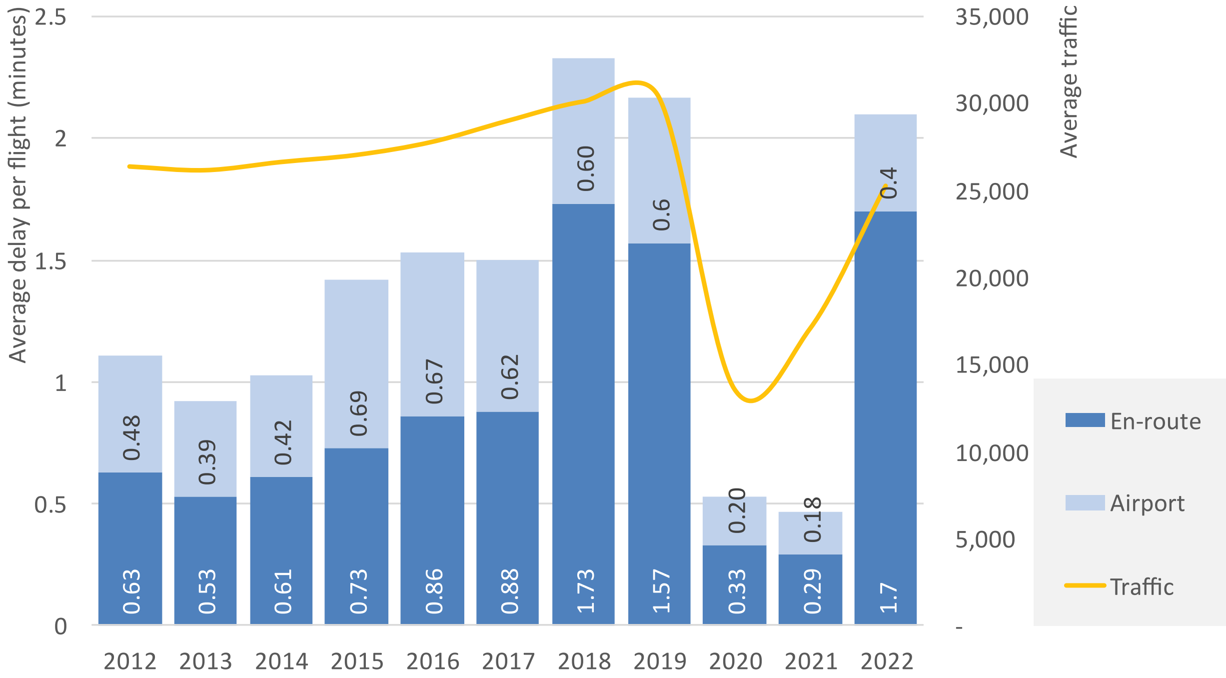


Figure 10: Average daily traffic and ATFM delay per flight 2012-2022[21]

[21] EUROCONTROL NMD/ACD/PRF, 'Network Operations Report 2022', May 2023, https://www.eurocontrol.int/publication/annual-network-operations-report-2022

4.4 Comment

Looking at both figures above, it can be observed that the ATFM delay, both at the airport and en-route, is higher when looking at the numbers provided by the airlines rather than that observed by the Network Manager. This is because the delay numbers provided by the Network Manager account for the planned delay due to restrictions in the airspace, while the numbers provided by the airlines cover the total delay, they attribute to ATFM, whether they come from the restrictions or any other planned ATFM delays, such as ATM system upgrades, training activities, etc.

Another important point to take into consideration when analysing the recommended values is the impact of COVID-19 pandemic. Both, the all-causes delay and the ATFM delay were impacted by the significant reduction in air traffic in 2020 and 2021, resulting in a strong drop in the total delay duration. Thus, when looking into these numbers it is equally important to consider the situation prior to 2020. For the All-causes delay this information can be found in the previous editions of CODA Digest, available in EUROCONTROL library.

Related inputs

Air traffic statistics and forecasts

Cost of delay

When to use the input?

It is recommended to use all causes of delay provided by CODA when analysing the impacts on airlines or on passengers/society (e.g., an airline upgrading the avionics in their aircraft; airport expansion, etc.). On the other hand, ATFM delay is recommended to be used when analysing projects aiming at improving flow management. Since primary delay shows the delay that is due to direct triggers, it is recommended to be used when analysing updates that would impact the non-reactionary delays.

5 Transit time

5.1 EUROCONTROL recommended values

The transit time per ANSP represents the average time flown by aircraft controlled in its airspace over a year. Table 8 provides the average transit time (expressed in minutes) per ANSP in 2022. The data that was used to build this table, as well as the most recent data, can be accessed on the data section of the AIU portal (which also contains data at ACC level).

ANSP	Transit time (min)	ANSP	Transit time (min)
Albcontrol	12	LGS	17
ANS CR	20	LPS	11
ARMATS	14	LVNL	16
Austro Control	18	MATS	36
AVINOR (Continental)	38	M-NAV	10
BHANSA	14	MOLDATSA	12
BULATSA	21	MUAC	21
Croatia Control	21	NATS (Continental)	36
DCAC Cyprus	29	NAV Portugal (Continental)	40
DFS	30	NAVIAIR	21
DHMI	59	Oro Navigacija	17
DSNA	45	PANSA	35
EANS	20	ROMATSA	35
ENAIRE	47	SAKAERONAVIGATSIA	23
ENAV	41	skeyes	11
Fintraffic ANS	28	Skyguide	17
HASP	44	Slovenia Control	10
HungaroControl	16	SMATSA	19
IAA	30	UkSATSE	45
LFV	37		

Table 8: Average transit time per ANSP in 2022

This metric is the ratio between the total flight hours controlled and the IFR flights controlled, where:

- Total IFR flight-hours controlled is the sum of the flight-hours controlled over the year by the ANSP. For a given flight, the flight-hours controlled are computed using information available in the Network Manager database as the difference between the exit time and the entry time in the controlled airspace.
- IFR movements controlled is the number of flights that have been controlled over the year by the ANSP as reported by EUROCONROL Performance Review Unit (PRU).

The data was recorded by the Network Manager for the 39 main ANSPs operating in Europe. In Figure 11, the range of transit time values for the ANSPs considered above can be observed. The European average in terms of flight time is 26 minutes per ANSP. A difference of 51 minutes between the highest (DHMI Türkiye) and the lowest (M-NAV North Macedonia and Slovenia Control) transit time can also be observed.

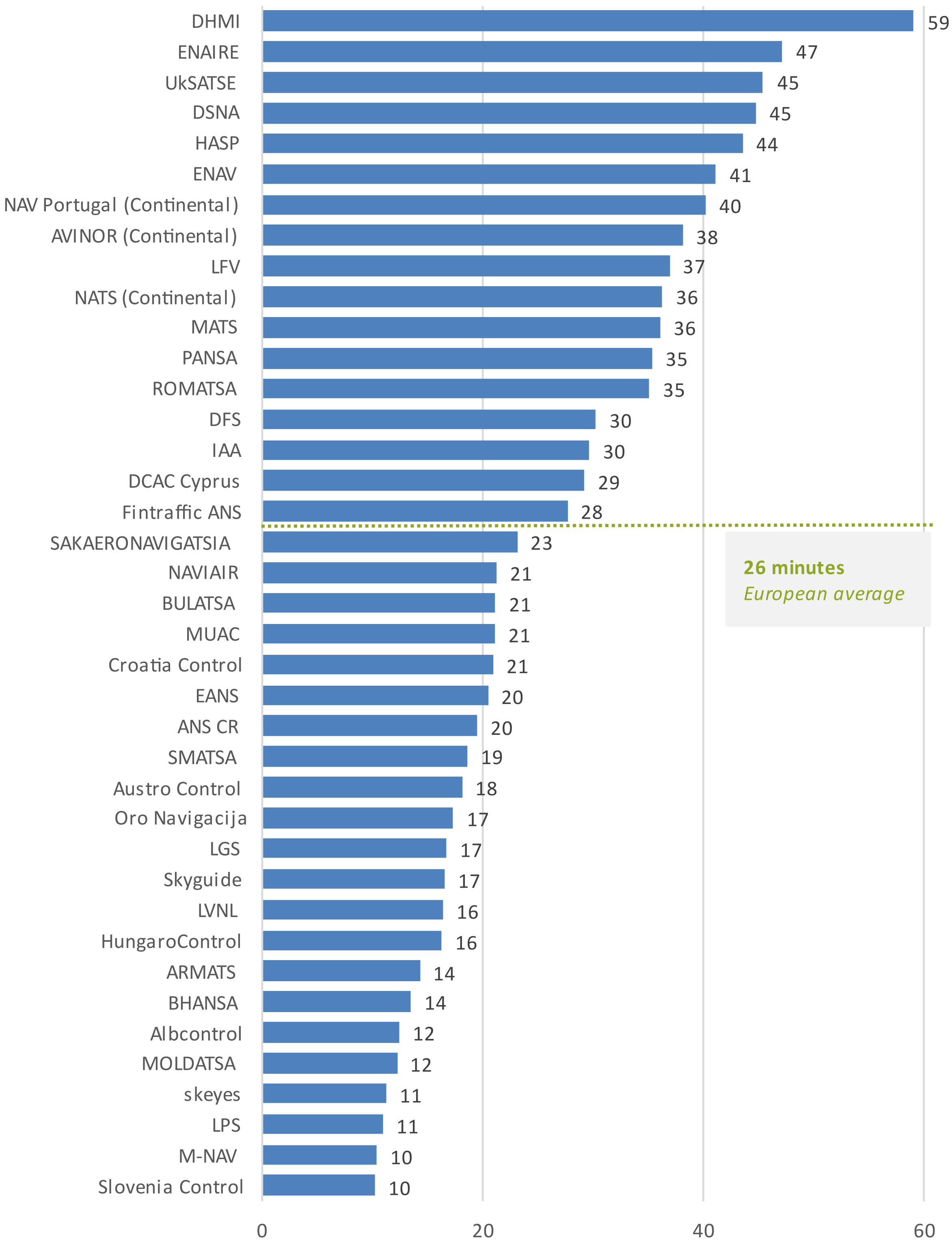


Figure 11: Average transit time per ANSP in 2022 (continental only)

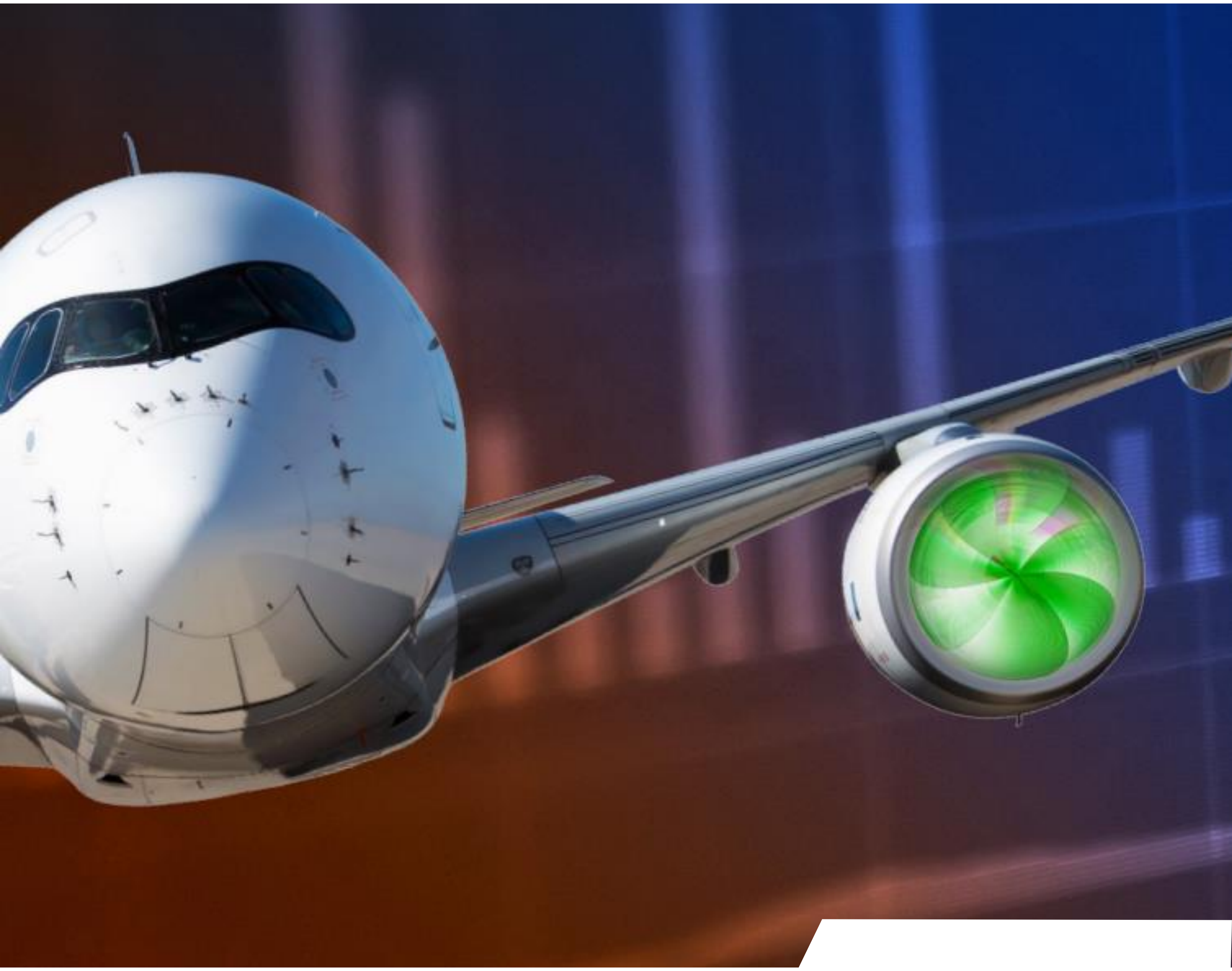
Related inputs

Medium-term capacity planning

When to use the input?

This input is recommended for those projects where the flying time in a given ANSP is key to the assessment. As an example, it has previously been used for several CNS-related studies, in particular when studying the cost of communication services that depend on connection times.

ENVIRONMENT



6 Rate of fuel burn

6.1 EUROCONTROL recommended values

This section provides the average number of kilograms per minute of fuel burn, by aircraft segment, in different flight phases.

Flight phase	Taxi	En-route	Arrival Management
Scheduled aviation	12.7	51.6	38.6
Regional aircraft	*8.2*	*24.6*	*19.9*
Narrow body aircraft	*11.7*	*40.1*	*35.2*
Wide body aircraft	*25.8*	*113.9*	*85.2*
Business aviation	NA	9.3	7.7
Rotorcraft	NA	8.8	8.8

Table 9: Average fuel burn rates (kg/minute)

Table 9 originates from the Base of Aircraft Data (BADA), an Aircraft Performance Model (APM) developed and maintained by EUROCONTROL, with the active cooperation of aircraft manufacturers and operating airlines. The data extracted use three different families of the BADA model.[22]

The operator segment values are weighted averages calculated based on (i) the number of flights per aircraft type (taxi and arrival phases) or (ii) the number of flight hours per aircraft type (en-route phase). The analysis covers the most-flying aircraft models in Europe, as per the flight plans submitted to the Network Manager in 2022:

- **Scheduled aviation:** Groups three (3) categories from the EUROCONTROL Market Segment Rules:[23]
  - **Regional (top 5):** AT76, E190, E195, CRJ9, and AT75.
  - **Mainline + Low-cost (incl. Charter) (top 15):** (a) narrow-body aircraft (B738, A320, A319, A20N, A321, A21N, B38M, BCS3, B734) and (b) wide-body aircraft (B77W, B789, A333, A332, B788, A359).
  - Due to the significant differences between them, Regional, narrow-body and wide-body values are included separately.
- **Business aviation (top 5):** C56X, PC12, BE20, E55P, and GLEX.
- **Rotorcraft (top 5):** S92, A139, EC75, AS32, and EC35.

[22] BADA 3 is a standard for aircraft performance modelling which models accurately aircraft behaviour over the nominal part of the flight envelope and covers close to 100% of aircraft types in ECAC area. BADA 4 is a new model that provides higher precision in aircraft performances parameters and enables modelling and simulation of advanced systems and future concepts. It covers close to 80% of aircraft types in ECAC. BADA Helicopters provides modelling for Helicopter aircraft types.
[23] EUROCONTROL, 'EUROCONTROL Market Segment Update 2022', May 2022, https://www.eurocontrol.int/publication/market-segment-rules

The above selection of aircraft covers (i) 76% of the IFR flights and (ii) 79% of the IFR flight hours registered by NM in 2022. Noting that NM data does not include full data on rotorcraft flights, as they usually fly within one state only and provide flight plans locally.

6.2 Other possible sources

Below, a list of other applicable sources that consider fuel burn rates:

- *ICAO Carbon Emissions Calculator*[24]

  ICAO has developed a methodology to calculate the carbon dioxide emissions from air travel for use in offset programmes. The methodology applies the best publicly available industry data to account for various factors such as aircraft types, route-specific data, passenger load factors and cargo carried.

- *EUROCONTROL Advanced Emission Model (AEM)*[25]

  AEM is a standalone application, developed and maintained by the EUROCONTROL Innovation Hub, which estimates aircraft emissions and fuel burn. AEM can estimate (i) the mass of fuel burned by the main engines of a specified type of aircraft with a specified type of engine flying a specified 4D trajectory; and (ii) the corresponding masses of certain gaseous and particulate emissions which are produced by the burning of that fuel. Access to the tool requires an AEM user license.

- *ICAO Engine Emissions Databank*[26]

  Manufacturer's datasheets that may contain the rates of fuel burn for different flight phases and individual engine types.

Related inputs

Fleet size

When to use the input?

The user should treat the values as high-level approximations of the average fuel burn per flight phase. Note that:

i. regional and business aviation groupings encompass turbofan-powered and turboprop-powered aircraft with fuel burn rates significantly different between them;
ii. the performance data do not consider the weather and atmospheric influences; and
iii. the performance data do not consider the impact of specific flight conditions (speed, altitude, aircraft weight, etc.).

Organisations interested in more aircraft types can request access to the full BADA model.

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24 ICAO, 'Carbon Emissions Calculator', n.d., https://www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx
25 EUROCONTROL, 'Advanced Emission Model', n.d., https://www.eurocontrol.int/model/advanced-emission-model
26 ICAO, 'Engine Emissions Databank', n.d., https://www.easa.europa.eu/en/domains/environment/icao-aircraft-engine-emissions-databank

7 Amount of emissions released by fuel burn

7.1 EUROCONTROL recommended values

This input represents the amount of emissions produced by combustion of aviation fuel (i.e. kerosene), focusing on the main types of pollutants.

Emission type	Emission
CO_2	3.15 kg[a]
H_2O	1.237 kg[a]
SOx	0.00084 kg[b]
	0.000114 kg[c]
NOx	0.0148 kg[d]
HC	0.00032 kg[d]
CO	0.00325 kg[d]
PM volatile	0.000092 kg[d]

[a] *Source 1*
[b] *assuming 440 ppm, Source 2*
[c] *assuming 600 ppm, Source 2*
[d] *Source 3*

Table 10: Estimated amount of emissions released per kg of fuel burnt[27] [28] [29]

The Committee on Aviation Environmental Protection (CAEP), a technical committee of the ICAO Council, recommends the use a conversion factor of **3.16 g of CO_2 per gram of Jet A.** The 3.16 value can be found in ICAO Doc 9889, 1st edition, 2011, and other documents.

However, in Europe, as early as 2009, Commission Decision 2009/339/EC indicated an **emission factor of 3.15 for the mass conversion from Jet A to CO_2** for the period after January 2021.

In view of the above, emission factor 3.15 should continue to be used in SESAR activities, for the sake of internal consistency within the programme, unless the EU ETS decides to move to 3.16. Emission factor 3.16 should be used when the evaluation concerns comparisons with studies carried out within the ICAO framework or using the factor recommended by ICAO, in order to ensure external consistency.[30]

[27] Source 1: EUROCONTROL, 'European Aviation Fuel Burn and Emissions Inventory System for the European Environment Agency', 2018, https://www.eurocontrol.int/publication/european-aviation-fuel-burn-and-emissions-inventory-system-feis-european-environment
[28] Source 2: MIT, 'Laboratory for Aviation and the Environment – Guidance on the Use of AEDT for Gridded Aircraft Emissions in Atmospheric Models', 2010, https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.719.2090&rep=rep1&type=pdf
[29] Source 3: EUROCONTROL, EASA, EU, 'European Aviation Environmental Report 2022', 21 September 2022, https://www.eurocontrol.int/publication/european-aviation-environmental-report-2022
[30] Digital European Sky guidance and expert opinion

7.2 Other possible sources

- *European Aviation Environmental Report Series*[31]

  The 2022 edition shows the aviation sector has taken steps to address environmental challenges but also that more decisive actions are needed. In particular, the latest trends in aircraft engine emissions are shown in section 3.2. of the document.

- *European Environment Agency (2019), EMEP*[32]*/EEA air pollutant emission inventory guidebook 2023*[33]

  Provides values for emission factors and fuel consumption in different phases of flight – including taxiing – for different aircraft types, using three different levels of accuracy and complexity, in section 1.A.3.a of the document.

- *ICAO Aircraft Engine Emissions Databank*

  Available on the EASA website, this source contains information on exhaust emissions of production aircraft engines, covering engine types whose emissions are regulated, namely turbojet and turbofan engines with a static thrust greater than 26.7 kilonewtons.

- *Swiss Federal Office of Civil Aviation, Aircraft Engine Emissions*[34]

  Presents a measurement and calculation methodology for aircraft piston engine emissions in order to improve aviation emission inventories, as developed by FOCA.

- *Swedish Defence Research Agency*[35]

  Holds a database of emission indices of NOx, HC, and CO, with corresponding fuel flows for turboprop engines.

Related inputs

Rate of fuel burn

Cost of emissions

IFR flight information per market segment

When to use the input?

This input is recommended for a wide use in assessments that focus on the assessment of environmental impact from the burning of fuel at any stage of the flight.

[31] EUROCONTROL, EASA, EU, 'European Aviation Environmental Report 2022'.
[32] EMEP is a cooperative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe
[33] European Environment Agency, 'EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023', 2023, https://www.eea.europa.eu/publications/emep-eea-guidebook-2023
[34] Swiss Federal Office of Civil Aviation, 'Aircraft Engine Emissions', n.d., https://www.bazl.admin.ch/bazl/en/home.html
[35] Swedish Defence Research Agency, 'The Environmental Impact of Aircraft', n.d., https://www.foi.se/en/foi/research/aeronautics-and-space-issues/environmental-impact-of-aircraft.html

8 Cost of emissions

8.1 EUROCONTROL recommended values

The data provided in the following sub-sections show estimations of the cost of CO_2 and other aircraft pollutants released by the combustion of aviation fuel. The data in the tables below comes from the EC DG MOVE Handbook on the external costs of transport.[36]

8.2 Air pollution

According to the Handbook on the External Costs of Transport, for air pollution costs, the marginal costs are virtually equal to the average costs. This is due to the fact that the dose-response relationships between the emissions of air pollutants and health effects are nearly linear.

Distance	Emissions class	Example of aircraft type	Cost per LTO[1]	Cost per pax km[2]	Cost per pax[2]
		Short-haul			
500 km	Low	Bombardier CRJ900	€ 120	€ 0.33	€ 1.68
500 km	High	Embraer 170	€ 162	€ 0.36	€ 1.80
		Medium-haul			
1,500 km	Low	Airbus 320	€ 196	€ 0.08	€ 1.32
1,500 km	High	Boeing 737	€ 219	€ 0.13	€ 1.87
3,000 km	Low	Airbus 320	€ 260	€ 0.06	€ 1.74
3,000 km	High	Boeing 737	€ 290	€ 0.08	€ 2.48
		Long-haul			
5,000 km	Low	Airbus 340	€ 595	€ 0.04	€ 2.01
5,000 km	High	Boeing 777	€ 987	€ 0.05	€ 2.28
15,000 km	Low	Airbus 340	€ 843	€ 0.02	€ 2.86
15,000 km	High	Boeing 777	€ 1,397	€ 0.02	€ 3.22

[1]LTO stands for Landing and Take-Off Cycle

[2]The monetary values originate from Table 23 of the source document and are adjusted from 2019 to 2022 prices according to inflation

Table 11: Marginal air pollution costs of aviation

[36] European Commission DG MOVE, 'Handbook on the External Costs of Transport', 2019, https://op.europa.eu/en/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1

8.3 Climate change

One of the approaches to monetise the climate change costs is to estimate the CO_2 cost avoidance, in compliance with the provisions of Paris Climate Agreement. Table 12 provides an estimate of CO_2 equivalent cost avoidance for the short and medium, and long run.

	Low[1]	Central[1]	High[1]
Short and medium run (up to 2030)	€ 71	€ 119	€ 224
Long run (from 2040 to 2060)	€ 185	€ 319	€ 590

[1]The values originate from Table 23 of the Handbook on the external costs of carbon and are adjusted from 2019 to 2022 prices according to inflation

Table 12: Climate change avoidance costs in euros per tonne of CO_2 equivalent

8.4 Other possible values

The well-to-tank emission costs represent the costs linked to the production of all different types of energy sources, which leads to emissions and other externalities. It includes the extraction of energy, processing, transport, and transmission, building of energy plants, etc.

Table 13 presents the estimated cost of well-to-tank emissions from aviation for 33 EU airports selected for the analysis, as well as its estimated split per passenger km and per passenger.

	Total cost (bn €)[1]	€-cents per pkm[1]	€-cents per pax[1]
Short-haul (< 1,500 km)	€ 1.1	€ 1.2	€ 6.6
Medium-haul (1,500 km > 5,000 km)	€ 2.4	€ 0.8	€ 14.4
Long-haul (> 5,000 km)	€ 6.6	€ 1.0	€ 80.6

[1]The values originate from Table 51 of the Handbook on the external costs of carbon and are adjusted from 2019 to 2022 prices according to inflation

Table 13: Total and average well-to-tank costs for aviation for 33 selected EU airports

Table 14 presents the damage cost factors used for calculation of the emissions impacts on health and other effects. The prices are expressed in euros per kg of emission and covers all modes of transport except maritime.

	NOx	NMVOC	SO_2	PM2.5 (exhaust)
EU27+UK	€ 12.9	€ 1.4	€ 12.9	€ 23.0

[1]The values originate from Table 14 of the Handbook on the external costs of carbon and are adjusted from 2016 to 2022 prices according to inflation

Table 14: Well-to-tank air pollution costs per kg of emission. Damage cost estimates for EU27+UK[37]

[37] European Commission DG MOVE.

8.5 Further reading

Below are listed some sources that may be interesting to consult in the frame of this topic:

- EUROCONTROL (2022), European Environmental Report[38]
- European Commission Climate Action[39]
- UK Department for Environment, Food and Rural Affairs (DEFRA) (2020), Air quality damage cost update 2020[40]

Related inputs

Rate of fuel burn

Amount of emissions released by fuel burn

When to use the input?

This input is recommended for use in assessments focussing on the wider cost/impact of the emissions released in aviation.

[38] EUROCONTROL, EASA, EU, 'European Aviation Environmental Report 2022'.
[39] European Commission, 'European Commission Climate Action', n.d., https://ec.europa.eu/clima/policies/ets/auctioning_en
[40] DEFRA, *Air Quality Damage Cost Update 2020*, 2020, https://uk-air.defra.gov.uk/library/reports?report_id=1006

9 Cost of noise

9.1 EUROCONTROL recommended values

The following figures are recommended to be used to estimate the cost of noise per person affected, taking into account the cost of annoyance as well as the health costs due to exposure to air traffic noise.

Table 15 provides an **estimation of the average cost of annoyance for the population, health-related costs, as well as a total cost (i.e. annoyance and health) from aviation traffic noise for EU27+UK.**

Annoyance refers to the disturbance which individuals experience when they are exposed to noise (e.g. discomfort, inconvenience, etc.).

Health impacts are those caused by long-term exposure to noise, such as stress-related health problems. Evidence has not been strong for all noise-related health impacts, and consequently in the European Handbook on External Costs of Transport, only the following health impacts are considered: hypertension, ischaemic heart disease, stroke, and dementia. Insomnia is not included in order to avoid double-counting with the costs of annoyance.

The data is presented for different noise levels and the values in euros represent the annual cost per person and dB.

Noise level (Lden in dB(A))[1,2]	Annoyance[3]	Health[3]	Total[3]
50-54	€ 40	€ 6	€ 46
55-59	€ 81	€ 7	€ 88
60-64	€ 81	€ 11	€ 91
65-69	€ 153	€ 14	€ 167
70-74	€ 153	€ 19	€ 172
≥ 75	€ 153	€ 25	€ 178

[1]Lden is the common EU indicator which corresponds to the weighted average noise level throughout the day, evening, and night to which a citizen is exposed over a year. One fundamental feature of Lden is that it assumes that evening and night-time noise is more of a nuisance than daytime noise. (Evening noise is given a penalty of 5 dB(A). Night-time noise is given a penalty of 10 dB(A).)

[2]The basic measurement index for noise is the decibel (dB). It is indexed logarithmically, reflecting the logarithmic manner in which the human ear responds to sound pressure. Within the human range of hearing, deep and very high tones at the same sound intensity are experienced as less noisy. To correct for this sensitivity, a frequency weighting is applied to measurements and calculations. The most common frequency weighting is the 'A weighting,' dB(A).

[3]The monetary values originate from Table 33 of the source document and are adjusted from 2016 to 2022 prices

Table 15: Yearly environmental cost of aviation traffic noise for the EU27+UK[41]

[41] European Commission DG MOVE, 'Handbook on the External Costs of Transport'.

Table 16 presents an assessment of the costs of noise for short, medium, and long-haul flights based on an analysis of 33 EU airports.

	Total costs	Average costs			
	€[1]	€ per LTO[1]	€ per pax[2,1]	€ per tonne[1]	€ per km[1]
Short-haul (< 1,500 km)	€ 1bn	€ 305	€ 2.43	€ 10.71	€ 0.55
Medium-haul (1,500 km > 5,000 km)	€ 1bn	€ 305	€ 2.43	€ 10.71	€ 0.33
Long-haul (> 5,000 km)	€ 1bn	€ 305	€ 2.43	€ 10.71	€ 0.01

[1]The monetary values originate from Table 36 of the source document and are adjusted from 2016 to 2022 prices

[2]Costs per pax include the complete flight (not only the half-way principle)

Table 16: Total and average costs of noise cost for aviation at 33 selected EU airports[42]

9.2 Other possible values

Below are presented the results of an economic valuation tool developed by the UK Department for Environment, Food and Rural Affairs. It converts changes in noise exposure to estimated monetary values, in order to support the assessment of the effects of environmental noise. It details the current understanding of the links between environmental noise and various effects, including sleep disturbance, annoyance, hypertension, and related diseases.

Increase in daytime noise metric by one decibel (dB)	Aviation noise marginal cost (excl. sleep disturbance)[1]	Sleep disturbance cost[1]
45-46	€ 20	€ 48
50-51	€ 49	€ 66
55-56	€ 62	€ 85
60-61	€ 80	€ 103
65-66	€ 101	€ 121
70-71	€ 123	€ 121
75-76	€ 146	€ 121
80-81	€ 158	€ 121

[1]The monetary values are adjusted from 2014 to 2022 prices

Table 17: Aviation noise marginal cost per household[43]

[42] European Commission DG MOVE.
[43] UK Department for Environment, 'Environmental Noise: Valuing Impacts on: Sleep Disturbance, Annoyance, Hypertension, Productivity and Quiet', 2014, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/380852/environmental-noise-valuing-imapcts-PB14227.pdf

10 Shadow cost of carbon

10.1 EUROCONTROL recommended values

The shadow cost of carbon is the cost of carbon required to drive the economy to meet the 1.5°C global temperature target set by the Intergovernmental Panel on Climate Change (IPCC). The values have been estimated based on the data provided by the European Investment Bank (EIB) in their 2021-2025 roadmap[44] and represent the cost in euros per tonne of CO_2 equivalent.

The input is an adjustment of the EIB recommended values to reflect the most realistic cost of meeting the Paris Climate Agreement to limit global warming well below 2 degrees Celsius, ideally 1.5 – compared to pre-industrial levels[45]. Please note that this input does not refer to the traditional market price but to the shadow cost of carbon (i.e. considering externalities and future policies). The original EIB proposed inputs are expressed in 2016 prices[46] and have been adjusted to 2022 price levels using the values provided in Table 1.

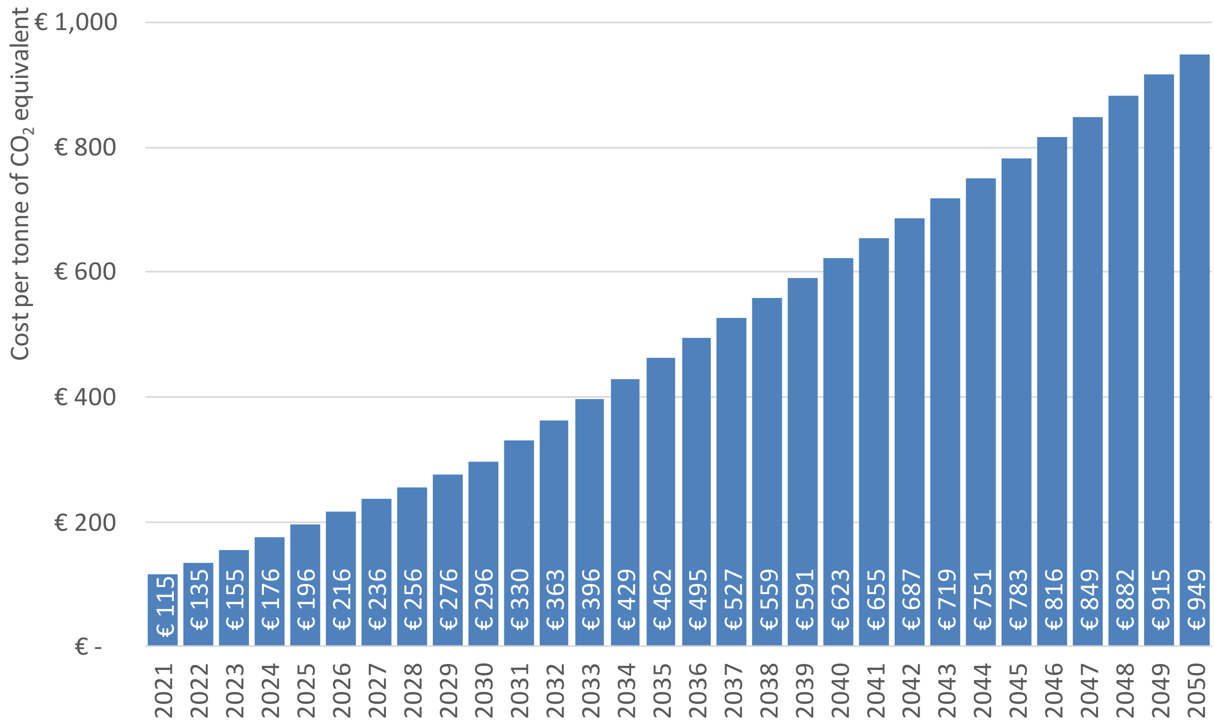

Figure 12: Forecast shadow cost of carbon for EU27 in 2022 prices

[44] European Investment Bank, 'EIB Group Climate Bank Roadmap 2021-2025', November 2020, https://www.eib.org/en/publications/the-eib-group-climate-bank-roadmap

[45] IPCC, 'Global Warming of 1.5 ºC', 2018, https://www.ipcc.ch/sr15/

[46] European Investment Bank, 'EIB Group Climate Bank Roadmap 2021-2025'.

10.2 Comment

In economic analyses the concept of 'shadow cost' is often used when working with an abstract commodity or intangible asset. Typically, two elements are reflected in the 'shadow cost':

- The cost of negative externalities, such as pollution in this case
- The shadow cost involves the consideration of future policies

Shadow costs are inexact by definition, as they are based on assumptions, but their usefulness resides in that they help to understand the full socio-economic merits of a project. Please note that the shadow cost of carbon does not constitute in any way an optimal value for any policy instrument.

Related inputs

Rate of fuel burn

Amount of emissions released by fuel burn

Cost of emissions

Proportion of sustainable aviation fuel

When to use the input?

This input is recommended for projects where the full socio-economic value of the initiative is studied, particularly involving the environmental assessment.

11 Proportion of sustainable aviation fuel

11.1 EUROCONTROL recommended values

This input represents the expected evolution in the proportion of Sustainable Aviation Fuel in the total fuel blend between 2023 and 2050. The evolution is estimated according to three scenarios:

- **Base scenario,** where a moderate traffic growth and uptake of SAF is assumed, in line with ReFuelEU Aviation[47] obligations.
- **High scenario** assumed that the high availability of SAF will foster the quicker adoption of these fuels than outlined in the current regulatory requirements.
- **Low scenario,** which assumes an uptake of SAF slower that outlined by existing regulation.

Year	High scenario	Base scenario	Low scenario
2023	1.4%	1.0%	0.8%
2024	2.1%	1.5%	1.2%
2025	2.8%	2.0%	1.6%
2026	4.2%	2.6%	2.1%
2027	5.7%	3.2%	2.6%
2028	7.1%	3.8%	3.0%
2029	8.6%	4.4%	3.5%
2030	10.0%	5.0%	4.0%
2035	29.6%	20.0%	16.0%
2040	49.1%	32.0%	25.6%
2045	68.7%	38.0%	30.4%
2050	88.2%	63.0%	50.4%

Table 18: Forecast evolution of SAF blend 2023-2050[48]

Table 18 shows the forecast sustainable aviation fuel blending percentage over total jet fuel for years 2023 to 2050. The values are provided based on the 3 forecast scenarios proposed by the EUROCONTROL Aviation Outlook.[49] The percentages of sustainable aviation fuel are based on:

- The series starting with a projection of the 2022 actual sustainable aviation fuel blending.
- A linear interpolation, until in 2030 the required 5% of the ReFuelEU Aviation proposal is met, followed by the same linear growth until 2050.

Other underlying assumptions worth mentioning are:

[47] 'Fit for 55 and ReFuelEU Aviation', EASA, accessed 12 December 2022, https://www.easa.europa.eu/en/light/topics/fit-55-and-refueleu-aviation

[48] EUROCONTROL, 'Objective Skygreen 2022-2030. The Economics of Aviation Decarbonisation towards the 2030 Green Deal Milestone', 23 May 2022, https://www.eurocontrol.int/publication/objective-skygreen-2022-2030

[49] EUROCONTROL, 'EUROCONTROL Aviation Outlook 2050'.

- The regulation imposes obligations only on the fuel suppliers, not on the airlines.
- Objective Skygreen 2022-2030 assumes that the SAF blending percentages apply to all the airports within the Network Manager area.

The figure below depicts the expected SAF blending percentages. Points are the yearly percentages expected and the dotted line is a trend line adjustment.

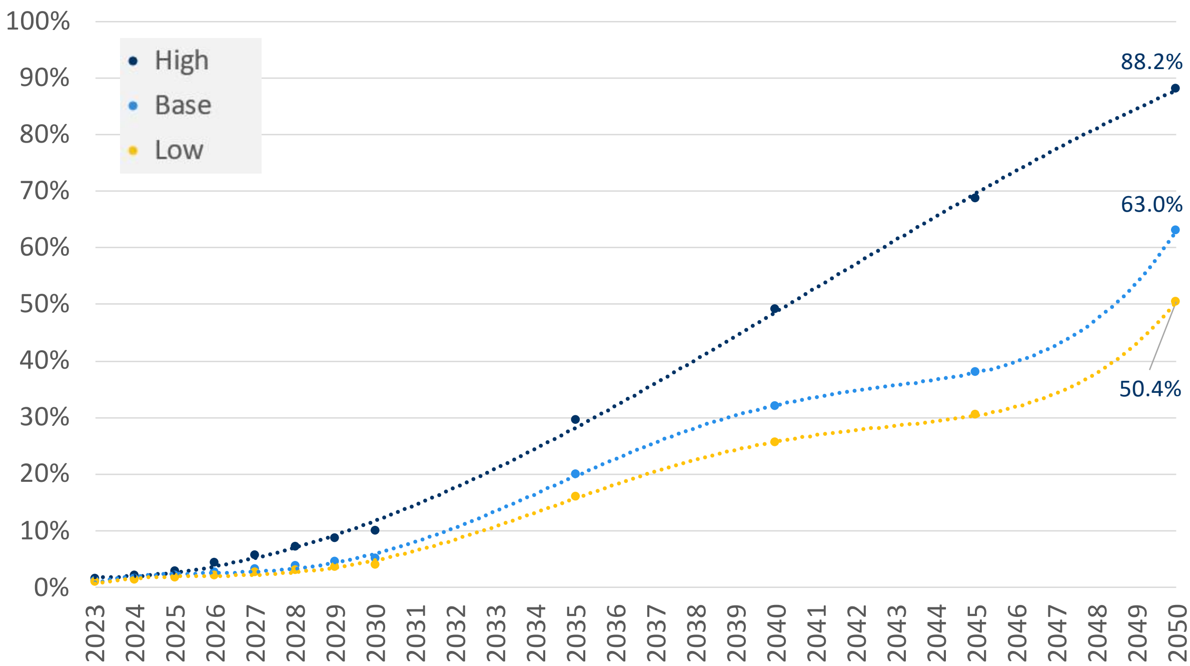

Figure 13: Forecast evolution of SAF proportion 2023-2050[50]

11.2 Comment

Non-conventional fuels – SAF are non-fossil derived – can be used in aviation if blended with conventional kerosene. Many experts agree that this is the most promising option to reduce aviation emissions in the short to medium term. The ReFuelEU Aviation initiative – put forward by the European Commission in the Fit for 55 package – imposes a mandate on fuel suppliers to provide SAF in jet fuel available in EU airports. The proposal defines a series of percentages of SAF blending that will have to be met at specific years. For further research, please visit the EUROCONTROL Aviation Sustainability Unit.

Related inputs

Rate of fuel burn

Amount of emissions released by fuel burn

Cost of emissions

Shadow cost of carbon

When to use the input?

This input is recommended to be used when dealing with environment-related assessments, such as to estimate the environmental impact from an initiative taking into consideration the possible change in the fuel mix.

[50] EUROCONTROL, 'Objective Skygreen 2022-2030. The Economics of Aviation Decarbonisation towards the 2030 Green Deal Milestone'.

AIRSPACE USERS

12 Aircraft operating costs

12.1 EUROCONTROL recommended values

Table 19 presents the flight and ground costs linked to the operation of an aircraft, such as fuel and oil, flight deck crew, flight equipment depreciation and amortisation, aircraft rentals, landing fees, ground handling, aircraft parking, air bridges and maintenance.

Aircraft type	Per aircraft per year ($M)	Per flight hour	Per flight cycle	Per available seat km (¢)	Per available ton km (¢)
B737 NG	$ 14.11	$ 4,337	$ 9,231	¢ 3.76	¢ 33.11
A320 Family	$ 12.84	$ 4,829	$ 8,851	¢ 3.60	¢ 36.92
B737 Classic	$ 8.26	$ 2,683	$ 5,366	¢ 2.96	¢ 25.28
B777	$ 40.01	$ 9,507	$ 60,367	¢ 3.53	¢ 22.07
A330	$ 29.87	$ 7,827	$ 35,857	¢ 3.61	¢ 24.48
B757	$ 18.21	$ 5,357	$ 18,508	¢ 3.73	¢ 30.51
B767	$ 26.00	$ 6,675	$ 40,899	¢ 3.61	¢ 22.18
B787	$ 30.58	$ 7,184	$ 50,827	¢ 3.11	¢ 19.86
EMB-190	$ 10.87	$ 4,097	$ 5,770	¢ 6.35	¢ 54.00
Dash 8	$ 4.03	$ 1,921	$ 1,921	¢ 6.12	¢ 58.08

Table 19: Aircraft Operating Costs in USD 2022 prices[51]

[51] 'IATA Airline Cost Management Group', n.d., https://www.iata.org/en/services/finance/airline-cost-mgmt/

Figure 14 shows the average airline cost structure for 2019 (considering the jet kerosene price at $66.9 per barrel).

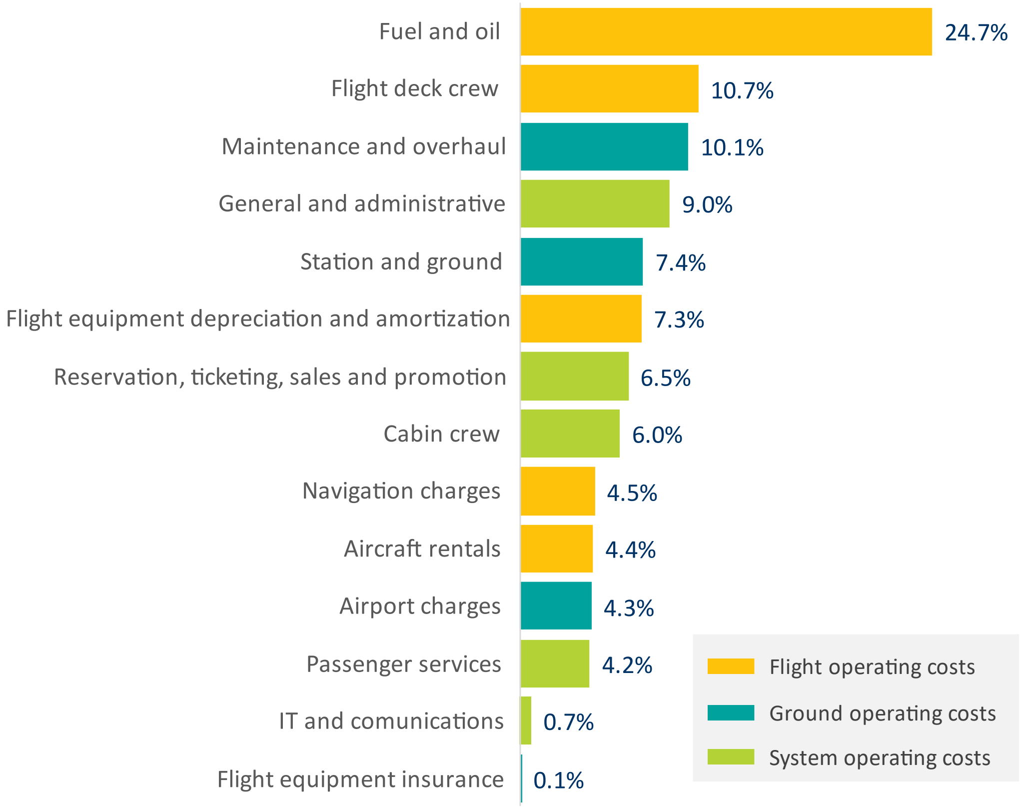

Figure 14: Airline Cost Structure (2019)[52]

The above values, provided by IATA, refer to the 2020 Airline Cost Management Group (ACMG) data collection (fiscal year 2019) and provide an overview of the operating costs for 10 types of aircraft (B737 NG, A320 family, B737 Classic, B777, A330, B757, B767, B787, EMB-190 and Dash 8). The IATA ACMG collects operating costs classified into three categories.

These categories are shown in Figure 15 and are defined as follows:

- **Flight operating costs** are direct operating expenses. They are directly related to the aircraft and the flight activities of an airline, such as flight crew, fuel, flight equipment and navigation. The biggest component of flight operating expenses is fuel and oil at 48%.
- **Ground operating costs** are also direct operating expenses. They are directly related to the ground activities of an airline, such as maintenance and overhaul, airport charges, station, and ground. Maintenance and overhaul are the biggest cost component at 46%.
- **System operating costs** are overheads and indirect operating expenses. They are not directly related to flight or ground operating expenses. They include costs for cabin crew, passenger service, load insurance, reservations, ticketing, sales, and promotion, IT and communications, and general and administrative costs, with the latter representing 34% of total system operating expenses.

[52] 'IATA Airline Cost Management Group'.

Below, the airline cost structure for each category of expenses (2019):

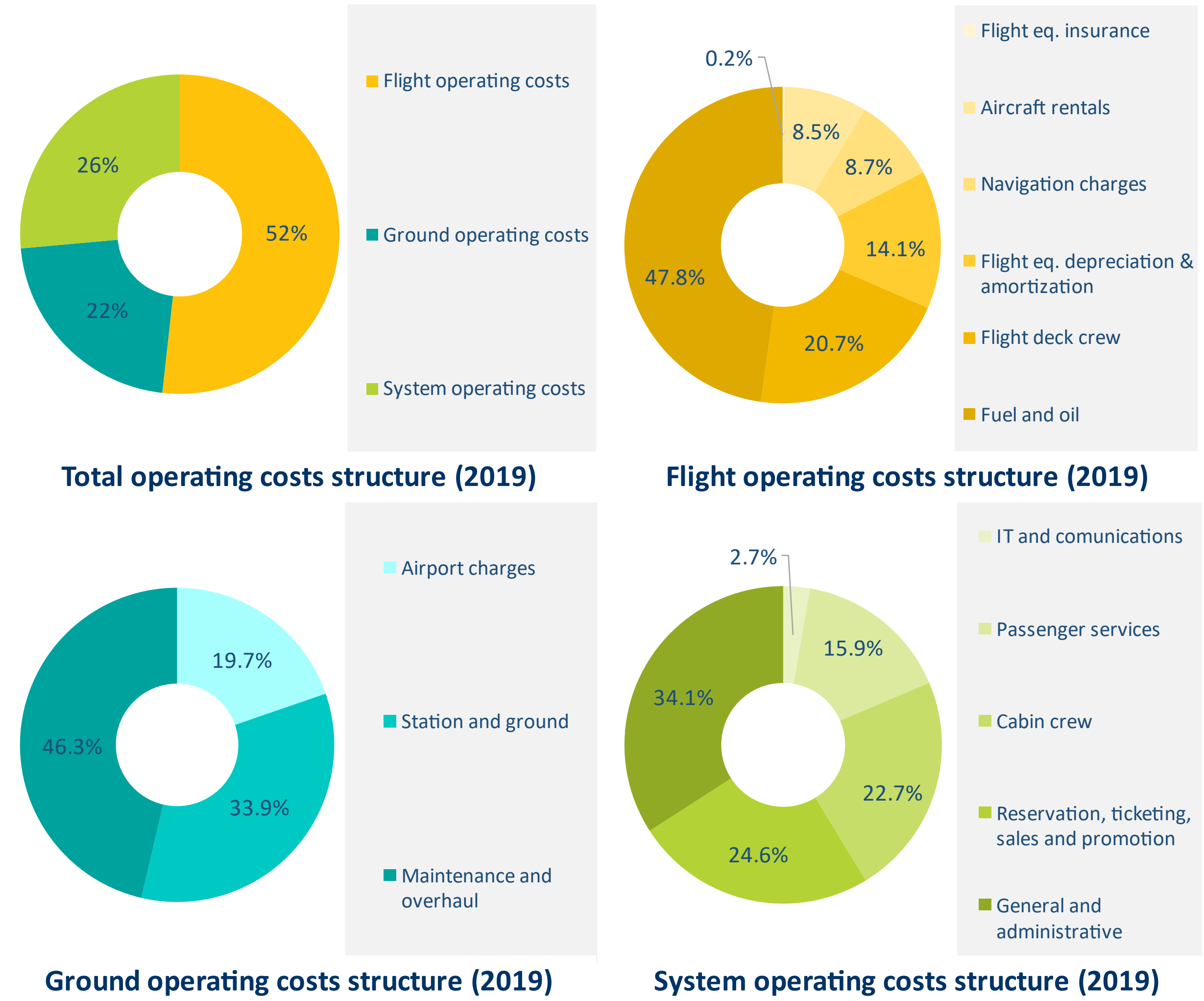

Figure 15: Airline cost structure

12.2 Data scope

The values used for analysis are the result of aggregating the cost data provided by 51 airlines worldwide ($26.5 billion expenditure), covering over 35% of the industry in terms of revenue passenger kilometres (RPKs), with European airlines representing 16% of the share and 12% in terms of passengers carried.

12.3 Data limitations

In a number of jurisdictions, airport charges and taxes that are levied on a per-passenger basis are not accounted for in airline profit and loss accounts. As a result, the share of airport charges is likely to be significantly understated, as airports may levy more on (i) a per-passenger or (ii) per-aircraft basis in some jurisdictions. To give an order of magnitude, in some regions the ACI (Airports Council International) estimates that over 50% of airport charges are collected on a per-passenger basis, reaching as much as 80% in some regions worldwide.

13 Average number of passengers

13.1 EUROCONTROL recommended values

Figure 16 presents an overview of the total and average number of passengers per flight in ECAC.

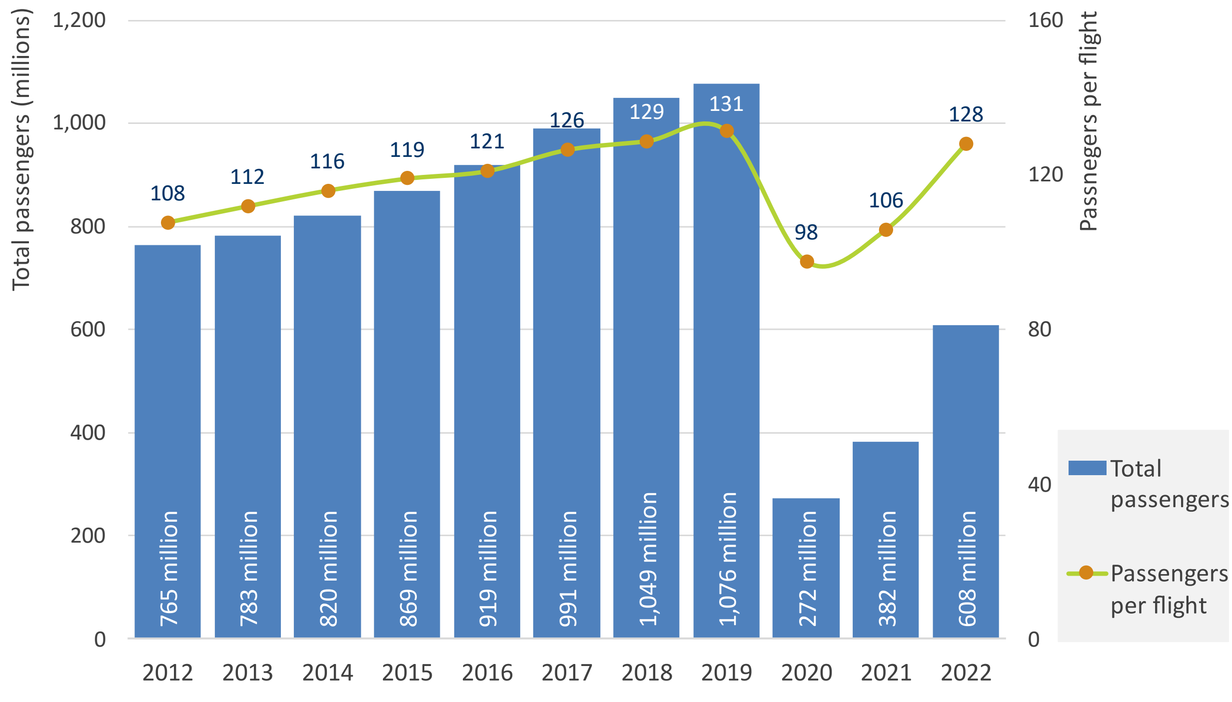

Figure 16: Number of passengers per flight in ECAC 2012-2022[53]

13.2 Comment

The Eurostat air transport domain contains national and international intra- and extra-EU data. This provides air transport data for passengers (in numbers of passengers) and for freight and mail (in thousands of tonnes), as well as air traffic data for airports, airlines, and aircraft. Data are transmitted to Eurostat by the Member States of the European Union as well as Iceland, Norway, Switzerland, and the candidate countries. The air transport data have been calculated using data collected at airports.

Related inputs

Number of IFR flights

When to use the input?

This input is suitable to be used in any analysis that requires historical data on the number of passengers per flight and/or per movement.

[53] EUROCONTROL STATFOR, 'STATFOR Interactive Dashboard'.

14 Cancellation cost

14.1 EUROCONTROL recommended values

Table 20 presents the average cost of cancellation of a commercial flight on the day of operation, adjusted from 2014 to 2022 prices. The values are provided for different types of aircraft, based on the number of seats.

	Narrow body				Wide body	
	Traditional network carrier			Low-cost carrier	Traditional network carrier	
Seats	50	120	180	189	250	400
Cost of cancellation	€ 6,790	€ 16,640	€ 25,720	€ 18,570	€ 85,570	€ 123,900
of which passenger care and compensation	*€ 3,100*	*€ 7,600*	*€ 12,400*	*€ 17,500*	*€ 40,500*	*€ 64,800*

Table 20: Average cost of cancellation of a commercial flight on the day of operation[54]

Note

Traditional carrier estimates can be used for regional carriers.

The values presented above refer to cancellation on the day of operation and include the following:

- Service recovery costs (i.e. passenger care), and passenger compensation for denied boarding and missed connections, estimated based on the application of the Regulation (EC) No 261/2004
- Loss of revenue
- Interlining costs
- Loss of future value (i.e. passenger opportunity cost (individual passenger delay expressed in value))
- Crew and catering costs
- Luggage delivery costs
- Operational savings (e.g. fuel, airport and navigation fees, maintenance, handling outstations, lounge outstations)

Ground handling costs (e.g. ramp services, passenger services and field operation services) are not included in the estimation.

An **alternative value** encompassing the **system-wide average cancellation cost** was also estimated by the experts, amounting approximately **€20,930** (adjusted from 2014 to 2022 prices).

[54] Data supplied by the airline members of the SESAR CBA team and expert judgment derived from an analysis of 2012 total flights carried out in Europe

14.2 Comment

When a flight is carried out, the airline incurs out-of-pocket expenses (i.e. variable costs) but receives revenues which are 60-100% greater than the out-of-pocket expenses. Cancelling a flight means that the airline forgoes a substantial operating profit. Also, in addition to the loss, costs are incurred for the care and compensation of passengers.

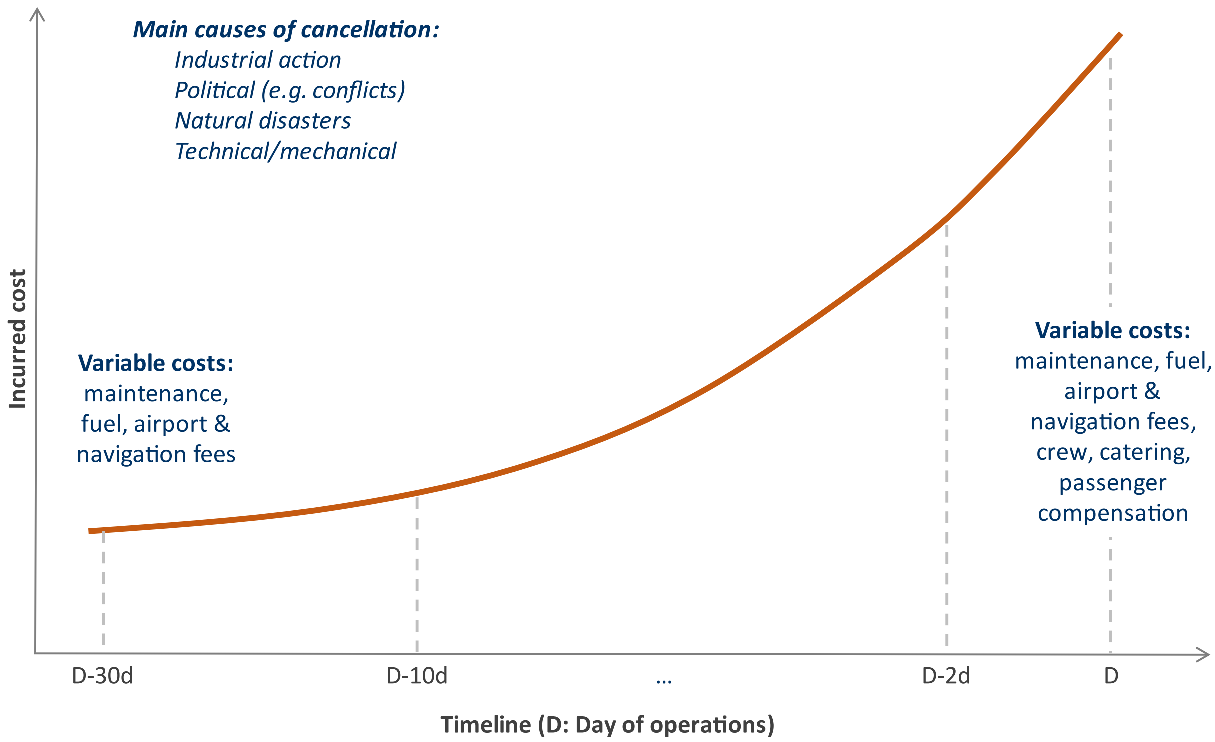

Figure 17: Cancellation costs as a function of time

Timely cancellation will enable the airline to take the necessary measures to mitigate the cost impact, for example by rebooking passengers on another flight and allocating crew and aircraft to a different destination. The cancellation costs will thus be minimal and more in the region of the incurred opportunity cost and passenger value of time. If the cancellation is nearer the flight time (i.e. on the day of operation (D)), the cost of cancellation increases, to cover expenses such as fuel, maintenance, and crew and catering.

Related inputs

Operational cancellation rate

15 Operational cancellation rate

15.1 EUROCONTROL recommended values

Below is presented the rate of IFR flight cancellations in Europe.

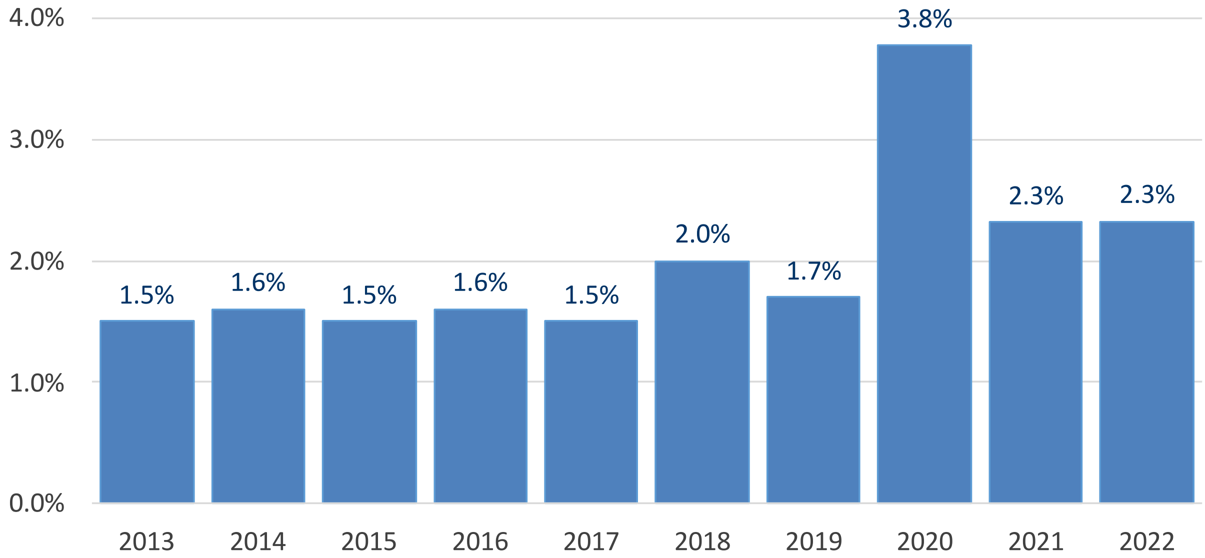

Figure 18: Operational cancellation rate in Europe[55]

According to EUROCONTROL Specification for Operational ANS Performance Monitoring - Air Transport Operator Data Flow, which is referenced in Commission Implementing Regulation EU No 2019/317 as a document containing the provisions for information that needs to be provided by the airlines, an 'operational cancellation' refers to a scheduled arrival or departure flight to which the following conditions apply:

- the flight received an airport slot (if the airport is subject to slot coordination), and
- the flight was confirmed by the air carrier the day before operations and/or it was contained in the daily list of flight schedules produced by the airport operator the day before operations, but
- the actual landing or take-off never occurred.

Reports about all causes of delay (and cancellation up to 2019) are available in the EUROCONTROL library.

Note

In 2020 the COVID-19 pandemic strongly influenced the entire aviation industry with more than double the cancellation rate seen in 2019.

Related inputs

Cancellation cost

[55] Source: Data provided by the airlines to EUROCONTROL Central Office for Delay Analysis.

16 Cost of delay

16.1 EUROCONTROL recommended values

The tables below present an overview of the **average cost per minute to the airline of ground or airborne delay of a commercial passenger flight.** Please note that all the numbers are based on studies performed by the University of Westminster. Values in Table 21 and Table 22 are calculated on the basis of University of Westminster (UoW) reference values (European airline delay cost reference values report, version 4.1). Delay cost details by aircraft and length of delay, extracted from the UoW report, are given in section 16.2.

The figures presented in this section constitute high-level averages and are valid as indicative estimates. **It is strongly recommended that they are used as indicators or for general insights into delay costs and not for specific analyses or operational planning.** Different values may be obtained for other contexts (e.g. other airspace areas or airports (hub or non-hub), etc.), with different aircraft and delay distributions.

Flight phase	All delays (0 to >300 min)	Short delays (<30 min)
Ground		
At gate	€ 166	€ 45
Taxiing in/out	€ 182	€ 62
Airborne		
En-route (cruise extension)	€ 212	€ 89
Arrival management	€ 206	€ 84

[1]The monetary values are adjusted to 2022 prices based on inflation

Table 21: Tactical delay cost with network effect (i.e. incl. reactionary delay) per minute[56]

Flight phase	Cost per minute
Ground	
At-Gate	€ 18
Taxi in / out	€ 47
Airborne	
En-Route (cruise extension)	€ 83

Table 22: Strategic delay cost[57]

On top of the above, **the network average cost of ATFM delay[58] amounts € 100 per minute.[59]**

[56] Calculated based on University of Westminster (2015), European airline delay cost reference values - version 4.1. Also available in 2004 iteration.

[57] Ibid.

[58] ATFM delay is defined as the duration between the last take-off time requested by the aircraft operator and the take-off slot allocated by the Network Manager following a regulation communicated by the flow management position (FMP), in relation to an airport (airport ATFM delay) or sector location (en route ATFM delay).

[59] This value is a reference extracted from a University of Westminster report (European airline delay cost reference values report, version 4.1). Please note that this is an average overarching value and should be regarded as such.

The University of Westminster (UoW) report, published in 2004 and updated in 2011 and 2015, represents the most recent and comprehensive appraisal of the cost of delay in the air traffic management system in Europe. The report is designed as a reference document for European delay direct costs incurred by airlines, both at strategic (planning) and tactical stages.

It contains a detailed assessment of the delay cost for 15 specific aircraft types (extended from 12 in the previous report versions), taking into account crew, fuel, fleet, maintenance, and passenger additional costs due to delay. Note that the list of aircraft used for this report does not include some recent types such as Airbus NEO Series, A220, A350 or B787.

In the study, costs are assigned under three cost scenarios: low, base, and high. These scenarios are designed to cover the probable range of costs for European operators. The base cost scenario is, to the greatest extent possible, designed to reflect the typical case and is, therefore, the one used in this value.

The University of Westminster report presents costs of delay in four flight phases: at gate, taxiing, en-route (cruise extension) and arrival management. For accuracy reasons, the definitions used by the University of Westminster are presented in Figure 19. They are extracted from the UoW 2004 and 2011 reports.

16.2 Flight phases, types of delay costs and calculation method used

Figure 19 describes the flight phases, types of delay costs and the calculation method used in the UoW study.

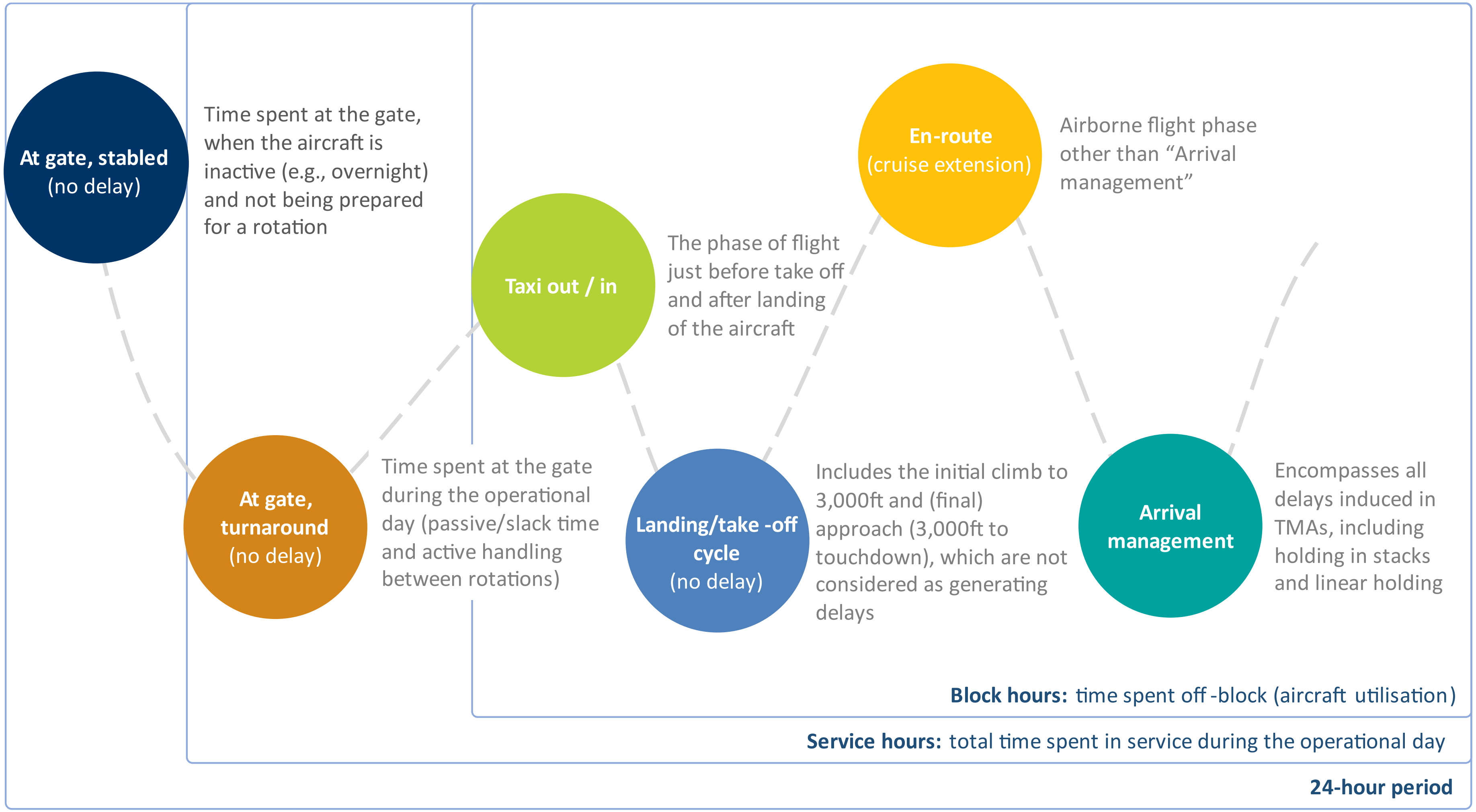

Figure 19: Overview of the different flight phases

Types of delay costs

- **Tactical delay costs are incurred on the day of operations.** In most cases, it is anticipated that the user will find it appropriate to use the full tactical costs in order to calculate these costs of delay. These include the reactionary costs of 'knock-on' delay in the rest of the network, i.e. the network effect, which it is usually pertinent to include.

- **Strategic delay costs are accounted for in advance.** Strategic costs are typically used to assess the cost of adding buffers to schedules. This could be by airline choice or imposed by scheduling constraints at an airport (and thus considered a cost of congestion, albeit one which offsets tactical delay costs). Strategic costs may also be incurred as a consequence of factors which contribute to an increase in flight time in a predictable way, such as delay due to route design.

Calculation method

The tactical and strategic delay costs referred to in Table 21 and Table 22 are calculated based on the results extracted from the University of Westminster (UoW) study report "European airline delay cost reference values – Updated and extended values Version 4.1" – December 2015. Explicit cost tables for analytical use (up to 30 minutes of delay) are presented at the end of this section. The extended tables can be found in the UoW report mentioned above.

As regards **tactical delay costs,** these are given for 5, 15, 30, 60, 90, 120, 180, 240 and 300 minutes in the UoW report. These are **scaled up to network level, because on the day of operations, original delays caused by one aircraft cause 'knock-on' effects** in the rest of the network (reactionary delays).

Based on at-gate data provided by the Central Office for Delay Analysis (CODA) on ranges of departure delays[60] by aircraft type for year 2014, assumptions have been made for the remaining three flight phases (i.e. taxi, en-route, and arrival management). The same delay distribution has been used as an assumption applicable to all flight phases.

The UoW results have been averaged by minute of delay per type of aircraft (15 in total) and further weighted by the distribution of the number of delayed flights per delay range, at departure, carried out by these aircraft in 2014.

Consequently, for each flight phase, two types of values have been calculated:

1. one taking into account long delays (i.e. 0 to more than 300 minutes)
2. one taking into account short delays (i.e. up to 30 minutes), which represent about 90% of all delays

As regards **strategic delay, since costs at the strategic level are incorporated into the aircraft operator's schedule in advance, they are associated with average costs** and, therefore, only a distribution of the number of flights was applied in order to calculate the strategic high-level averages.

[60] In the University of Westminster 2015 Study Report, departure delay is assumed to equal arrival delay. For consistency purposes, the calculation methodology developed uses the same assumption.

Use of costs in business cases

When comparing two scenarios, it is not correct to calculate the delay avoided as a benefit without taking into account the corresponding marginal cost of capacity. In other words, there is a delay threshold below which the marginal cost of capacity outweighs the delay avoidance benefit.

Every CBA should carefully consider whether the improvements envisaged by the project are of a tactical or strategic nature. For the correct use and precise understanding of the tactical and strategic delay concepts, see section 4 of, and Annex I to, the 2004 University of Westminster delay study.

16.3 Delay cost details by aircraft type and duration

In the tables below are presented the explicit cost data as extracted from University of Westminster study and adjusted to 2022 prices.

	Delay magnitude (minutes)											
	At gate			Taxiing			En-route			Arrival management		
Aircraft type	5'	15'	30'	5'	15'	30'	5'	15'	30'	5'	15'	30'
A319	€ 83	€ 523	€ 1,901	€ 154	€ 724	€ 2,305	€ 286	€ 1,128	€ 3,112	€ 262	€ 1,057	€ 2,982
A320	€ 95	€ 594	€ 2,162	€ 178	€ 844	€ 2,672	€ 297	€ 1,199	€ 3,386	€ 297	€ 1,187	€ 3,350
A321	€ 119	€ 689	€ 2,566	€ 201	€ 927	€ 3,041	€ 357	€ 1,414	€ 4,015	€ 333	€ 1,343	€ 3,873
A332	€ 213	€ 1,176	€ 4,218	€ 404	€ 1,722	€ 5,310	€ 677	€ 2,542	€ 6,961	€ 558	€ 2,185	€ 6,237
AT43	€ 36	€ 213	€ 724	€ 71	€ 309	€ 915	€ 83	€ 345	€ 986	€ 83	€ 345	€ 986
AT72	€ 47	€ 286	€ 974	€ 83	€ 392	€ 1,199	€ 107	€ 463	€ 1,343	€ 107	€ 440	€ 1,295
B733	€ 83	€ 511	€ 1,842	€ 166	€ 749	€ 2,317	€ 297	€ 1,140	€ 3,112	€ 250	€ 1,010	€ 2,851
B734	€ 95	€ 570	€ 2,067	€ 178	€ 820	€ 2,577	€ 309	€ 1,199	€ 3,326	€ 297	€ 1,164	€ 3,243
B735	€ 83	€ 463	€ 1,663	€ 166	€ 712	€ 2,150	€ 274	€ 1,045	€ 2,816	€ 213	€ 879	€ 2,483
B738	€ 107	€ 641	€ 2,305	€ 178	€ 856	€ 2,745	€ 321	€ 1,283	€ 3,599	€ 297	€ 1,211	€ 3,457
B744	€ 286	€ 1,627	€ 5,939	€ 546	€ 2,400	€ 7,484	€ 1,104	€ 4,086	€ 10,857	€ 844	€ 3,279	€ 9,242
B752	€ 119	€ 736	€ 2,720	€ 237	€ 1,093	€ 3,445	€ 404	€ 1,592	€ 4,431	€ 345	€ 1,402	€ 4,062
B763	€ 201	€ 1,069	€ 3,802	€ 345	€ 1,497	€ 4,656	€ 606	€ 2,281	€ 6,225	€ 570	€ 2,173	€ 6,022
DH8D	€ 47	€ 297	€ 1,057	€ 83	€ 404	€ 1,272	€ 130	€ 534	€ 1,520	€ 130	€ 534	€ 1,520
E190	€ 71	€ 380	€ 1,366	€ 130	€ 558	€ 1,722	€ 213	€ 832	€ 2,269	€ 213	€ 820	€ 2,234

Table 23: Total tactical delay costs with network effect - base scenario[61]

[61] University of Westminster, 'European Airline Delay Cost Reference Values - Version 4.1', 2015, https://www.eurocontrol.int/publication/european-airline-delay-cost-reference-values

Aircraft type	At gate	Taxiing	En-route
A319	€ 962	€ 2,281	€ 4,062
B734	€ 1,069	€ 2,566	€ 4,145
B735	€ 1,248	€ 2,756	€ 4,906
B738	€ 2,043	€ 5,036	€ 8,576
B752	€ 274	€ 891	€ 1,069
B763	€ 404	€ 1,164	€ 1,509
B744	€ 641	€ 2,031	€ 3,802
A319	€ 712	€ 2,221	€ 3,908
A320	€ 606	€ 2,031	€ 3,504
A321	€ 1,199	€ 2,459	€ 4,336
AT43	€ 1,782	€ 5,892	€ 13,007
AT72	€ 856	€ 2,839	€ 5,001
DH8D	€ 1,556	€ 4,015	€ 7,401
E190	€ 641	€ 1,354	€ 1,936
A332	€ 915	€ 2,043	€ 3,267

Table 24: Strategic delay costs per hour - base scenario[62]

Related inputs

Air traffic statistics and forecasts

Air traffic delay

When to use the input?

This input is suitable for calculation of the cost of a delayed flight on airspace users.

[62] University of Westminster.

17 Cost of diversion

17.1 EUROCONTROL recommended values

Table 25 and Table 26 present the estimated **average cost of the diversion of a flight to an airport other than the one initially planned.** The values are split between commercial and business aviation, and, where available, represent a range of values as estimated by the airline members consulted.

Type of flight	Cost of diverted flight[1]
Regional flights	€ 1,000 – € 7,000
Continental flights	€ 1,400 – € 10,500
Intercontinental flights	€ 7,000 – € 77,200

[1]*Monetary values were adjusted from 2006 to 2022 prices according to inflation*

Table 25: Estimated average cost of a diversion for commercial aviation[63]

Note

The penalties associated with the late delivery of cargo are not considered in the estimation, as this type of data is not yet readily available.

Type of flight	Cost of diverted flight[1]
Business aviation	€ 8,800

[1]*Monetary values were adjusted from 2012 to 2022 prices according to inflation*

Table 26: Estimated cost of diversion for business aviation[64]

Note

The estimated cost for business aviation assumes that for each diverted flight there is one additional positioning flight.

In 2022, out of the total number of flights (9.3 million) with a destination in the EUROCONTROL Network Manager area, 28,738 flights (0.3%) landed at an airport other than the one initially planned.

[63] Data supplied by the airline members of the SESAR evaluation team, derived from an analysis of 2006 ECAC data
[64] Data supplied by the airline members of the SESAR CBA team (2015)

18 Turnaround time

18.1 EUROCONTROL recommended values

Turnaround time represents the time taken for unloading and ground handling preparation for the return journey of an aircraft. This corresponds to the time during which the aircraft must remain parked at the gate, including air traffic flow management (ATFM) delay.

Table 27 presents the evolution of mean scheduled and mean actual turnaround time, in minutes, for medium and heavy aircraft. Please note that this data was provided by EUROCONTROL Central Office for Delay Analysis (CODA) and can be accessed, upon registration, together with a number of additional information, on the MIRROR tool.

	Heavy[1]		Medium[1]	
Year	**Scheduled**	**Actual**	**Scheduled**	**Actual**
2018	117	131	49	57
2019	117	131	50	57
2020	116	127	50	56
2021	116	125	51	57
2022	119	134	50	59

[1]Heavy, medium, and light (not included here) relate to ICAO wake vortex aircraft categories based on the maximum certified take-off mass: Heavy aircraft types of 136,000 kg (300,000 lb) or more; Medium aircraft types less than 136,000 kg (300,000 lb) and more than 7,000 kg (15,500 lb); Light aircraft types of 7,000 kg (15,500 lb) or less

Table 27: Scheduled vs. actual turnaround time in ECAC, in minutes[65]

The values presented in Table 27 include the data on the following market segments: traditional scheduled, low-cost and charter.

The total ground time of an aircraft includes overnight stops, maintenance slots, fire breaks, etc., so specific cut-off values are applied to obtain the turnaround time. The turnaround cut-off time for wake turbulence category H (Heavy) is 180 minutes, and for M (Medium) 150 minutes.

The actual turnaround time represents the difference between the actual off-block time (AOBT) of a departing flight and the actual in-block time (AIBT) of the same aircraft on the previous inbound flight. The scheduled turnaround time is the difference between scheduled time of departure (STD) of the departing flight and the scheduled time of arrival (STA) of the same aircraft on the previous inbound flight.

[65] EUROCONTROL – Computed from data supplied by the airline members to CODA

18.2 Other possible values

Table 28 presents, for 2022, an overview of turnaround time ranges for the 10th (Low), 50th (Base) and 90th (High) percentiles.

Aircraft category	Low	Base	High
Actual			
Heavy	60	90	150
Medium	25	45	80
Scheduled			
Heavy	67	106	168
Medium	31	52	93

Table 28: Turnaround time ranges, in minutes, in 2022[66]

18.3 Comment

Turnaround time and ground time typically vary as a function of:

- the airport
- the market segment (traditional scheduled airline, low-cost, business aviation, etc.)
- the type of service/segment (charter, scheduled, positioning, etc.)
- the type of flight (short, medium, or long-haul)
- the type of aircraft (B738, A320, etc.)

The turnaround process involves activities related to the handling of tasks to ensure the cleanliness, safety, and efficiency of the next flight. The difference between a turnaround and ground time is that an aircraft at its home base airport will have longer ground time to cover, for example, the time it needs for maintenance. Figure 20 shows the scope of the various activities, including ground handling time[67].

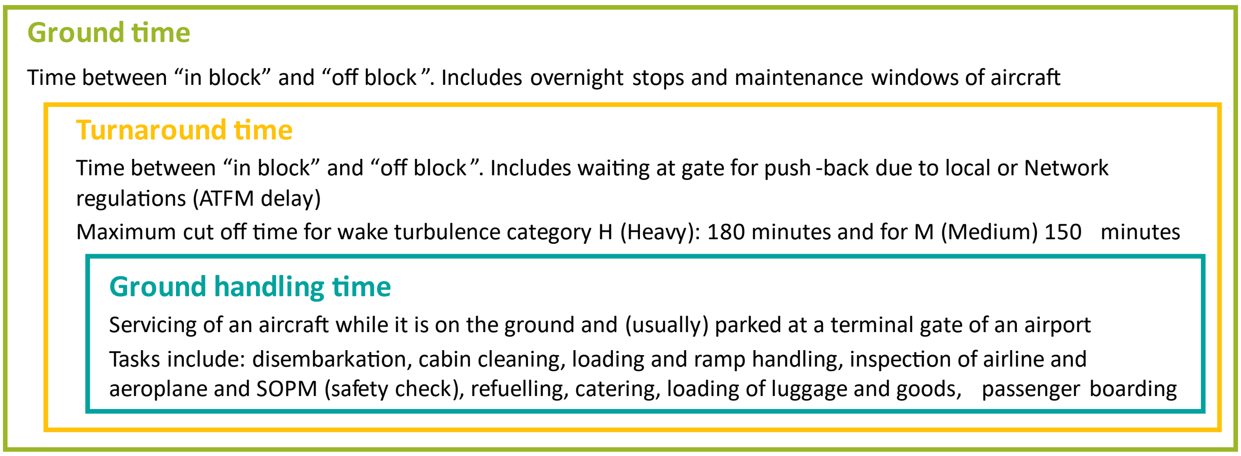

Figure 20: Overview of activities involved in turnaround process

[66] EUROCONTROL – Computed from data supplied by the airline members to CODA
[67] An exhaustive definition and list of ground handling services is given in Council Directive 96/67/EC

19 IFR average flight distance and duration

19.1 EUROCONTROL recommended values

Table 29 presents an overview of the average flight distance flown in the ECAC region, as well as the average flight time in the same region for the period 2017-2022.

The data was obtained by dividing the total distance actually flown and the total yearly IFR flight hours, respectively, by the yearly number of IFR flights in the ECAC airspace. Please note that the numbers for 2020 and 2021 are considerably lower due to the effect of the COVID-19 pandemic.

	2017	2018	2019	2020	2021	2022
Distance (km)	1,197	1,209	1,220	510	661	1,067
Distance (NM)	646	653	659	275	357	576
Flight time (min)	98.4	100.1	101.3	97.5	100.0	108.7

Table 29: Average IFR flight distance and duration in ECAC[68] [69] [70]

With regard to flight distance, Figure 21 illustrates that nearly 90% of IFR flight distances for flights arriving or departing within the Network Manager area (excl. overflights) are less than 1,000NM long.

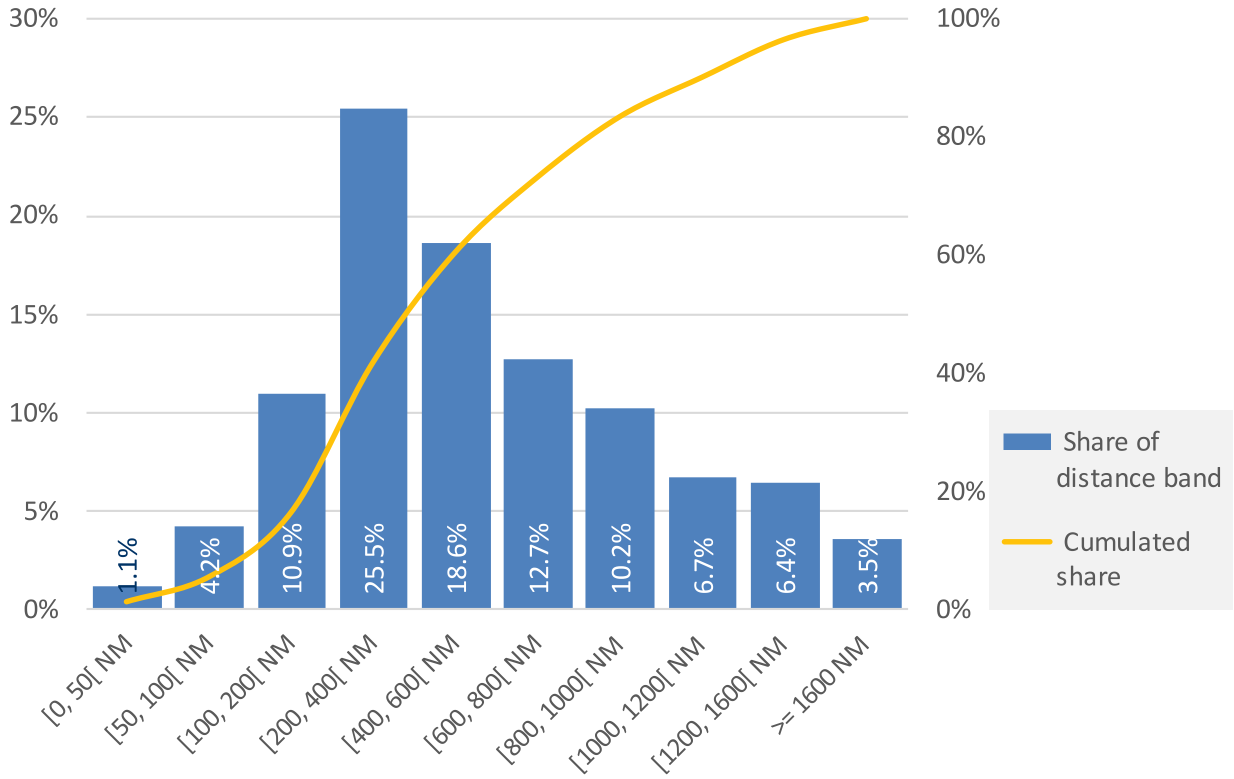

Figure 21: Distribution of traffic demand per distance band in 2022 within the EUROCONTROL Network Manager area

[68] EUROCONTROL, 'Performance Review Report (PRR) 2020', 2021, https://www.eurocontrol.int/publication/performance-review-report-prr-2021
[69] EUROCONTROL.
[70] EUROCONTROL STATFOR, 'STATFOR Interactive Dashboard'.

Related inputs

IFR flight information per market segment

Distance flown by charging zone

20 IFR flight information per market segment

20.1 EUROCONTROL recommended values

Table 30 shows the mean distance, fuel consumption and flight duration of an IFR flight, per market segment, in the ECAC region. These values refer to year 2021.

Market segment	Number of IFR flights	Average flight distance (NM)	Average flight duration (min)	Average fuel burn (kg)
Flights within ECAC				
Traditional scheduled	2,028,273	466	97	3,144
Low-cost	1,423,613	706	127	4,695
Business aviation	595,555	402	92	861
Non-scheduled charter	209,977	586	118	3,538
Other types	265,609	189	88	392
All cargo	229,566	478	99	5,955
Total/average	**4,752,593**	**471**	**104**	**3,098**
International flights entering and leaving ECAC				
Traditional scheduled	671,271	2,855	396	36,909
Low-cost	97,720	1,344	212	9,106
Business aviation	87,016	1,969	291	5,856
Non-scheduled charter	151,769	1,933	289	19,996
Other types	8,142	2,331	343	23,044
All cargo	113,382	3,310	450	60,065
Total/average	**1,129,300**	**2,290**	**330**	**25,829**

Table 30: Average IFR flight values per market segment, year 2021[71]

The calculations were made on the basis of:

- Full year total distance and ECAC distance flown, extracted from data collected by the Network Manager, not including overflights
- The EUROCONTROL Small Emitters Tool (SET) approved by the European Commission by Commission Regulation (EU) No 606/2010
- Use of the latest version of the BADA[72] tabulated model 4 and AEM (Advanced Emission Model)
- Fuel burn figures, not taking into account the reduction in the aircraft's weight in fuel during the flight

[71] EUROCONTROL – calculated by AEM, BADA tabulated
[72] EUROCONTROL, 'Base of Aircraft Data (BADA)', n.d., https://www.eurocontrol.int/model/bada

Related inputs

Number of IFR flights

Rate of fuel burn

Amount of emissions released by fuel burn

Cost of emissions

IFR average flight distance and flight duration

Fleet size

Taxi time

21 Distance flown by charging zone

21.1 EUROCONTROL recommended values

Table 31 shows the million kilometres flown by charging zone.

State	2014	2015	2016	2017	2018	2019	2020	2021	2022
Albania	33	34	31	32	34	36	16	24	38
Armenia	9	7	7	10	13	12	3	5	11
Austria	202	204	204	219	235	244	109	135	232
Belgium-Luxembourg	175	181	183	189	193	187	75	82	149
Bosnia and Herzegovina	59	64	63	74	79	88	41	55	90
Bulgaria	174	201	205	208	233	236	101	139	231
Croatia	131	133	131	134	148	161	66	110	164
Cyprus	104	109	109	123	136	146	56	84	122
Czech Republic	167	177	189	193	208	204	78	90	128
Denmark	120	123	125	127	130	133	52	56	99
Finland	58	55	54	59	65	68	31	32	46
France	1,489	1,514	1,594	1,673	1,714	1,729	689	902	1,506
Georgia	40	41	41	42	42	37	20	23	41
Germany	990	994	1,029	1,087	1,130	1,137	505	578	951
Greece	332	344	328	364	401	426	182	275	447
Hungary	158	173	178	189	207	202	89	114	201
Ireland	197	209	224	224	226	228	95	115	209
Italy	671	660	671	697	753	796	321	467	757
Latvia	54	55	54	59	63	64	27	33	34
Lithuania	36	35	36	39	44	45	22	31	29
Malta	41	46	49	50	52	57	23	28	38
Moldova	9	6	5	6	7	7	3	4	2
Netherlands	202	213	226	232	242	240	101	106	188
North Macedonia	19	20	19	23	26	30	12	20	31
Norway	172	173	181	182	183	177	94	108	158
Poland	289	288	306	316	344	360	148	183	237
Portugal Lisboa	216	226	252	272	277	287	112	144	266
Portugal Santa Maria	196	217	236	251	259	260	117	143	243
Romania	251	266	257	274	298	299	126	175	276
Serbia / Montenegro / Kosovo Force	133	149	158	166	186	195	83	113	194

State	2014	2015	2016	2017	2018	2019	2020	2021	2022
Slovak Republic	72	72	76	79	86	86	31	41	65
Slovenia	37	37	39	41	44	48	20	28	45
Spain-Canarias	101	98	106	114	124	131	356	73	124
Spain-Continental	707	725	780	835	881	909	57	512	875
Sweden	257	258	261	276	287	283	120	129	199
Switzerland	120	121	124	134	144	144	54	75	127
Turkey	789	856	853	933	1,021	1,036	460	658	938
United Kingdom	706	720	768	821	838	852	335	360	719
Subtotal	**9,516**	**9,805**	**10,153**	**10,748**	**11,352**	**11,582**	**4,829**	**6,250**	**10,208**
Estonia[1]				41	56	55	23	26	29
Ukraine[2]									12
Ukraine south									2
Total	**9,516**	**9,805**	**10,153**	**10,789**	**11,407**	**11,636**	**4,853**	**6,279**	**10,239**

[1]Estonia integrated as of April 2017

[2]Ukraine integrated as of November 2021

Table 31: Distance flown by charging zone in million km[73]

For the most updated information, please refer to the Aviation Intelligence En-Route Dashboard.

The Report on the Operation of the Route Charges System is published by the CRCO on an annual basis and provides data on traffic volumes and ATM costs for the States for which the CRCO collects en-route and terminal charges.

Table 31 sets out the number of millions of kilometres recorded in the airspace of the Contracting States from 2014 to 2022 for the calculation of route charges (great circle distance after deduction of 20 km for departing and arriving flights).

Information on the various charges levied by the CRCO, in particular the charge calculation methods, the basic billing documents, the methods of payment and the submission of claims is described in customer guide to charges”.

Related inputs

IFR average flight distance and flight duration

En-route ANS costs

Route charge share per market segment

When to use the input?

This input is suitable for use in assessments aiming at estimating the airspace users’ operating costs, namely when it comes to the route charges.

[73] EUROCONTROL PRU, ‘ATM Cost Effectiveness (ACE) Reports’, n.d., https://ansperformance.eu/publications/prc/ace/

22 Load factor - cargo

22.1 EUROCONTROL recommended values

Figure 22 presents the percentage of cargo space in flights filled by paid cargo.

Cargo flights can be defined here as either freight carriers or passenger/cargo carriers. Note that geographical coverage of IATA Europe covers ECAC States and other countries, including Russia, Tajikistan, Turkmenistan, and Uzbekistan.

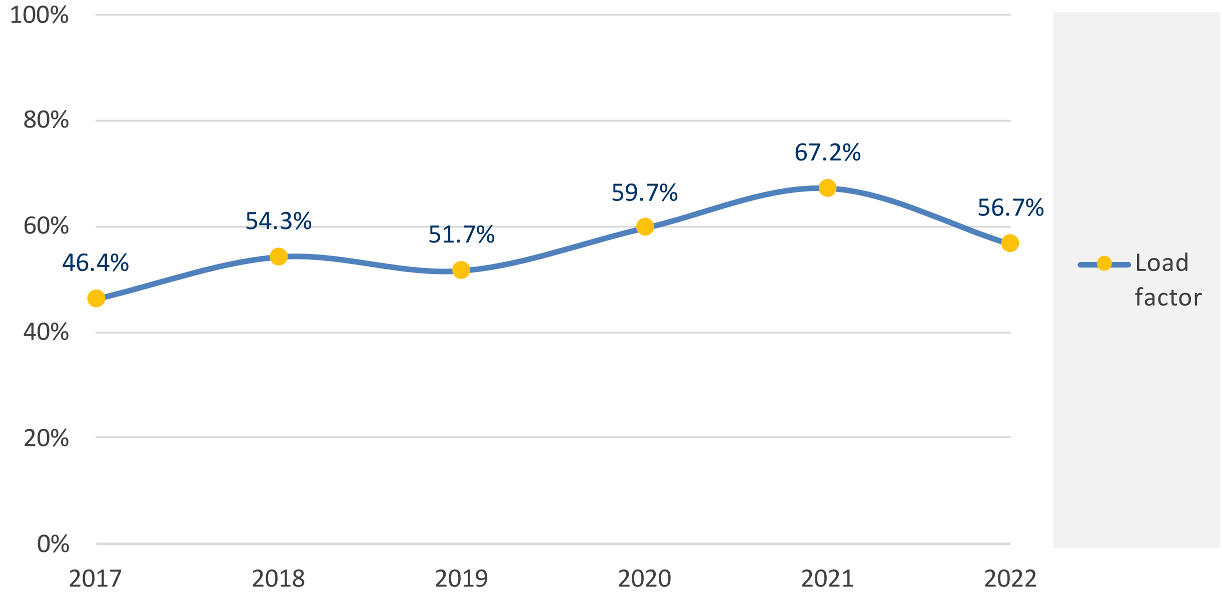

Figure 22: Cargo load factor – IATA values[74] [75]

[74] IATA – Economics, Air Freight Market Analysis for December 2017-2022. Available at IATA Economics

[75] The values used in this figure were extracted from IATA monthly Air Freight Market Analysis reports for the month of December of each year. The data is extracted from the table "Air freight market detail", looking at Total market in Europe, column CLF (level) for calendar year.

23 Load factor - passengers

23.1 EUROCONTROL recommended values

The load factor represents the percentage of seats filled by fare paying passengers on a flight. Figure 23 shows the estimated passenger load factor according to EUROCONTROL STATFOR values. These values were obtained by dividing the total number of passengers by the total number of available seats on the flights. This information is based on the data produced by Eurostat and covers the EU27+UK, and four European Free Trade Association (EFTA) states.[76]

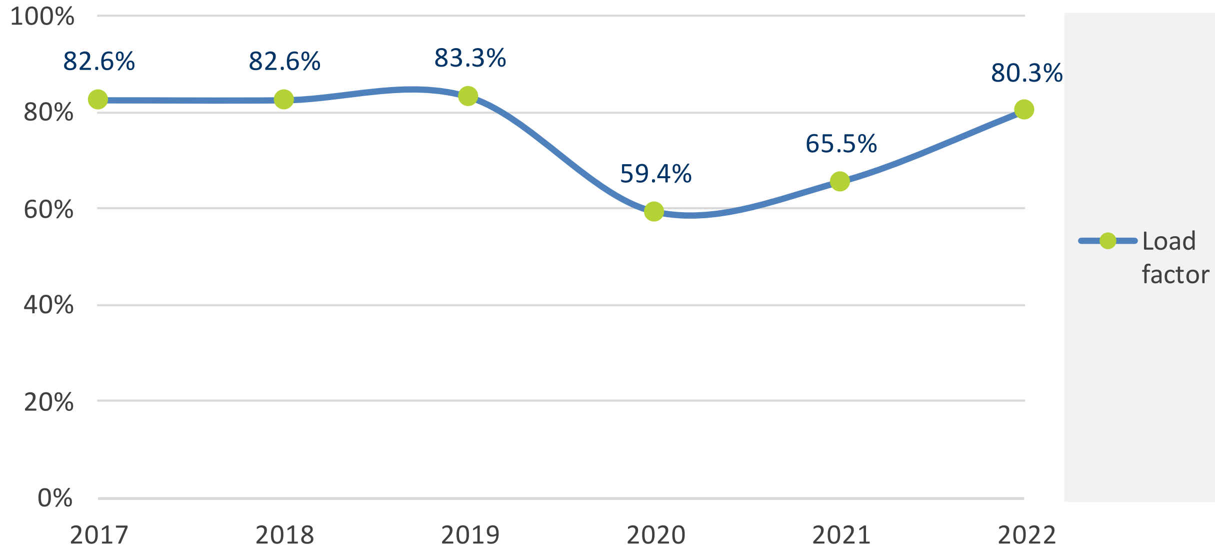

Figure 23: Passenger load factor – EUROCONTROL values[77]

Figure 24 presents the evolution in the passenger load factor according to IATA data. These values represent the ratio of revenue passenger km to available seat km. **The difference from values in Figure 23 is the geographical coverage:** IATA's Europe area is larger than EU Europe statistical area used by STATFOR, it also covers countries such as Russia, Tajikistan, Turkmenistan, and Uzbekistan.

[76] European Free Trade Association: Iceland, Liechtenstein, Norway, and Switzerland

[77] EUROCONTROL STATFOR, 'STATFOR Interactive Dashboard'.

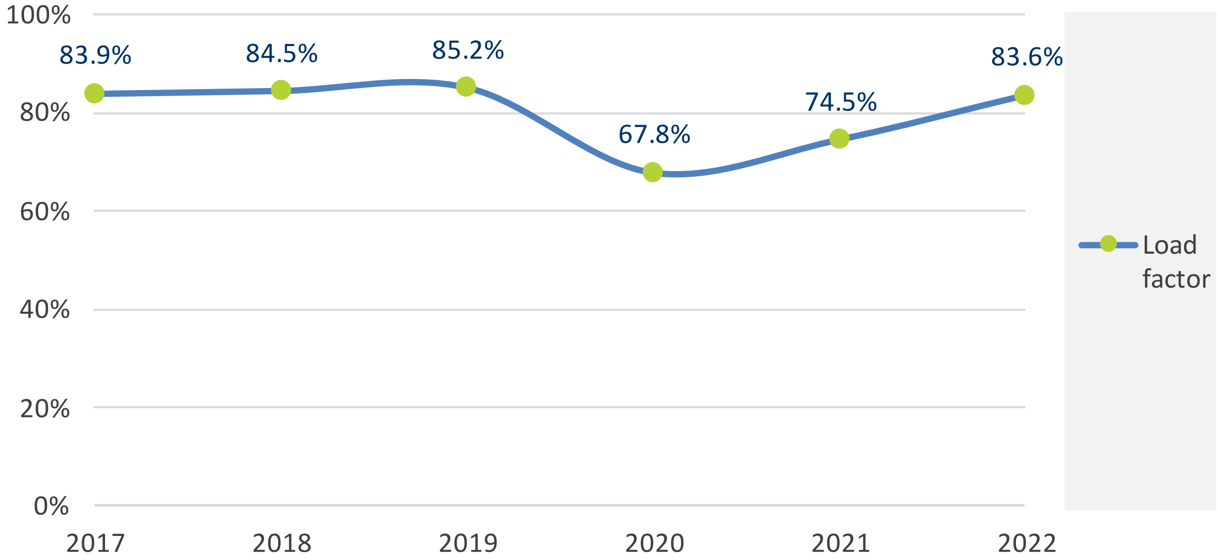

Figure 24: Passenger load factor – IATA values[78]

A wide range of economic reports from IATA can be accessed on the IATA website.

[78] The values used in this table come from IATA monthly Air Passenger Market Analysis reports for the month of December of each year. The data is extracted from the table "Air passenger market detail", looking at Total market in Europe, column PLF (level) for the calendar year.

24 Cost of aviation fuel

24.1 EUROCONTROL recommended sources

The source recommended to consult for the latest data on the cost of aviation fuel is the IATA Jet Fuel Price Monitor.

On its website, IATA provides jet fuel prices for the major regions of the world, together with analysis and commentary. The values are based on Platts Energy Market Data.

When estimating the jet fuel price, consideration should be given to the selection of the geographical area, and hence currency, as a change in oil price can have a different effect on the jet fuel price owing to currency fluctuations, e.g. the downturn in the euro in 2015.

The 'spread' between the aviation fuel price and the underlying oil price covers the cost of refining, but it can vary significantly with time depending on underlying demand (e.g. from consumers needing a similar fraction to aviation), and on supply problems (such as a breakdown at a refinery or increasing local prices relative to oil).

24.2 Other possible sources

Other sources that may be interesting to consult to estimate the price of jet fuel include:

- IATA Airline Industry Economic Performance Report and Tables
- US Energy Information Administration (2022), Annual Energy Outlook 2023

25 Value of an average passenger flight

25.1 EUROCONTROL recommended values

This value represents the monetised benefits of an average passenger flight in EU27[79].

	International flight[1]	Domestic flight[1]
Consumer benefits per flight	€ 27,636	€ 5,070
Airline benefits per flight (excl. fuel and labour)	€ 829	€ 149
Other producer benefits per flight (excl. fuel and labour)[2]	€ 1,493	€ 739

[1]The values were adjusted to 2022 prices based on inflation

[2]Other producers along the air transport value chain are airports, ANSPs, manufacturers, lessors, GDS/CRSs, travel agents, ground services, catering, and maintenance

Table 32: Value of an average passenger flight[80]

There is no commonly accepted standard for the value of a flight. The value will vary over time and between routes and whether it is an additional frequency on an existing route or a new connection. The COVID-19 pandemic will most probably change the overall picture. This should be taken into account when the above values are used.

The values quoted above are the result of an IATA study on the benefits in monetary value of an average passenger flight in the EU27.

IATA, in its briefing note, assesses the economic benefits of an average scheduled passenger flight from the perspective of the consumer, producers (split into Airline and other producers in Table 32) and the economy as a whole (not included in Table 32). Its approach to the various benefits is outlined below.

Consumer benefits are the benefits to passengers in the EU market. Most passengers value air services more than their expenditure. The difference between the consumer's willingness to pay (or the gross consumer benefit) and the price paid constitutes the net consumer benefit.

Producer benefits are assessed from an investor perspective. Investors will measure profitability by what that profit represents as a return on invested capital (ROIC). That return is calculated before payments of debt interest and shows the earnings available to pay both debt and equity investors.

This analysis draws on earlier work undertaken by McKinsey & Company for IATA on profitability and the air transport value chain, which calculates the global return on invested capital over the last business cycle 2004-2011.[81] The calculated global return on invested capital for each sector in the value chain is

[79] Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom, Austria, Finland, Sweden, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, Romania

[80] IATA, 'IATA Economic Briefing. The Value of an Average Passenger Flight in the EU27', n.d., https://www.iata.org/en/iata-repository/publications/economic-reports/value-of-an-average-passenger-flight-in-eu-27/

[81] IATA, 'Profitability and the Air Transport Value Chain', 2013, https://www.iata.org/en/iata-repository/publications/economic-reports/profitability-and-the-air-transport-value-chain/

based on sample data and represents actual returns earned rather than required and/or desired returns.[82]

On the basis of these figures, the share of producer net benefits accrued in the EU27 is estimated.[83]

On top of this, there are also some **wider economic benefits,** which are the benefits to the wider economy, which go beyond the direct users of air transport. They may include spill over impacts in and across economies as a result of increased competition and more efficient movement of capital and labour.

One of the largest economic benefits of increased connectivity comes from its impact on the long-term productivity of the wider economy. There are several approaches which may be used to quantify this benefit. One conservative approach which has been developed, on the basis of the statistical relationship between air connectivity and labour productivity, yields an estimate that **a 10% rise in connectivity, relative to a State's GDP, will boost labour productivity levels by 0.07%.** The methodology for the analysis is detailed in IATA's 2007 Aviation Economic Benefits study.[84]

When to use the input?

The use of these values depends on the scope and the viewpoint of the analysis. For example, an assessment from the point of view of airlines will focus on the benefits that an additional flight brings to airlines, whereas an analysis from the perspective of a government or the European Commission should also include an assessment of benefits for consumers and the wider economy.

Note also that these values reflect the market conditions and the passenger demand at the time of the study. For example, changes in passengers' income, changes in their preferences for air transport or changes in airlines' market structure can affect these values.

[82] IATA does not endorse the use of the estimated rates of return on invested capital for purposes of economic regulation or for determining the appropriate or desirable rate of return on invested capital. The figures used are based on a global assessment of the actual prevailing returns on invested capital in the air transport value chain

[83] The allocation of producer benefits for airports, GDS/CRS, and travel agents is based on the share of global passengers flown either domestically (6%) or internationally (18%) from and within the EU-27. This approach treats domestic and international passengers equally in their contribution to the producer benefit. The allocation of producer benefits for airlines, ANSPs, manufactures, lessors, ground services, catering, and maintenance is based on the share of global available seat kilometres flown either domestically (2%) or internationally (19%) from and within the EU27. These approaches do not account for structural differences which may exist between the EU and other regions. Nevertheless, these approaches provide a relevant estimation, because they are less prone to short- and medium-term shocks such as natural disasters and macroeconomic crises, which can create temporary distortions in the value chain.

[84] IATA, 'Aviation Economic Benefits', 2007, https://www.iata.org/en/iata-repository/publications/economic-reports/aviation-economic-benefits/

26 Fleet age

26.1 EUROCONTROL recommended values

The sections below refer to the age of the aircraft operating IFR flights in Europe.

26.2 Age, number of aircraft and number of flights according to the aircraft build year

Build Year	Age	Number of aircraft	Flights in 2022
2022	0	812	143,326
2021	1	786	312,504
2020	2	719	316,766
2019	3	1,190	526,072
2018	4	1,207	587,450
2017	5	1,077	523,181
2016	6	1,037	583,602
2015	7	973	437,116
2014	8	1,037	349,573
2013	9	884	308,068
2012	10	876	383,691
2011	11	807	427,566
2010	12	889	405,560
2009	13	869	505,334
2008	14	970	465,372
2007	15	896	396,296
2006	16	721	300,833
2005	17	511	194,098
2004	18	405	147,659
2003	19	395	147,586
2002	20	439	158,016
2001	21	548	175,071
2000	22	519	172,889
1999	23	479	152,486
1998	24	411	111,587
1997	25	256	79,570
1996	26	248	79,072
1995	27	155	48,231

Build Year	Age	Number of aircraft	Flights in 2022
1994	28	192	62,915
1993	29	204	60,005
1992	30	245	55,084
1991	31	187	52,850
1990	32	160	39,327
1989	33	135	29,426
1988	34	104	18,502
1987	35	68	14,082
1986	36	74	12,643
1985	37	49	6,648
1984	38	68	5,123
1983	39	34	3,818
1982	40	92	5,410
before 1982	> 40	894	41,246
unknown	unknown	301	243,333
Grand Total	**NA**	**22,923**	**9,088,987**[1]

[1]This value may vary from the total number of flights reported earlier in this document due to a slight difference in scope of data available

Table 33: Build year of civil aircraft operating in EUROCONTROL Network Manager area in 2022[85]

The information presented in Table 33 is derived from flight plans submitted to the EUROCONTROL Network Manager for flights in 2022. These aircraft were therefore active in European airspace at some point during that year. The information was analysed using the EUROCONTROL PRISME fleet database to derive the aircraft ages.

Since the numbers are based on flight plans, they exclude aircraft which do not fly in controlled airspace and therefore do not submit flight plans to the NM. The 301 aircraft whose age was unknown were aircraft which are not recorded in the PRISME database. These are mostly privately owned aircraft or aircraft based outside Europe, together with some smaller aircraft not flying regularly in controlled airspace and some new aircraft which do not feature in the database.

[85] EUROCONTROL Network Manager flight plans and PRISME fleet data, March 2023

26.3 Average aircraft age per flight (EU27+EFTA)

Figure 25 shows the average aircraft age in years by EUROCONTROL market segment[86] for the aircraft operating in 2022.

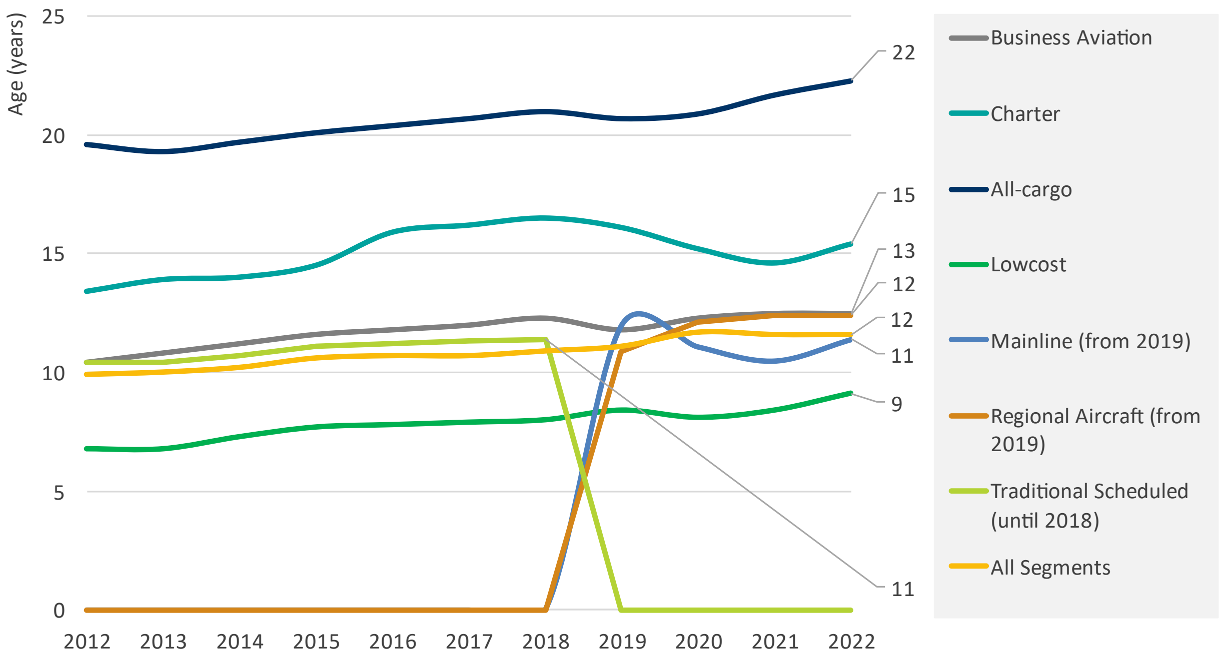

Figure 25: Average aircraft age per flight in EU27 +UK + EFTA[87] [88]

> **Note**
>
> EUROCONTROL market segments were updated in 2022 and saw the "Traditional Scheduled" segment split into "Mainline" and "Regional" according to EUROCONTROL Market Segment Rules.[89] The new segmentation started to be taken into account as of 2019, which explains some segments being set at zero before or after that date.

Low-cost carriers have the youngest fleet on average, at 9 years in 2022, while charter and all-cargo have older fleets, at 15 and 22 years respectively. The increase in market share of all-cargo and business aviation in the aftermath of the COVID-19 pandemic, has pushed the average age of the overall fleet to 11.6 years in 2022 from 11.1 in 2019.

[86] EUROCONTROL, 'EUROCONTROL Market Segment Update 2022'.
[87] EUROCONTROL STATFOR, 'STATFOR Interactive Dashboard'.
[88] European Free Trade Association whose Member States comprise Iceland, Liechtenstein, Norway, and Switzerland
[89] EUROCONTROL, 'EUROCONTROL Market Segment Update 2022'.

26.4 Commercial aircraft fleet by age of aircraft

Figure 26 shows the commercial aircraft fleet size by age of aircraft.

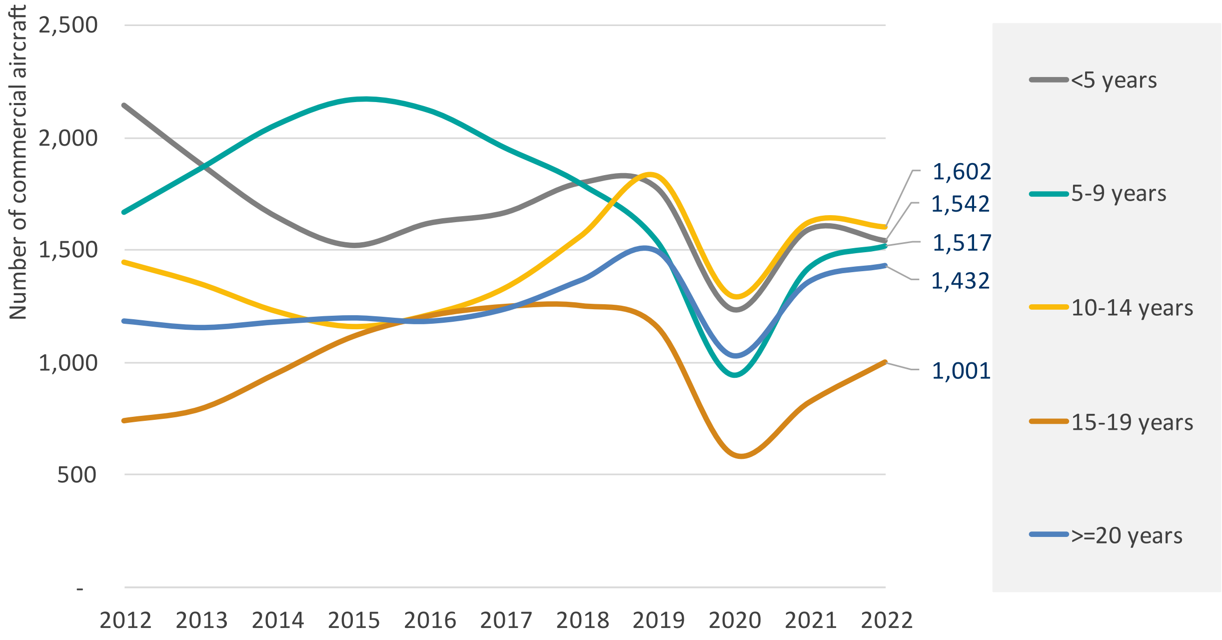

Figure 26: Number of aircraft per age group in EU27 + UK + EFTA[90]

EUROSTAT publishes annual statistics on commercial aircraft fleet by age of aircraft and State of operator/State of registration.

Related inputs

Number of IFR flights

Fleet size

When to use the input?

Depending on the market, an aircraft can remain in service for about 30 years. While an aircraft follows a specific maintenance cycle, its performance can degrade over time due to engine and aerodynamic deterioration, leading to additional CO_2 emissions. Fleet renewal helps reduce aviation's environmental impact as newer aircraft tend to be more fuel efficient and quieter, therefore the average age of the European fleet is a good indicator of its environmental performance.

[90] EUROSTAT, 'Commercial Aircraft Fleet by Age of Aircraft and State of Operator', 30 January 2023, https://ec.europa.eu/eurostat/databrowser/view/AVIA_EQ_ARC_AGE/default/table?lang=en&category=avia.avia_eq

27 Fleet size

27.1 EUROCONTROL recommended values

This input presents the number of aircraft, per type, operating in Europe. Table 34 shows the top 30 civil aircraft operating in 2022 in the airspace controlled by the EUROCONTROL Network Manager.

Aircraft type	Number of aircraft	Number of flights	Proportion of aircraft	Cumulative	Proportion of flights	Cumulative
B738	1,705	1,722,929	7.43%	7.43%	18.96%	18.96%
A320	1,569	1,421,804	6.84%	14.27%	15.64%	34.60%
B77W	712	164,394	3.10%	17.37%	1.81%	36.41%
GLF5	627	15,601	2.73%	20.10%	0.17%	36.58%
GLEX	565	30,789	2.46%	22.56%	0.34%	36.92%
A20N	557	461,640	2.43%	24.99%	5.08%	42.00%
B789	508	136,468	2.21%	27.20%	1.50%	43.50%
A21N	499	300,283	2.17%	29.38%	3.30%	46.80%
A319	478	515,513	2.08%	31.46%	5.67%	52.47%
A321	473	372,532	2.06%	33.52%	4.10%	56.57%
GLF4	454	9,475	1.98%	35.50%	0.10%	56.68%
CL60	443	24,016	1.93%	37.43%	0.26%	56.94%
DA42	436	53,303	1.90%	39.33%	0.59%	57.53%
GLF6	429	13,921	1.87%	41.20%	0.15%	57.68%
A333	418	129,940	1.82%	43.02%	1.43%	59.11%
B763	384	65,906	1.67%	44.70%	0.73%	59.84%
A359	368	78,582	1.60%	46.30%	0.86%	60.70%
B38M	365	271,476	1.59%	47.89%	2.99%	63.69%
PC12	358	55,886	1.56%	49.45%	0.61%	64.30%
A332	352	86,506	1.53%	50.98%	0.95%	65.25%
F900	295	10,078	1.29%	52.27%	0.11%	65.37%
B788	294	80,970	1.28%	53.55%	0.89%	66.26%
F2TH	284	27,439	1.24%	54.79%	0.30%	66.56%
B77L	258	69,049	1.12%	55.91%	0.76%	67.32%
B744	254	39,504	1.11%	57.02%	0.43%	67.75%
FA7X	253	13,650	1.10%	58.12%	0.15%	67.90%
B772	240	66,430	1.05%	59.17%	0.73%	68.63%
PA34	239	11,781	1.04%	60.21%	0.13%	68.76%
GL5T	213	10,043	0.93%	61.14%	0.11%	68.87%

Aircraft type	Number of aircraft	Number of flights	Proportion of aircraft	Cumulative	Proportion of flights	Cumulative
BE20	206	47,688	0.90%	62.04%	0.52%	69.40%
Other types	8,712	2,781,391	37.96%	100.00%	30.60%	100.00%
Total	**22,948**	**9,088,987**[1]	**100%**		**100%**	

[1]This value may vary from the total number of flights reported earlier in this document due to a slight difference in scope of data available

Table 34: Top 30 civil aircraft operating in NM area[91]

The 22,948 civil aircraft in Table 34 include 500 unique aircraft types. The top 30 aircraft types listed above represent approximately 62% of the total fleet and 69% of flights.

Table 35 shows the number of military aircraft by category in 2019 vs 2023 in Europe, USA, and Commonwealth of Independent States (CIS) countries.[92] [93]

Aircraft type	Europe 2019	Europe 2023	USA 2019	USA 2023	CIS 2019	CIS 2023
Combat aircraft	2,066	2,008	2,879	2,820	1,936	1,864
Special Mission[1]	245	245	780	758	125	147
Tanker	56	49	592	638	19	19
Transport	648	588	979	990	443	484
Combat helicopter	3,359	3,328	5,555	5,704	1,807	1,915
Training aircraft	2,201	1,912	2,996	2,766	574	624
Total military fleet	**8,575**	**8,130**	**13,781**	**13,676**	**4,904**	**5,053**
% difference		**-5.19%**		**-0.76%**		**3.04%**

[1]Special Mission Aircraft are those platforms specifically developed to undertake an over-battlefield role by utilization of advanced onboard equipment or specialized trait

Table 35: Military aircraft in 2023 vs 2019[94]

VFR airframes in ECAC

20,329 aeroplanes
18,555 gliders
3,532 helicopters
6,623 balloons

IFR helicopter fleet

2,208 helicopters in Europe and Eastern Europe

1,312 helicopters in CIS countries

Figure 27: Number of helicopters and VFR airframers in Europe[95]

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[91] EUROCONTROL Network Manager flight plans, 2022

[92] Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, and Uzbekistan

[93] FlightGlobal, '2023 World Air Forces Directory', 2023, https://www.flightglobal.com/reports/2023-world-air-forces-directory/151088.article

[94] FlightGlobal.

[95] Airbus Global Market Forecast for 2022-2041; European Helicopter Association, European Helicopter IFR Fleet Analysis, 2013

27.2 Other possible sources - forward-looking

The **Airbus Global Market Forecast for 2022-2041** presents a forward-looking view of the evolution of the air transport sector, accounting for factors such as demographic and economic growth, tourism trends, oil prices, the development of new and existing routes, and ultimately highlighting demand for aircraft covering the spectrum of sizes from 100 seats to the very largest aircraft of over 500 seats.

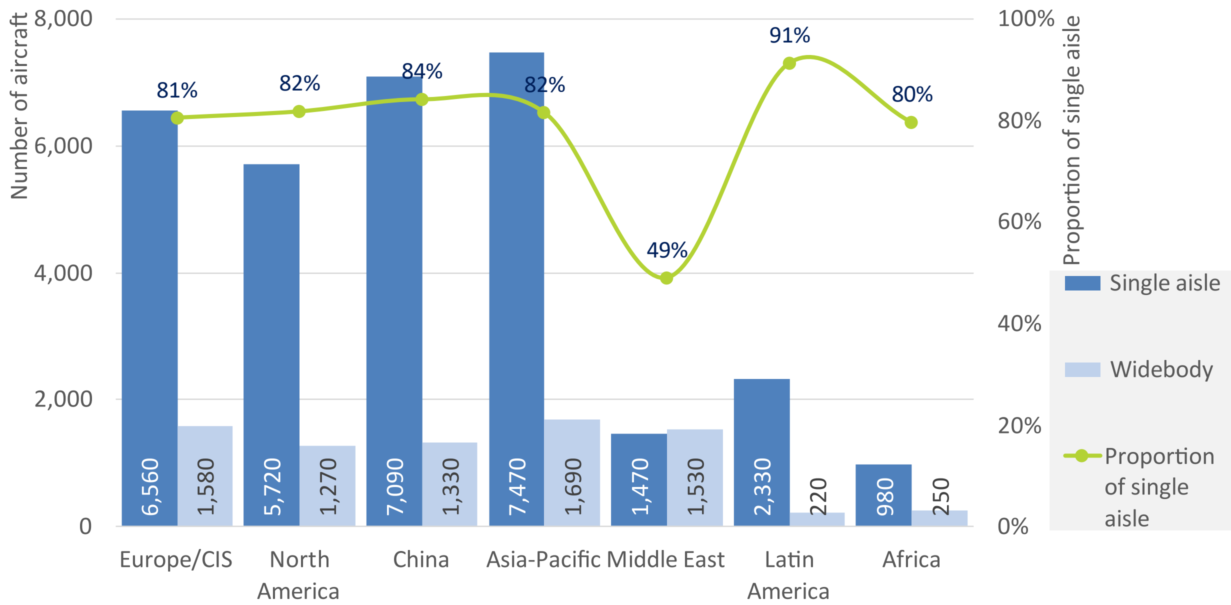

Figure 28: Airbus commercial aircraft demand 2022-2041[96]

As shown in Figure 28, **for the years 2022-2041, Airbus forecasts a demand for 39,490 new commercial aircraft worldwide,** of which 8,140 units (21%) are for Europe/CIS regions. Asia-Pacific, China and the US are driving the growth, while single-aisle aircraft dominate the demand (>80%).

For the same period (2022-2041), Boeing forecasts a global demand for 40,170 new commercial aircraft of which 8,550 units (21%) are for Europe. Europe, Asia-Pacific, US, and China are the drivers for growth owing to the demand for single-aisle aircraft which represents between 69% (in US) and 82% (in Europe) of the total fleet forecast. Figure 29 shows the Boeing forecast demand for new aircraft by category and world regions with a focus on single-aisle aircraft which lead the market growth.

[96] Stan Shparberg, Bob Lange, 'Global Market Forecast 2022-2041', 2022, https://www.airbus.com/en/products-services/commercial-aircraft/market/global-market-forecast

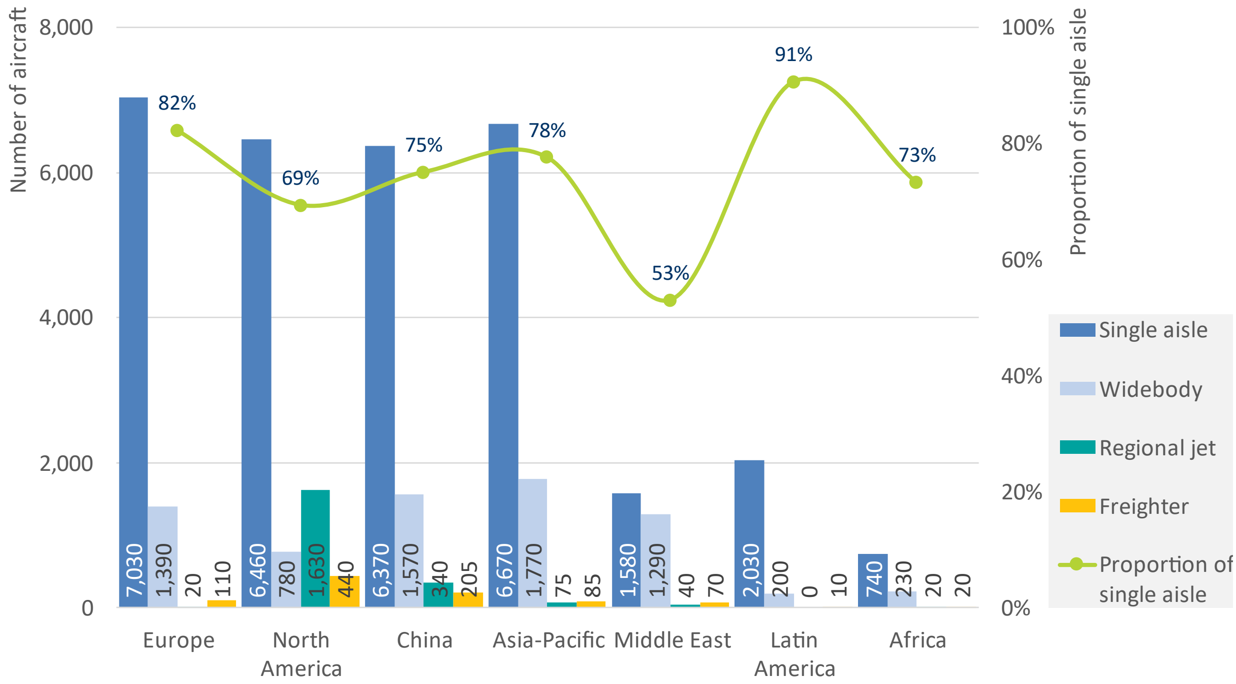

Figure 29: Boeing commercial aircraft demand 2022-2041[97]

Related inputs

Number of IFR flights

IFR flight information per market segment

Fleet age

[97] Boeing, 'Commercial Market Outlook 2022–2041', n.d., https://www.boeing.com/commercial/market/commercial-market-outlook/index.page#/overview

28 Fleet CNS capability

28.1 EUROCONTROL recommended values

The subsections below provide statistics on flights and aircraft with certain Communication, Navigation and Surveillance (CNS) equipment and capabilities.

The EUROCONTROL Aircraft communication, navigation & surveillance (CNS) dashboard provides information for monitoring fleet capabilities and preparing performance-based navigation (PBN) deployment plans. It does so by analysing CNS and PBN information contained in ICAO flight plans and generates reports on aircraft or flight characteristics. Note that the capabilities of aircraft which do not submit flight plans are not covered in the dashboard figures. The missing information is to a large extent for general aviation (GA) flights.

The dashboard provides statistics on equipment and capabilities such as:

- Communication: FMC WPR ACARS, HF RTF; CPDLC FANS 1/A HFDL; etc.
- Navigation: RNAV 5, RNAV 1, RNP 1, RNP APCH (including LPV capability), GBAS, etc.
- Surveillance: ADS-B, ADS-C, Mode S transponder, etc.

Different periods of time, airports, airlines, or aircraft types (depending on the user profile) can be analysed.

To access the dashboard, you first need to register on the OneSky Online portal using the link in the source above.

28.2 Navigation (NAV) flight capabilities

The values presented in the tables hereafter are weighted by flight and represent the values for 2022. All values come from EUROCONTROL Aircraft communication, navigation & surveillance (CNS) dashboard. Please refer to this source for more detailed information and further data.

Capability	Number of flights[1]	Share of total flights
A – GBAS landing system	2,029,678	10.97%
B – LPV (APV with SBAS)	1,856,684	10.03%
D – RNAV 1	17,931,330	96.88%
O – Basic RNP 1	15,712,410	84.89%
S – RNP APCH	17,295,534	93.44%

[1]The number of flights is the number of arrivals or departures, or arrivals and departures in line with the selection criteria in the CNS dashboard

Table 36: NAV flight capabilities as a % of total flights in 2022

Airport	A - GBAS landing system[1]	B - LPV (APV with SBAS)	D - RNAV 1	O - Basic RNP1	S - RNP APCH
Barcelona	5.14%	3.40%	99.47%	94.64%	98.35%
Frankfurt Main	9.29%	3.70%	99.89%	94.56%	99.23%

Airport	A - GBAS landing system[1]	B - LPV (APV with SBAS)	D - RNAV 1	O - Basic RNP1	S - RNP APCH
Istanbul/New airport	39.25%	0.94%	98.77%	95.61%	93.25%
London/Gatwick	5.90%	4.29%	99.91%	94.37%	99.88%
London/Heathrow	11.99%	3.53%	99.95%	94.41%	99.78%
Madrid Barajas	7.78%	11.15%	99.20%	94.39%	98.11%
Munich	4.91%	17.06%	99.51%	95.56%	98.93%
Paris Ch de Gaulle	3.35%	6.79%	99.91%	93.92%	98.01%
Rome Fiumicino	13.64%	1.67%	99.91%	95.14%	98.95%
Schiphol Amsterdam	3.25%	4.01%	99.87%	93.50%	99.01%

[1] *The values for GBAS are corrected values. They exclude DHC8 equipment only compatible with a GBAS precursor system*

Table 37: NAV flight capabilities as a % at the top 10 European Airports in Q4 2022

Airport	A - GBAS landing system	B - LPV (APV with SBAS)	D - RNAV 1	O - Basic RNP1	S - RNP APCH
Barcelona	10.41%	12.28%	98.79%	87.80%	98.35%
Frankfurt Main	12.31%	14.49%	99.25%	87.78%	98.35%
Istanbul/New airport	13.13%	6.95%	97.45%	88.75%	89.78%
London/Gatwick	12.32%	4.29%	99.82%	92.89%	99.33%
London/Heathrow	19.33%	5.97%	99.89%	94.87%	99.56%
Madrid Barajas	11.47%	15.26%	98.67%	87.57%	98.11%
Munich	9.49%	17.06%	98.44%	86.12%	98.02%
Paris Ch de Gaulle	10.48%	4.38%	99.79%	91.27%	98.55%
Rome Fiumicino	13.43%	3.65%	99.65%	92.67%	98.89%
Schiphol Amsterdam	7.98%	14.24%	99.30%	88.17%	98.81%

Table 38: NAV aircraft capability at the top-10 European airports over a one-month period in Q4 2022

Aircraft	A - GBAS landing system	B - LPV (APV with SBAS)	D - RNAV 1	O - Basic RNP 1	S - RNP APCH
B737	21.45%	1.74%	97.64%	89.36%	92.12%
A320	2.08%	0.87%	99.40%	88.74%	96.72%
A319	0.89%	0.67%	99.11%	88.91%	96.23%
A321	6.22%	0.00%	98.09%	93.30%	97.37%
DHC8	0.00%	15.27%	95.42%	70.99%	87.02%
ATR72	0.00%	9.31%	94.14%	60.69%	85.86%
B777	0.19%	0.19%	99.81%	99.71%	98.95%
A330	2.89%	1.13%	99.68%	92.77%	95.66%

Aircraft	A - GBAS landing system	B - LPV (APV with SBAS)	D - RNAV 1	O - Basic RNP 1	S - RNP APCH
E190	0.57%	1.70%	99.43%	73.30%	99.43%
A320 NEO	11.04%	0.00%	99.60%	96.59%	99.60%
B787	49.87%	0.00%	99.87%	92.93%	99.37%
CL900RJ	0.00%	0.00%	97.59%	93.98%	98.80%
E195	0.00%	0.00%	97.85%	77.42%	94.62%
B767	4.17%	1.19%	98.81%	90.77%	87.50%
E175	0.00%	0.00%	92.86%	91.07%	89.29%

Table 39: NAV flight capability by main aircraft model, December 2022

28.3 Communication (COM) flight capabilities

The values presented in the tables hereafter are weighted by flight. Values are based on flights arriving at ECAC Airports and the data is originated from EUROCONTROL Aircraft communication, navigation & surveillance (CNS) dashboard. Please refer to this source for more detailed information and further data.

	Capability	Number of flights	As a % of all flights
Datalink	E2 - D-FIS ACARS	34,120,473	41,70%
	E3 - PDC ACARS	3,682,878	44,98%
	J1 - CPDLC ATN VDL Mode 2	5,836,183	71,29%
	J4 - CPDLC FANS 1/A VDL Mode 2	914,209	11,20%
	J5 - CPDLC FANS 1/A SATCOM (INMARSAT)	647,681	7,90%
	J7 - CPDLC FANS 1/A SATCOM (iridium)	241,932	2,96%
Voice	H - HF RTF	3,547,340	43,33%
	M1 - ATC RTF SATCOM (INMARSAT)	616,204	7,53%
	M2 - ATC RTF (MTSAT)	35,481	0,43%
	M3 - ATC RTF (iridium)	329,184	4,02%
	U - UHF RTF	262,483	3,21%
	V - VHF RTF	906,101	11,07%
	Y - VHF with 8.33 kHz channel spacing capability	8,168,841	99,78%

Table 40: COM flight capabilities as a % of total flights in 2022

Airport	E2 – D-FIS ACARS	E3 – PDC ACARS	J1 – CPDLC ATN VDL Mode 2	J4 – CPDLC FANS 1/A VDL Mode 2	J5 – CPDLC FANS 1/A SATCOM (INMARSAT)	J7 – CPDLC FANS 1/A SATCOM (Iridium)
EBBR	26,77%	60,62%	78,74%	13,75%	14,31%	3,75%
EDDB	60,50%	60,44%	85,97%	8,34%	4,31%	2,03%
EDDF	81,81%	81,39%	74,01%	17,82%	22,92%	3,21%
EDDL	56,31%	56,36%	89,32%	3,32%	2,91%	0,78%

Airport	E2 – D-FIS ACARS	E3 – PDC ACARS	J1 – CPDLC ATN VDL Mode 2	J4 – CPDLC FANS 1/A VDL Mode 2	J5 – CPDLC FANS 1/A SATCOM (INMARSAT)	J7 – CPDLC FANS 1/A SATCOM (Iridium)
EDDM	80,34%	78,06%	83,34%	9,66%	9,77%	1,79%
EGCC	37,51%	43,30%	82,56%	10,63%	10,07%	5,62%
EGKK	65,13%	73,83%	93,56%	9,05%	5,81%	2,29%
EGLL	33,55%	85,41%	80,77%	28,85%	38,59%	3,91%
EGSS	16,54%	12,67%	88,81%	7,40%	5,76%	6,22%
EHAM	81,24%	83,51%	84,67%	9,25%	16,27%	3,34%
EIDW	38,20%	43,31%	81,12%	12,60%	9,02%	8,09%
EKCH	31,09%	65,94%	78,61%	11,03%	5,38%	4,17%
ENGM	40,54%	81,07%	84,32%	5,43%	5,87%	4,62%
ESSA	32,98%	61,43%	81,61%	6,44%	4,98%	4,10%
LEBL	23,87%	27,96%	88,21%	7,91%	6,37%	2,05%
LEMD	24,42%	31,84%	82,47%	15,84%	17,66%	1,65%
LEPA	37,06%	33,21%	84,40%	3,12%	2,22%	1,33%
LFMN	58,99%	62,77%	71,69%	14,48%	9,62%	3,43%
LFPG	79,76%	83,27%	75,17%	24,45%	23,67%	3,98%
LFPO	35,46%	40,36%	87,55%	7,81%	9,10%	1,45%
LIMC	55,88%	60,82%	77,75%	19,60%	12,85%	3,58%
LIRF	30,68%	35,68%	89,31%	14,63%	8,77%	3,07%
LOWW	78,17%	42,95%	86,39%	9,78%	6,92%	2,07%
LSZH	74,62%	76,52%	79,96%	15,29%	14,41%	2,15%
LTFM	83,85%	83,34%	75,29%	27,27%	26,44%	0,66%

Table 41: COM datalink flight capabilities as a % at the Pilot Common Project airports in 2022

Airport	H – HF RTF	M1 – ATC RTF SATCOM (INMARSAT)	M2 – ATC RTF (MTSAT)	M3 – ATC RTF (iridium)	U – UHF RTF	V – VHF RTF	Y – VHF with 8.33 kHz channel spacing
EBBR	62,09%	14,50%	0,72%	2,91%	2,90%	39,06%	99,98%
EDDB	39,36%	5,53%	0,01%	2,83%	2,24%	9,44%	100%
EDDF	35,50%	22,34%	0,63%	3,07%	1,17%	8,52%	99,99%
EDDL	36,10%	2,89%	0,01%	1,51%	1,84%	22,52%	100%
EDDM	24,08%	9,70%	0,02%	2,59%	1,93%	6,86%	99,99%
EGCC	54,92%	10,04%	0,37%	3,71%	0,75%	5,88%	99,99%
EGKK	63,05%	6,06%	2,77%	2,13%	0,36%	7,10%	99,99%
EGLL	62,34%	38,56%	12,71%	4,14%	0,97%	5,99%	99,97%

Airport	H – HF RTF	M1 – ATC RTF SATCOM (INMARSAT)	M2 – ATC RTF (MTSAT)	M3 – ATC RTF (iridium)	U – UHF RTF	V – VHF RTF	Y – VHF with 8.33 kHz channel spacing
EGSS	33,02%	4,59%	0,01%	4,33%	0,65%	4,87%	99,98%
EHAM	41,08%	8,23%	0,12%	3,64%	0,63%	7,06%	99,99%
EIDW	45,90%	8,38%	0,38%	6,42%	1,09%	3,55%	99,99%
EKCH	40,04%	6,01%	0,01%	2,03%	1,15%	7,12%	99,99%
ENGM	47,36%	3,99%	0,25%	2,06%	0,80%	3,43%	99,99%
ESSA	32,84%	6,38%	0,65%	1,81%	1,01%	6,80%	100%
LEBL	51,13%	5,56%	0,06%	2,47%	1,02%	41,13%	99,98%
LEMD	60,76%	16,08%	0,16%	1,78%	0,85%	3,15%	99,93%
LEPA	49,97%	1,74%	0,01%	2,10%	0,78%	13,57%	99,99%
LFMN	49,33%	5,94%	0,07%	5,97%	2,17%	5,51%	99,98%
LFPG	50,29%	24,18%	0,62%	4,71%	1,33%	6,79%	99,96%
LFPO	72,59%	9,73%	0,03%	1,47%	0,04%	16,21%	99,93%
LIMC	57,93%	14,12%	0,24%	2,72%	2,13%	8,59%	99,98%
LIRF	38,17%	9,26%	0,24%	2,43%	1,78%	9,70%	99,99%
LOWW	40,40%	7,12%	0,45%	2,75%	1,22%	6,35%	99,99%
LSZH	37,58%	13,60%	0,03%	3,34%	1,58%	7,30%	99,99%
LTFM	93,76%	31,51%	0,01%	11,83%	0,87%	4,88%	99,98%

Table 42: COM voice flight capabilities as a % at the Pilot Common Project Airports in 2022

Aircraft type	E2 – D-FIS ACARS	E3 – PDC ACARS	J1 – CPDLC ATN VDL Mode 2	J4 – CPDLC FANS 1/A VDL Mode 2	J5 – CPDLC FANS 1/A SATCOM (INMARSAT)	J7 – CPDLC FANS 1/A SATCOM (Iridium)
A319	59,79%	64,74%	81,86%	8,66%	9,07%	1,24%
A320	53,22%	49,94%	85,12%	7,60%	1,68%	0,19%
A320 NEO	34,85%	42,89%	81,86%	9,48%	0,82%	6,19%
A321	71,30%	70,22%	83,91%	14,78%	4,35%	1,96%
A330	59,85%	71,59%	10,10%	54,29%	85,48%	9,72%
ATR72	6,98%	6,98%	0,84%	0%	0%	0%
B737	27,38%	31,89%	70,71%	9,94%	5,32%	4,78%
B767	42,80%	68,72%	15,02%	54,53%	36,63%	40,33%
B777	62,90%	92,36%	46,35%	61,38%	97,11%	9,85%
B787	57,98%	84,51%	91,43%	88,15%	98,00%	4,58%
CL900RJ	42,17%	66,27%	78,31%	1,20%	0%	1,20%

Aircraft type	E2 – D-FIS ACARS	E3 – PDC ACARS	J1 – CPDLC ATN VDL Mode 2	J4 – CPDLC FANS 1/A VDL Mode 2	J5 – CPDLC FANS 1/A SATCOM (INMARSAT)	J7 – CPDLC FANS 1/A SATCOM (Iridium)
DHC8	7,69%	2,20%	0,55%	0%	1,10%	2,20%
E175	75,00%	73,21%	71,43%	5,36%	0%	0%
E190	65,61%	66,67%	89,95%	9,52%	1,06%	3,70%
E195	63,22%	71,26%	91,95%	21,84%	0%	0%

Table 43: COM datalink flight capabilities for main aircraft models in 2022

Aircraft type	H – HF RTF	M1 – ATC RTF SATCOM (INMARSAT)	M2 – ATC RTF (MTSAT)	M3 – ATC RTF (iridium)	U – UHF RTF	V – VHF RTF	Y – VHF with 8.33 kHz channel spacing
A319	42,27%	7,42%	0%	1,24%	3,09%	11,55%	100%
A320	75,71%	5,80%	0,13%	0,58%	4,77%	14,37%	100%
A320 NEO	52,37%	3,09%	0%	5,15%	3,71%	22,68%	100%
A321	64,57%	6,30%	0%	5,00%	6,52%	7,61%	100%
A330	98,61%	73,86%	0,13%	8,46%	6,57%	18,06%	99,87%
ATR72	25,70%	0,56%	0%	0%	4,75%	5,59%	99,72%
B737	73,54%	7,34%	0%	7,80%	4,55%	11,89%	99,43%
B767	94,86%	31,89%	0%	41,77%	8,23%	11,32%	99,79%
B777	100%	94,23%	7,56%	7,89%	0,93%	7,98%	100%
B787	99,88%	91,78%	16,20%	1,41%	6,46%	16,43%	100%
CL900RJ	21,69%	0%	1,20%	2,41%	2,41%	2,41%	100%
DHC8	28,57%	3,85%	0,55%	2,20%	6,04%	28,02%	100%
E175	26,79%	0%	0%	0%	3,57%	26,79%	100%
E190	51,85%	3,70%	0%	3,17%	2,65%	18,52%	100%
E195	29,89%	0%	0%	0%	0%	22,99%	100%

Table 44: COM voice flight capabilities for main aircraft models in 2022

28.4 Surveillance (SUR) flight capabilities

The values presented in the tables hereafter refer to the level of flight capabilities in terms of surveillance equipment. All values are weighted by flight and represent the situation for 2022. The data used is originated from EUROCONTROL Aircraft communication, navigation & surveillance (CNS) dashboard. Please refer to this source for more detailed information and further data.

Capability	Number of flights[1]	As a % of all flights
SSR Mode S		
L – Mode S, including aircraft identification, pressure-altitude, extended squitter (ADS-B) and enhanced surveillance capability	4,841,403	52.3%
H – Mode S, including aircraft identification, pressure-altitude, and enhanced surveillance capability	1,437,964	15.5%
E – Mode S, including aircraft identification, pressure-altitude, and extended squitter (ADS-B) capability	274,513	3.0%
S – Mode S, including both pressure-altitude and aircraft identification capability	2,645,524	28.6%
P – Mode S, including pressure-altitude, but no aircraft identification capability	2,729	0.0%
I – Mode S, including aircraft identification, but no pressure-altitude capability	975	0.0%
X – Mode S with neither aircraft identification nor pressure-altitude capability	3,512	0.0%
C – Mode A (4 digits - 4096 codes) and Mode C	122,008	1.3%
A – Mode A (4 digits - 4096 codes)	88,646	1.0%
ADS-B		
B1 – ADS-B with dedicated 1090 MHz ADS-B “out” capability	7,409,392	80.1%
B2 – ADB-B with dedicated 1090 MHz ADS-B “out” and “in” capability	329,079	3.6%
U1 – ADS-B “out” capability using UAT	44,076	0.5%
U2 – ADS-B “out” and “in” capability using UAT	9,195	0.1%
V1 – ADS-B “out” capability using VDL Mode 4	64,899	0.7%
V2 – ADS-B “out” and “in” capability using VDL Mode 4	6,092	0.1%

[1] Figures in this value are per flight from departure to destination, while values per airport are per flight but also include any flight departing from or arriving at that airport

Table 45: SUR flight capabilities as a % of total flights in 2022

Airport	Capability								
	L	H	E	S	P	I	X	C	A
Istanbul Main	87.7%	6.9%	0.7%	4.3%	0.0%	0.0%	0.0%	0.4%	0.0%
Amsterdam Schiphol	75.7%	17.5%	1.2%	5.6%	0.0%	0.0%	0.0%	0.1%	0.3%
Paris Ch. de Gaulle	53.0%	42.3%	0.8%	3.9%	0.0%	0.0%	0.0%	0.2%	0.4%
Frankfurt Main	41.7%	51.8%	1.4%	5.2%	0.0%	0.0%	0.0%	0.4%	0.1%
London/Heathrow	57.9%	8.9%	1.6%	31.5%	0.0%	0.0%	0.0%	0.5%	2.2%

Airport	Capability								
	L	H	E	S	P	I	X	C	A
Madrid Barajas	34.4%	16.6%	6.1%	42.9%	0.0%	0.0%	0.0%	0.1%	0.0%
Barcelona	65.4%	9.3%	1.5%	23.8%	0.0%	0.0%	0.0%	0.1%	0.2%
Munich	31.9%	57.6%	2.2%	8.3%	0.0%	0.0%	0.0%	0.2%	0.1%
Palma de Mallorca	46.1%	17.4%	4.8%	31.7%	0.0%	0.0%	0.0%	0.2%	0.7%
London/Gatwick	82.8%	1.7%	1.5%	13.9%	0.0%	0.0%	0.0%	0.1%	0.0%

Table 46: SSR/Mode S declared capabilities in flight plans at the top 10 European airports in 2022

Airport	Capability					
	B1	B2	U1	U2	V1	V2
Istanbul Main	91.6%	1.7%	0.2%	0.0%	0.3%	0.0%
Amsterdam Schiphol	95.6%	1.3%	0.1%	0.0%	0.3%	0.1%
Paris Ch. de Gaulle	89.8%	2.2%	0.1%	0.0%	0.4%	0.0%
Frankfurt Main	86.2%	3.1%	0.4%	0.0%	0.4%	0.0%
London/Heathrow	86.1%	8.6%	0.0%	0.0%	0.1%	0.0%
Madrid Barajas	88.3%	4.7%	0.0%	0.0%	1.1%	0.0%
Barcelona	92.7%	1.5%	0.1%	0.0%	0.8%	0.0%
Munich	87.2%	2.3%	0.2%	0.1%	0.1%	0.0%
Palma de Mallorca	81.0%	4.9%	0.0%	0.0%	0.5%	0.1%
London/Gatwick	97.3%	0.7%	0.1%	0.0%	0.3%	0.0%

Table 47: ADS-B declared capabilities in flight plans at the top 10 European airports in 2022

Aircraft type	Capability								
	L	H	E	S	P	I	X	C	A
B737-800	46.9%	3.1%	1.0%	49.0%	0.0%	0.0%	0.1%	0.0%	0.0%
A320	58.6%	19.9%	0.6%	20.8%	0.0%	0.0%	0.0%	0.0%	0.7%
A319	57.8%	28.7%	7.4%	5.7%	0.0%	0.0%	0.0%	0.4%	0.0%
A320 NEO	70.8%	12.1%	0.0%	17.1%	0.0%	0.0%	0.0%	0.0%	16.0%
A321	64.1%	25.3%	0.0%	10.6%	0.0%	0.0%	0.0%	0.0%	0.0%
A321 NEO	81.2%	6.4%	0.7%	11.6%	0.0%	0.0%	0.0%	0.0%	0.0%
B737 Max	40.2%	5.7%	1.0%	53.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ATR72-600	42.9%	9.4%	8.1%	39.5%	0.0%	0.0%	0.0%	0.0%	0.0%
E190	28.5%	46.9%	0.0%	24.6%	0.0%	0.0%	0.0%	0.0%	0.0%
B777-300ER	96.4%	2.4%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B787 Dreamliner	92.3%	3.5%	1.5%	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%
A330-300	88.3%	4.9%	5.7%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%
E195	70.9%	16.0%	8.9%	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%

Aircraft type	Capability								
	L	H	E	S	P	I	X	C	A
CRJ9	0.0%	55.8%	38.1%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ATR72-500	33.5%	2.3%	0.0%	64.1%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 48: SSR/Mode S declared capabilities in flight plans for main aircraft models in 2022

Aircraft type	Capability					
	B1	B2	U1	U2	V1	V2
B737-800	96.5%	0.3%	0.1%	0.0%	0.2%	0.0%
A320	86.5%	1.2%	0.4%	0.0%	1.7%	0.1%
A319	79.6%	7.4%	0.0%	0.0%	0.0%	0.0%
A320 NEO	93.4%	2.7%	0.1%	0.0%	0.0%	0.0%
A321	91.0%	0.2%	1.2%	0.0%	0.2%	0.0%
A321 NEO	94.1%	5.4%	0.3%	0.0%	0.2%	0.0%
B737 Max	97.2%	1.1%	4.9%	0.0%	6.5%	0.0%
ATR72-600	56.7%	0.1%	0.0%	0.0%	0.0%	0.0%
E190	94.9%	0.1%	0.0%	0.0%	0.0%	0.0%
B777-300ER	99.6%	0.0%	0.0%	0.0%	0.0%	0.0%
B787 Dreamliner	64.1%	35.5%	1.5%	0.0%	1.7%	0.0%
A330-300	89.6%	9.9%	0.0%	0.0%	0.0%	0.0%
E195	97.5%	0.0%	0.0%	0.0%	0.0%	0.0%
CRJ9	82.7%	0.0%	0.0%	0.0%	0.0%	0.0%
E170	58.6%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 49: ADS-B declared capabilities in flight plans for main aircraft models in 2022

28.5 Comment

The numbers of flights and aircraft provided by the CNS dashboard are derived from flight plans submitted to the EUROCONTROL Network Manager. Consequently, the statistics do not include the capability of aircraft flying in uncontrolled airspace or under VFR and thus do not submit flight plans to the NM. On-board capability and equipment data made available via the CNS dashboard are those declared in ICAO FPLs by operators. The information is therefore only as reliable as declared. For detailed analysis, additional local assessment is recommended.

Related inputs

Number of IFR flights

CNS infrastructure

PBN and precision approach procedures

AIR TRAFFIC MANAGEMENT

29 En-route ANS cost

29.1 EUROCONTROL recommended values

The costs of Air Navigation Services (ANS) in en-route airspace that is under the control of States/ANSPs. Table 50 shows the real en-route ANS costs for the EUROCONTROL Area in total and split into the SES States and non-SES States. The en-route ANS costs per Total Service Unit (TSU) are calculated as the ratio between the Total en-route ANS costs and Total en-route service units. The monetary values are presented in 2022 prices.

	2017	2018	2019	2020	2021	2022
SES States[1]	€ 6,904	€ 6,979	€ 7,064	€ 6,852	€ 6,524	€ 6,672
Non-SES States[2]	€ 1,436	€ 1,504	€ 1,538	€ 1,574	€ 1,423	€ 1,572
Total en-route ANS costs	**€ 8,340**	**€ 8,483**	**€ 8,602**	**€ 8,426**	**€ 7,947**	**€ 8,244**
SES States	115	122	125	53	67	108
Non-SES States	33	35	36	16	20	33
Total en-route service units (million)	**148**	**157**	**161**	**68**	**87**	**141**
SES States	€ 60	€ 57	€ 56	€ 131	€ 98	€ 62
Non-SES States	€ 44	€ 43	€ 42	€ 100	€ 72	€ 48
En-route ANS costs per TSU	**€ 56**	**€ 54**	**€ 53**	**€ 123**	**€ 92**	**€ 58**

[1]SES States refer to the 27 Member States of the European Union (EU), plus Switzerland and Norway

[2]Non-SES States refer to ten States which are not bound by SES regulations, but which were part of the EUROCONTROL Multilateral Route Charges System in 2020 (i.e. Albania, Armenia, Bosnia-Herzegovina, Georgia, Moldova, North Macedonia, Serbia, Montenegro, United Kingdom, and Türkiye)

Table 50: En-route ANS costs in million euros (2022 prices)[98]

For more details and analysis regarding the ANS costs please refer to the EUROCONTROL Performance Review Report (PRR) 2022. Previous versions of the PRR can be accessed via the EUROCONTROL Library.

> **Note**
>
> Please note the difference between Total Service Units (TSU) and Terminal Service Units (TNSU).

> **Note**
>
> The Unit Rate of Charge is the charge in euro applied by a Charging Zone to a flight operated by an aircraft of 50 metric tonnes (weight factor of 1.00) and flying 100 kilometres (distance factor of 1.00) in the charge area of that State.

The **Total en-route ANS costs** values in Table 50 are actual values. Often these can also be presented as 'determined' (a projection in the future) costs. This is typically the case when en-route ANS costs are

[98] Source: Data provided by EUROCONTROL Performance Review Unit (PRU)

forecast for a reference period of five years and represent costs pre-determined by the SES States as referred to in Article 15(2)(a) of Regulation (EC) No 550/2004 for providing air navigation services.

The **Total en-route Service Units** are used for the calculation of route charges that airspace users are billed to cover the costs of air navigation services received.

> **Note**
>
> Information on calculating unit rates can be found on the customer guide to charges website.

29.2 Other possible sources

Another source could be the EUROCONTROL Central Route Charges Office. At the time of writing, the most recent published version is the 2022 Report on the Operation of the Route Charges System.[99] Please, check regularly the CRCO full list of reports on the operation of the route charges system for the latest information.

The CRCO calculates route charges using flight messages sent by the Contracting States' Route Charges Offices (CRCOs) and additional flight information made available via the EUROCONTROL Network Management Directorate (NMD). The CRCO bills aircraft operators on a monthly basis, collects charges and disburses the amounts collected to the States every week.

29.3 Comment

Terminal ANS costs and ANSP gate-to-gate economic performance are described separately in chapter 7 of the latest EUROCONTROL Performance Review Report.[100]

Related inputs

Distance flown by charging zone

[99] EUROCONTROL, 'Report on the Operation of the Route Charges System in 2022', 2023, https://www.eurocontrol.int/publication/report-operation-route-charges-system-2022

[100] EUROCONTROL, 'Draft Performance Review Report (PRR) 2022', 2023, https://www.eurocontrol.int/publication/performance-review-report-prr-2022

30 Route charge share per market segment

30.1 EUROCONTROL recommended values

This input presents the proportion of route charges[101] from ATM services in Europe (infrastructure, staff, and other operational costs) collected per market segment in 2022.[102]

Market segment	As % of flights	As % of NM flown	As % of total charges collected
Mainline	40.2%	32.4%	49.8%
Low-cost	32.8%	24.4%	36.3%
All-cargo	3.8%	13.1%	5.3%
Charter	2.9%	4.8%	3.3%
Business aviation	8.8%	18.5%	2.8%
Regional aircraft	6.2%	1.5%	1.3%
Military	2.1%	4.3%	1.1%
Other types	3.3%	1.1%	0.3%
Total	**100%**	**100%**	**100%**

Table 51: Proportion of route charges per market segment in 2022[103]

On behalf of EUROCONTROL Member States, CRCO bills and collects route charges, which fund air navigation facilities and services and support air traffic management developments. It also bills and collects, on a bilateral basis, terminal charges, and air navigation charges on behalf of non-Member States, as well as communication charges in the Shanwick area.

Each aircraft operator receives a single bill per month in euros, no matter how many EUROCONTROL Member States were overflown. The billing and recovery of air navigation charges ensure that air navigation facilities and services are steadily financed and safely operated, paving the way for the future evolution of the pan-European ATM system in the context of the Single European Sky and the European ATM Master Plan (SESAR).

Information on the different charges levied by the CRCO, in particular the charge calculation methods, the basic billing documents, the methods of payment and the submission of claims, can be found in the customer guide to charges.

Related inputs

Number of IFR flights

Distance flown by charging zone

En-route ANS cost

[101] There are different sorts of air navigation charges, namely route charges, terminal navigation charges and communication charges. The above distribution relates to route charges only.
[102] EUROCONTROL, 'EUROCONTROL Market Segment Update 2022'.
[103] Calculated based on data from EUROCONTROL STATFOR, EUROCONTROL PRISME and EUROCONTROL CRCO

31 ANSP employment costs

31.1 EUROCONTROL recommended values

This section considers ANSPs' average annual employment costs for one Full Time Equivalent (FTE) in euros by category of staff. Table 52 shows the recommended values in 2022.

Staff function	EUROCONTROL area	SES area
ATCOs in OPS	€ 149,000	€ 174,600
Support Staff	€ 78,600	€ 96,700
Average all staff	**€ 101,300**	**€ 122,900**

Table 52: Average yearly ANSP employment costs (2021 prices)[104]

One FTE is the equivalent of a single person carrying out a particular job or activity working on a full-time basis for a year. A part-time employee working half-time would be counted as 0.5 FTEs. A full-time Air Traffic Control Officer (ATCO) working two-thirds of their time on duty in ops and one third of their time on teaching at a training academy would be counted as a 0.67 FTE ATCO in ops and a 0.33 FTE Support Staff.

Employment costs comprise gross wages and salaries, payment for overtime, employer contributions to social security schemes and taxes, pension contributions and other benefits. For a study on employment costs, the categories of staff working in an ANSP have been divided into two:

- **ATCOs in ops:** ATCOs participating in an activity which is either directly related to the control of traffic or where there is a necessary requirement for ATCOs to be able to control traffic
- **Support staff or non-ATCO in ops:** this category includes all other staff. It includes ATCOs on other duties (participating in an activity outside ops, such as special projects, teaching at a training academy, providing instruction in a simulator, working in a full-time management position, etc.), trainees, ATC assistants, technical and operational support staff, administration staff, and others

The following table gives an overview of individual ANSPs and average European system FTE costs for the two categories. The values were calculated based on information extracted from EUROCONTROL ACE Report.

ANSP	ATCO in ops	Support staff	All staff
Albcontrol	€ 25,157	€ 12,004	€ 14,278
ANS CR	€ 92,480	€ 48,890	€ 59,632
ARMATS	€ 26,608	€ 15,573	€ 18,564
Austro Control	€ 212,241	€ 144,827	€ 168,198
Avinor (Continental)	€ 200,980	€ 100,844	€ 141,867
BHANSA	€ 33,229	€ 27,790	€ 29,339
BULATSA	€ 97,975	€ 43,886	€ 57,983

[104] EUROCONTROL PRU, 'ATM Cost-Effectiveness (ACE) Benchmarking Report (2023 Edition)'.

ANSP	ATCO in ops	Support staff	All staff
Croatia Control	€ 114,253	€ 55,490	€ 75,575
DCAC Cyprus	€ 103,333	€ 65,184	€ 82,867
DFS	€ 259,922	€ 108,590	€ 154,303
DHMI	€ 48,531	€ 13,627	€ 21,911
DSNA	€ 135,757	€ 101,783	€ 114,204
EANS	€ 118,386	€ 44,161	€ 68,337
ENAIRE	€ 189,385	€ 100,512	€ 136,938
ENAV	€ 160,131	€ 107,708	€ 131,787
Fintraffic ANS	€ 121,324	€ 91,881	€ 106,711
HASP	€ 79,373	€ 56,721	€ 64,127
HungaroControl	€ 117,751	€ 45,005	€ 62,468
IAA	€ 136,394	€ 110,856	€ 123,423
LFV	€ 208,646	€ 94,208	€ 147,432
LGS	€ 68,079	€ 33,846	€ 42,079
LPS	€ 111,971	€ 36,682	€ 53,725
LVNL	€ 169,343	€ 130,050	€ 137,302
MATS	€ 95,426	€ 58,823	€ 70,659
M-NAV	€ 62,311	€ 26,413	€ 34,070
MOLDATSA	€ 29,717	€ 16,586	€ 20,429
MUAC	€ 342,107	€ 201,643	€ 248,610
NATS (Continental)	€ 188,931	€ 79,441	€ 115,172
NAV Portugal (Continental)	€ 276,568	€ 105,979	€ 152,942
NAVIAIR	€ 178,196	€ 94,628	€ 121,307
Oro navigacija	€ 74,537	€ 45,941	€ 54,690
PANSA	€ 73,375	€ 39,198	€ 50,061
ROMATSA	€ 104,383	€ 108,547	€ 107,060
Sakaeronavigatsia	€ 25,549	€ 14,059	€ 15,626
Skeyes	€ 211,550	€ 149,456	€ 164,922
Skyguide	€ 228,225	€ 173,362	€ 184,996
Slovenia Control	€ 113,759	€ 80,276	€ 93,083
SMATSA	€ 65,527	€ 43,370	€ 51,731
EUROCONTROL area -average values	**€ 149,078**	**€ 78,632**	**€ 101,304**

Table 53: Individual ANSP and average European system FTE costs in thousand euros (2021 prices)[105]

[105] EUROCONTROL PRU.

The values in Table 53 were calculated using values provided in Annex 5, Tables 0.3 and 0.5 of the source document. The employment costs refer to gate-to-gate cost (i.e. en-route and terminal costs) and are expressed in 2021 prices.

Related inputs

ATM cost effectiveness indicators

32 Asset life

32.1 EUROCONTROL recommended values

Table 54 presents the accounting period, in years, for a given asset used to derive the depreciation of investment expenditure.

Asset type	Expected life (years)
Freehold buildings, including related works services	20–40
Furniture and fittings	10–15
Motor vehicles	4–10
Electronic equipment (including telecommunications equipment)	7–15
General equipment	7–10
Computer equipment	3–10
Basic software and, if appropriate, application software	3–8
Aircraft	10–20
Leasehold buildings	Over the entire period of lease

Table 54: Estimated asset life[106]

Asset life as used in cost-benefit analyses reflects the expected operating life of the specific equipment concerned, which is also the basis for calculating depreciation costs which are taken into account to determine route charges.

The above data provide indicative parameters for classes of equipment for economic analyses. The actual percentages to be applied in calculating the depreciation of fixed assets must be determined in accordance with the expected operating life and the pertinent International Financial Reporting Standards issued by the International Accounting Standards Board.

32.2 Other possible sources

- *ICAO (2013), Manual on Air Navigation Services Economics (Doc 9161)*
- *European Commission DG REGIO (2014), Guide to Cost-Benefit Analysis of Investment Projects for Cohesion Policy 2014-2020*
- *European Commission DG REGIO (2022), Economic appraisal vademecum 2021-2027 General principles and sector applications*

[106] EUROCONTROL, 'Principles for Establishing the Cost-Base for Route Charges and the Calculation of the Unit Rates', 2011.

33 ATM cost-effectiveness indicators

33.1 EUROCONTROL recommended values

This section considers some key performance indicators of cost-effectiveness and productivity for the Air Navigation Services Providers (ANSP) in the EUROCONTROL area.

Year	ATCO-hour productivity (composite flight-hours per ATCO-hour)	Employment cost per ATCO-hour (euro per ATCO-hour in OPS)	Support cost ratio (gate-to-gate ANS staff to ATCOs in OPS)
2015	0.83	€ 112	3.2
2016	0.84	€ 113	3.1
2017	0.88	€ 114	3.1
2018	0.93	€ 115	3.1
2019	0.97	€ 118	3.1
2020	0.47	€ 131	3.1
2021	0.60	€ 126	3.2

Table 55: Average ANSP cost-effectiveness and productivity indicators[107]

Table 55 shows the trends in European system averages for the years 2015 through 2021. The ACE benchmarking reports comprise data about and analysis of cost-effectiveness and productivity for the ANSPs in EUROCONTROL's Member States. The key performance drivers of cost-effectiveness are (i) productivity, (ii) employment costs and (iii) support costs, comprising costs for non-ATCOs in OPS employment, non-staff operating costs, exceptional costs, depreciation, and capital-related costs

On top of the above values, 2021 key performance drivers of financial cost-effectiveness for ANSPs are summarised in Figure 2.7 of the source document.[108] **A wide variation per ANSP can be observed:**

- ATCO productivity ranges from 0.14 to 1.52 (Figure 2.8 of the source document)
- Employment costs per ATCO-hour vary from a minimum of €17 to a maximum of €358 per ATCO-hour (Figure 2.10 of the source document)
- Support cost ratio varies from 0.22 to 1.48 in 2021 (Annex 3, Table 0.1 of the source document)

Note

The employment costs above refer to gate-to-gate cost (i.e. en-route and terminal costs) and are expressed in nominal prices.

Related inputs

ANSP employment costs

[107] EUROCONTROL PRU, 'ATM Cost-Effectiveness (ACE) Benchmarking Report (2023 Edition)'.
[108] EUROCONTROL PRU.

34 ATM operational units

34.1 EUROCONTROL recommended values

This value represents the number of ATC units (air traffic centres) providing ATC services across Europe for the purpose of preventing collisions between aircraft, and on the manoeuvring area between aircraft and obstructions, and expediting and maintaining an orderly flow of air traffic.

Year	ANSP[1]	ACC[2]	APP[3]	TWR[4]	AFIS units[5]	ATC sectors[6]
2011	37	63	257	433	73	705
2012	37	63	260	425	81	716
2013	37	63	261	422	82	724
2014	37	63	280	215	128	707
2015[109]	38	63	276	407	129	719
2016	38	63	282	409	129	739
2017	38	63	278	404	128	740
2018	38	63	277	402	131	733
2019	38	63	276	406	131	755
2020	38	63	279	396	130	655
2021[110]	38	60	276	381	81	639

[1]ANSP - Air Navigation Service Provider
[2]ACC - Area Control Centre
[3]APP - Approach Units
[4]TWR – Tower
[5]AFIS - Airport/Aerodrome Flight Information Service
[6]ATC - Air Traffic Control

Table 56: Number of ATM operational units in Europe[111]

34.2 Comment

Please note that the analysis presented in ACE Benchmarking reports, on which this input was based, excludes elements related to services provided to military operational air traffic (OAT), oceanic ANS, and landside airport management operations. It presents a review and comparison of ATM cost effectiveness for the 38 ANSPs in Europe, which provide coverage for EUROCONTROL's 41 Member States.

Related inputs

ATM cost-effectiveness indicators

When to use the input?

The values presented above can be used in analyses where the level of granularity of information per type of provider or per provider is important. This is typically interesting for studies looking into costs or benefits per ANSP/ACC/Tower/other.

[109] Sakaeronavigatsia was added to the analysis in 2015.
[110] In 2021, UkSATSE was not included in the analysis of operational units, while BHANSA was added to the list, impacting the numbers presented in the table.
[111] EUROCONTROL ATM Cost-Effectiveness (ACE) Benchmarking Reports

35 CNS infrastructure

35.1 EUROCONTROL recommended values

The values below show the number of civil-owned systems installed which are devoted to carrying out navigation and surveillance functions in ECAC.

35.2 Navigation aids

Table 57 shows the number of Navigation aids in ECAC at the end of 2022. Please note there might be some marginal differences with the latest available picture in the EUROCONTROL Ground-based Navigation Infrastructure Map Tool (GNI tool) depending on the date of extraction.

							ILS			
State	DME Standalone	TACAN standalone	VOR standalone	VOR/DME	VORTAC	NDB	No CAT	CAT I	CAT II/III	DME / ILS
Albania	-	-	-	1	-	-	-	1	-	1
Armenia	-	-	-	1	-	6	-	1	1	1
Austria	7	-	-	9	-	11	2	3	6	11
Azerbaijan	-	-	-	7	-	4	-	13	6	19
Belgium	1	3	-	12	2	10	-	13	5	10
Bosnia and Herzegovina	-	-	-	7	-	7	-	4	-	4
Bulgaria	5	-	-	7	-	6	-	4	1	4
Croatia	5	-	-	8	-	26	-	8	1	5
Cyprus	-	-	-	2	-	3	1	2	-	2
Czech Republic	2	-	-	9	-	19	-	10	2	12
Denmark	5	1	1	5	3	21	2	18	7	26
Estonia	3	-	-	-	1	2	-	6	-	6
Finland	13	-	-	12	-	20	1	23	5	27
France	14	15	20	52	1	106	6	55	30	84
Georgia	5	-	-	2	-	5	-	5	-	5
Germany	37	-	7	39	5	45	5	35	43	46
Greece	-	-	2	46	-	40	2	3	6	10
Hungary	2	-	-	11	-	21	4	4	4	12
Iceland	2	1	-	2	1	30	1	7	2	10
Ireland	5	-	-	7	-	13	1	6	7	14
Italy	4	18	-	53	9	21	5	27	13	45
Latvia	3	-	-	6	1	-	-	2	2	4
Lithuania	4	1	-	4	-	3	-	5	2	5

							ILS			
State	**DME Standalone**	**TACAN standalone**	**VOR standalone**	**VOR/DME**	**VORTAC**	**NDB**	**No CAT**	**CAT I**	**CAT II/III**	**DME / ILS**
Luxembourg	-	-	-	2	-	-	-	1	1	2
Malta	-	-	-	1	-	1	-	2	-	2
Moldova	-	-	-	1	-	-	-	1	1	2
Monaco	-	-	-	-	-	-	-	-	-	-
Montenegro[1]	-	-	-	-	-	-	-	-	-	-
Netherlands	7	6	-	4	-	1	8	9	7	24
North Macedonia	2	-	-	3	-	3	-	2	-	1
Norway	14	13	-	31	-	53	27	27	6	58
Poland	17	-	-	22	-	22	-	6	9	15
Portugal[2]	13	4	1	15	2	9	1	7	4	9
Romania	8	-	-	16	-	22	-	10	11	21
San Marino	-	-	-	-	-	-	-	-	-	-
Serbia[3]	-	-	-	10	-	36	1	4	1	4
Slovak Republic	5	-	-	5	-	10	-	4	2	5
Slovenia	-	-	-	5	-	6	-	2	1	3
Spain[4]	6	13	-	83	2	52	1	48	17	64
Sweden	19	-	-	23	-	66	8	56	8	57
Switzerland	6	-	-	9	-	2	-	11	3	14
Türkiye	5	24	-	74	1	73	12	50	19	77
Ukraine	9	-	-	7	-	42	-	17	6	11
United Kingdom	16	1	1	46	-	68	4	54	28	86
Total ECAC	**244**	**100**	**32**	**659**	**28**	**885**	**92**	**566**	**267**	**818**

[1]Considered in Serbia as service is provided by SMATSA

[2]Including Azores and Madeira

[3]Considering jointly the State of Serbia and the State of Montenegro

[4]Including Canary Islands; Ceuta and Melilla and Spain Continental

Table 57: Navigation aids in the ECAC Member States in 2022[112]

The GNI Tool illustrates the current status, and the evolution plans for the Ground-based Navigation Infrastructure in ECAC. The Navaids database is updated based on the information published in the European AIS Database (EAD) and the planning provided by Air Navigation Service Providers. Please note the evolution plans shall not be considered as a commitment by a State or ANSP.

[112] EUROCONTROL Ground-based Navigation Infrastructure Map Tool

35.3 Surveillance units

Table 58 shows the number of Surveillance units in ECAC at the end of 2022.

State	PSR	Mode A/C	Mode-S	WAM/ADS-B[1]	ADS-B
Albania	-	1	1	7	-
Armenia	3	3	1	28	-
Austria	4	4	9	74	-
Belgium	6	1	11	-	-
Bosnia & Herzegovina	1	-	2	-	-
Bulgaria	5	4	21	44	-
Croatia	-	-	10	-	2
Cyprus	2	-	6	-	3
Czech Republic	1	-	10	40	-
Denmark	3	4	9	32	22
Estonia	-	2	4	26	-
Finland	-	-	-	117	-
France	4	36	40	17	16
Georgia	-	-	4	31	7
Germany	21	15	57	37	14
Greece	7	13	-	-	-
Hungary	4	-	12	-	4
Iceland	-	1	4	-	-
Ireland	4	4	7	-	5
Italy	25	-	48	-	-
Latvia	1	-	6	-	-
Lithuania	2	-	7	30	-
Luxembourg	1	1	1	-	-
Malta	2	1	3	4	3
Moldova	2	2	1	-	1
Montenegro	-	-	1	15	-
Netherlands	1	1	10	-	-
Norway	6	12	13	-	12
Poland	4	4	20	180	-
Portugal	1	2	9	10	2
Romania	1	2	9	60	-
Serbia	-	-	5	43	-
Slovak Republic	2	-	7	-	3

State	PSR	Mode A/C	Mode-S	WAM/ADS-B[1]	ADS-B
Slovenia	2	1	4	-	-
Spain	12	9	40	36	35
Sweden	1	4	12	2	-
Switzerland	1	-	15	-	-
Turkey	-	-	33	37	20
Ukraine	-	9	16	-	6
United Kingdom	13	3	58	38	-
Total	**142**	**139**	**526**	**908**	**155**

[1]The WAM/ADS-B column lists the number of sensors. The configurations and system boundaries for several WAM/ADS-B implementations are complex and site specific. It is therefore not possible to consistently identify the corresponding number of systems.

Table 58: Surveillance units in EUROCONTROL Member States in 2022[113]

The Mode-S, Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR) (i.e. Mode A/C) numbers are extracted from the surveillance database of the EUROCONTROL CNS unit.

According to the most recent figures, in Europe there are 526 Mode-S radars, 142 PSRs and 139 SSRs, either combined or standalone. As the allocation and implementation of Mode-S interrogator codes (ICs) require a coordinated approach, every installation of a Mode-S radar is officially registered. The numbers of PSRs and SSRs reported above are not necessarily accurate, as they are based on voluntary reports by the Member States on updates and changes to their surveillance infrastructure. Work on the collection of multilateration (MLAT)/ADS-B stations is still in progress.

The wide-area multilateration (WAM)/ADS-B (wide-area multilateration/automatic dependent surveillance-broadcast) and ADS-B data originate from the database which is maintained by the EUROCONTROL Surveillance and Code Coordination Unit and is based on inputs from stakeholders. The ADS-B and WAM Section coordinates the deployment of initial ADS-B applications and WAM in Europe.

The WAM/ADS-B sensor count only includes sensors mainly used for surveillance of airborne aircraft (e.g. in TMAs or en route). It does not include sensors mainly used for airport surface surveillance (e.g. airport MLAT used for A-SMGCS).

Related inputs

Fleet CNS capability

PBN and precision approach procedures

[113] EUROCONTROL Surveillance Unit Surveillance Database; LSSIP+ Cycle 2022 – SUR Questionnaire

36 PBN and precision approach procedures

36.1 EUROCONTROL recommended values

The values hereafter present the proportion of runway ends in ECAC with published Performance-Based Navigation (PBN) instrument approach procedures fully implemented. The data presented in the tables comes from EUROCONTROL Performance Based Navigation Map Tool. Please refer to this source for any further information.

Approach type	Runway ends covered	% of runway ends covered
RNP APCH to LNAV	1,154	71%
RNP APCH to LNAV/VNAV	833	51%
RNP APCH to LPV	754	46%
Any RNP APCH (LNAV or LNAV/VNAV or LPV)	1,173	72%
RNP AR APCH	36	2%
ILS (all, see breakdown below)	775	47%
GLS[1]	40	2%
3D (ILS Cat I or ILS Cat II/II or APV)	948	58%

[1] 'GLS' does not include instrument approach procedures based on GBAS proprietary precursor systems

Table 59: PBN approach deployment status, March 2023

Approach type	Runway ends covered	% of runway ends covered
ILS Cat I (and no Cat II/III)	512	31.3%
ILS Cat II/III	263	16.0%

Table 60: ILS Cat I, Cat II/III deployment status, March 2023

The EUROCONTROL PBN Map Tool illustrates the deployment of PBN instrument approach procedures against objectives set in ICAO Assembly Resolution 37-11 and the European Regulation on PBN (in particular Commission Implementing Regulation (EU) 2018/1048 of 18 July 2018).

PBN approaches include instrument approach procedures compliant with the following navigation specifications of the PBN Manual (ICAO Doc 9613):

- RNP APCH
- RNP AR APCH

The PBN Map tool provides a list of the current and planned airports and runway ends covered by each type of approach. The tool gives information about:

- deployment progress since 2012, on the basis of actual publications
- future deployment trends based on the draft PBN Transition plans submitted to EUROCONTROL Network Manager for consultation

- the availability of PBN approaches with vertical guidance (APV) on all runway ends or on runway ends without precision landing (e.g. ILS, MLS or GBAS)
- the deployment status for ECAC, individual countries, Pilot Common Project (PCP) airports and individual airports

In March 2023 (on the basis of the AIRAC cycle, see comments), 1,676 runways ends were equipped with instrument approach procedures.

36.2 Comment

The PBN Map Tool is updated in accordance with publications for every AIRAC cycle[114]. It therefore provides up-to-date information on the current deployment status.

[114] For more details about the AIRAC cycles and the corresponding dates, please refer to the corresponding EUROCONTROL page.

AIRPORTS

37 Airport classification

37.1 EUROCONTROL recommended values

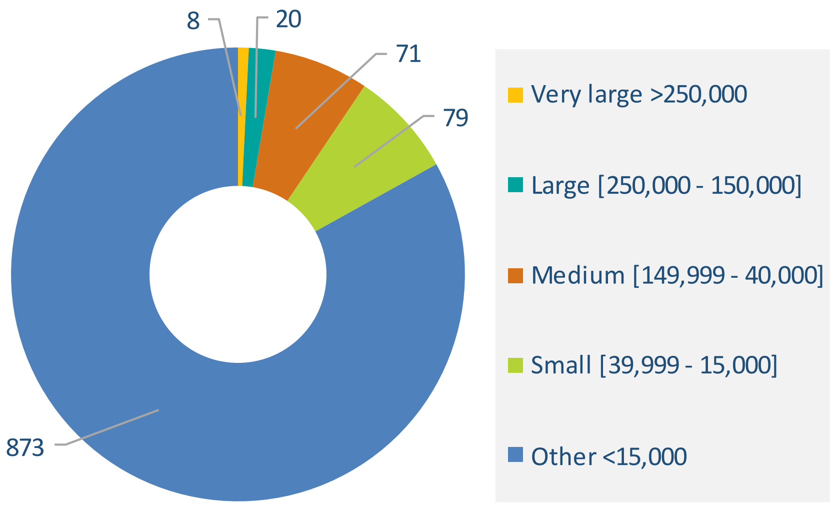

Figure 30: Airport classification in ECAC based on annual IFR movements in 2022

This input represents the number of airports per bracket of annual IFR movements[115].

The list of airports used for this classification was developed using a two-step procedure:

Step 1: the initial airport list provided by EUROCONTROL Performance Review Unit (PRU) was restricted to airports located in ECAC Member States and having both ICAO and IATA codes, in order to focus on airports providing commercial air transport services. Additional airports located in ECAC Member States were included in the airport list in order to scope all airports for which the EUROCONTROL PRU provided operational data.

Step 2: the data obtained in step 1 was sorted into brackets according to the number of annual IFR movements, based on which the airports were allocated to categories, ranging from Small to Very large.

Note

Please note that, within the category "Other", on top of the 873 airports presented in Figure 30, there are also 36 airports with no movements recorded in 2022.

Statistics on individual airport movements and operations at airports can be downloaded from Aviation Intelligence Unit Dashboard.

37.2 Other possible sources

Information on airports that have implemented Airport Collaborative Decision-Making (A-CDM) can be found via this link.

Airport CDM aims to improve the overall efficiency of airport operations by optimising the use of resources and improving the predictability of events. It focuses especially on aircraft turnaround and pre-departure sequencing processes.

The A-CDM concept has been globally recognised. A-CDM is fully implemented in 32 airports across Europe (status: December 2020), including Amsterdam, Barcelona, Bergamo, Berlin Brandenburg "Willy Brandt", Brussels, Copenhagen, Düsseldorf, Frankfurt, Geneva, Hamburg, Helsinki, Lisbon, London Gatwick, London Heathrow, Lyon, Madrid, Milan Malpensa, Milan Linate, Munich, Naples, Nice, Paris

[115] A movement is either a take-off or a landing at an airport

CDG, Paris Orly, Oslo, Palma de Mallorca, Prague, Rome Fiumicino, Stockholm Arlanda, Stuttgart, Venice, Warsaw, and Zurich.

More details for a selected airport are available in the EUROCONTROL Airport Corner.

37.3 Comment

The mapping of airports to categories in the recommended value is purely indicative and is based on the situation in 2022. The local situation of many airports may not be known or be interpreted differently. Final applicability of the assigning of airports to categories needs to be checked and confirmed by the appropriate airport or authority.

Related inputs

Turnaround time

38 Taxi time

38.1 EUROCONTROL recommended values

Table 61 shows the mean duration, in minutes, of taxi times at airports, based on flights in the ECAC area.

	All airports		Large and very large airports[1]		Medium and small airports[2]	
Year	**Taxi-in**	**Taxi-out**	**Taxi-in**	**Taxi-out**	**Taxi-in**	**Taxi-out**
2015	5.9	12.5	6.8	14.2	5.1	11.0
2016	6.0	12.8	6.8	14.6	5.2	11.3
2017	6.1	12.9	6.8	14.4	5.5	11.8
2018	6.2	13.8	6.8	14.9	5.6	12.1
2019	6.2	13.4	7.1	15.2	5.4	11.7
2020	5.7	11.4	6.8	13.2	4.5	9.6
2021	5.7	11.7	6.8	13.3	4.7	10.1
2022	6.0	12.3	7.2	14.1	4.8	10.5

[1]*Large and very large airports: >150,000 movements per year*

[2]*Medium and small airports: 14,999 to 150,000 movements per year*

Table 61: Average taxi-in and taxi-out time (minutes)[116]

Data in Table 61 is based on actual data from CODA. The taxi-out time is defined as the time spent by a flight between its actual off-block time (AOBT) and actual take-off time (ATOT). The taxi-in time is defined as the time spent between its actual landing time (ALDT) and actual in-block time (AIBT). The taxi-in and taxi-out durations are calculated on the basis of data sent by airlines to CODA.

Table 62 shows the average additional taxi out time per departure in the top 30 airports in terms of movements.

Year	2015	2016	2017	2018	2019	2020	2021	2022
Minutes	3.70	3.91	3.85	4.21	4.22	2.16	2.10	3.22

Table 62: Average additional taxi-out time per departure[117]

Values in Table 62 are based on actual data from airports. The additional taxi-out time is a proxy for the average departure runway queuing time on the outbound traffic flow during congested periods at airports. It is the difference between the actual taxi-out time of a flight and a statistically determined unimpeded taxi-out time[118] based on taxi-out times in periods of low traffic demand. There is one unimpeded time per stand/runway combination at each airport.

[116] Computed from actual data provided by the EUROCONTROL Central Office for Delay Analysis (CODA)
[117] EUROCONTROL, 'Performance Review Report (PRR) 2021', 2022, https://www.eurocontrol.int/publication/performance-review-report-prr-2021
[118] The unimpeded taxi-out time is the taxi-out time in non-congested conditions at airports.

38.2 Other possible sources

EUROCONTROL CODA Taxi times - Summer and Winter reports[119] show, by airport, seasonal taxi time statistics for the IATA winter season and the IATA summer season:

- Taxi-in times
- Taxi-out times
- Taxi-out times by wake turbulence category

These taxi times are calculated using the airline reported actual off-block time, actual take-off time, actual landing time and actual in-block time, providing the aviation community with seasonal benchmark values.

For additional granularity, taxi-out times by wake turbulence category are also offered for a number of airports.

Related inputs

IFR average flight distance and flight duration

IFR flight information per market segment

[119] EUROCONTROL CODA, 'Taxi Times - Summer and Winter Reports', n.d., https://www.eurocontrol.int/search?keywords=Taxi+times&sort_by=search_api_relevance

DRONES

39 Investment in U-space

39.1 EUROCONTROL recommended sources

U-space[120]-related investments are required to allow access to airspace for a large numbers of drones[121]. Below are presented some **key sources that are recommended to be consulted** in the frame of this value.

- *SESAR Joint Undertaking (SJU) (2020), European ATM Master Plan Edition 2020 Digitalising Europe's Aviation Infrastructure*[122]

  Highlights the growing importance in a time of new entrants. In particular, the Business View includes a section (6.2) on the "Holistic View of SESAR Net benefits for Drones" from which further U-space-related information can be retrieved.

- *SESAR Joint Undertaking (SJU) (2018), European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace*[123]

  The investment level considered is that necessary to support the safe and efficient deployment of drones in Europe as described in the European ATM Master Plan 2020. The values consider the civil side of the investments. Military investments are not taken into account. There are three categories of investments considered, namely infrastructure and services, airborne investments, and human resources. Further details of sub-categories and examples are to be found in Annex 3.

- *SESAR Joint Undertaking (SJU) (2016), European Drones Outlook Study. Unlocking the value for Europe*[124]

  Describes the growing potential of the European market for drones. The development of the drone fleet is dependent on the ability of the industry to operate various areas of airspace. The document analyses the likely evolution of the fleet, linking it with the expected use, whether for military, government and commercial, or leisure purposes.

- *EASA Drones & Air Mobility*[125]

  Contains a comprehensive information base about the current and ever-evolving situation with drones in Europe, the corresponding regulatory evolution, drone categorisation information, among other.

[120] U-space is a set of new services and specific procedures designed to support safe, efficient, and secure access to airspace for large numbers of drones. Source: SJU U-Space Blueprint
[121] Drones, UAS, RPAS? In line with the Drones Outlook Study and the U-Space Blueprint document, the term "drones" is used as a generic term to cover all types of unmanned aircraft systems (UAS), whether remotely piloted (RPAS – remotely piloted aircraft system) or automated.
[122] SESAR Joint Undertaking (SJU), 'European ATM Master Plan', n.d., https://www.sesarju.eu/masterplan
[123] SESAR Joint Undertaking (SJU), 'European ATM Master Plan: Roadmap for the Safe Integration of Drones into All Classes of Airspace', 2018, https://www.sesarju.eu/node/2993
[124] SESAR Joint Undertaking (SJU), 'European Drones Outlook Study. Unlocking the Value for Europe', 2016, https://www.sesarju.eu/sites/default/files/documents/reports/European_Drones_Outlook_Study_2016.pdf
[125] EASA, 'Drones & Air Mobility', n.d., https://www.easa.europa.eu/en/domains/civil-drones

- *SKYbrary*[126]

  An electronic repository of safety knowledge related to ATM and aviation safety in general. It contains information about U-Space and provides useful links and frequently updated information.

Note

As drones are an emerging and dynamic business, the estimates and assumptions made for the sources referenced could already be outdated and should be treated with caution.

[126] SKYbrary, 'U-Space', n.d., https://skybrary.aero/articles/u-space

40 Drone fleet

40.1 EUROCONTROL recommended sources

Drone fleet represents an estimate of the size of the future drone fleet operating in Europe. Below are presented some **key sources that can be consulted in order to obtain information about the drone fleet in Europe.**

- *SESAR Joint Undertaking (SJU) (2016), European Drones Outlook Study. Unlocking the value for Europe*[127]

  Describes the growing potential of the European market for drones. The development of the drone fleet is dependent on the ability of the industry to operate various areas of airspace. The document analyses the likely evolution of the fleet, linking it with the expected use, whether for military, government and commercial, or leisure purposes.

- *SJU (2018), European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace*[128]

  Outlines which drone related-research and development (R&D) activities should be prioritised in order to support the expansion of the drone market and achieve the smooth, safe, and fair integration of these new aircraft systems into the European airspace. It also provides an ambitious rollout plan for these technological developments. The document concentrates on the link with the Master Plan 2020 Business View and brings in the topic of urban air mobility.

Note

In view of the rapid evolution in recent years, the role of drones is likely to expand more than the source documents consider. The fleet is rapidly growing, making outlook analyses unstable. The data provided in the source documents should be seen as an estimate and will be reviewed in future editions of the standard inputs as additional data become available.

[127] SESAR Joint Undertaking (SJU).

[128] SESAR Joint Undertaking (SJU), 'European ATM Master Plan: Roadmap for the Safe Integration of Drones into All Classes of Airspace'.

PASSENGERS

41 Purpose of passenger travel

41.1 EUROCONTROL recommended values

Figure 31 shows the distribution of aircraft according to the purpose of travel.

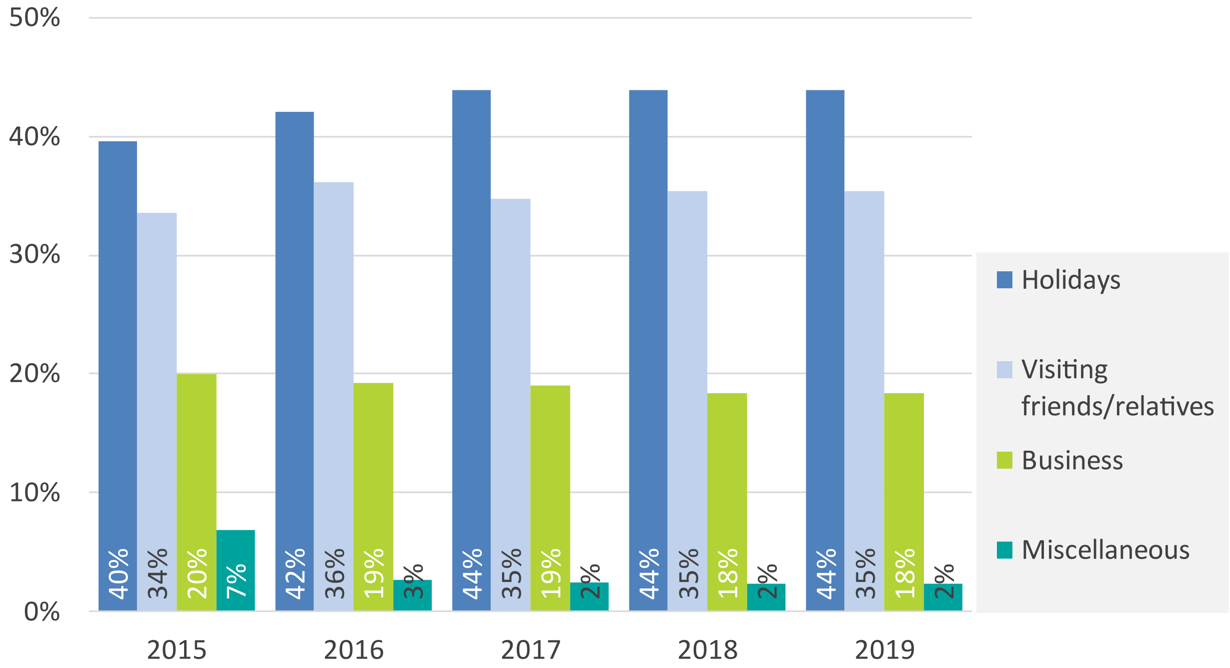

Figure 31: Purpose of air passenger travel at selected UK airports[129]

The results are based on the UK Civil Aviation Authority (CAA) departing passenger survey, which is carried out at selected airports (Gatwick, Heathrow, Luton, Stansted, and Manchester), usually every year but interrupted from March 2020 onwards due to the COVID-19 pandemic.

The scope of the statistics is travel to, from and within the UK over a five-year period (2015 – 2019).

The "holidays" travel increased by 4 percentage points (p.p.) and "visiting friends and relatives" was up 2 p.p. On the other hand, "business travel" went down by 2 p.p., while "miscellaneous" travel decreased by 5 p.p. between 2015 and 2019.

41.2 Further reading

Below are listed some sources recommended to consult in the frame of this topic:

- *EUROCONTROL airport corner*[130] provides access to non-confidential information relating to the purpose of travel from a specific airport
- *UK Department for Transport in its table TSGB0114b*[131] publishes overseas travel by air: visits to and from the UK by area and purpose – all modes for years 2011-2019 and 2021. This data does not include domestic travel by air

[129] UK Department of Transport, 'Aviation Statistics', 2022, https://www.gov.uk/government/statistical-data-sets/tsgb02

[130] EUROCONTROL, 'Airport Corner', n.d., https://www.eurocontrol.int/tool/airport-corner

[131] UK Department for Transport, 'Statistical Data Set - Modal Comparisons', n.d.

- *UK Civil Aviation Authority Passenger Survey Reports*[132]
- *In its Yearly Compendium of Tourism Statistics, UN World Tourism Organisation*[133] publishes arrivals by main purpose (personal, business, and professional)

132 UK Civil Aviation Authority, 'Annual Departing Passenger Survey Reports', n.d., https://www.caa.co.uk/Data-and-analysis/UK-aviation-market/Consumer-research/Departing-passenger-survey/Survey-reports/
133 UN World Tourism and Organisation, 'Yearly Compendium of Tourism Statistics', n.d., https://www.e-unwto.org/doi/epdf/10.18111/9789284423583

42 Passenger value of time

42.1 EUROCONTROL recommended values

Travel purpose	Time value (€/hour)
EU25[1]	
Personal	€ 20.47
Business	€ 49.98
France[2]	
Personal - holiday	€ 59.80
Personal - other	€ 61.20
Business	€ 83.50
All purpose	€ 62.10
United Kingdom[3]	
Leisure	€ 8.60
UK business	€ 63.80
Foreign business	€ 60.70

[1]*Values adjusted from 2002 to 2022 prices based on inflation*

[2]*Values adjusted from 2015 to 2022 prices based on inflation*

[3]*Values adjusted from 2014 to 2022 prices based on inflation and using the exchange rate in general parameters*

Table 63: Average value of travel time in EU25, France and UK

This input provides an estimation of the average value of passenger time spent travelling, which might alternatively be spent on other activities (e.g. working or leisure). It is essentially the **opportunity cost which corresponds to the monetary value associated with a passenger during a journey.** It shows how much a passenger would be willing to pay in order to save time during a journey (e.g. by travelling on a quicker service or using a faster transport mode), or how much 'compensation' they would accept, directly or indirectly, for time lost. Table 63 presents a collection of different values that can be used for this purpose. It is to be noted that, in this section, the value of time is not cited as a function of delay duration. This is an important consideration when using the value, since the longer the delay duration, the higher the value.[134] [135] [136]

[134] European Commission, *HEATCO - Developing Harmonised European Approaches for Transport Costing and Project Assessment*, 2006, https://trimis.ec.europa.eu/sites/default/files/project/documents/20130122_113653_88902_HEATCO_D5_summary.pdf

[135] French Ministry of Ecological Transition, 'Recommended Values for Calculating Average Long-Distance Travel', May 2019, https://www.ecologie.gouv.fr/sites/default/files/V.3.pdf

[136] Airports Commission, 'Delay Impacts Assessment Methodology Paper', November 2014, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/372606/AC08a_tagged.pdf

42.2 Comment

When looking into the values in the table, a few points regarding the sources should be taken into consideration:

- The source used for the UK values sets out a methodology for analysis which has been undertaken to estimate benefits from reduced delay time to airlines and passengers from changes in aviation capacity constraints in the UK for 11 airports.
- The values for France rely on a working paper on recommended values for calculating the components of a socio-economic net present value, which include travel time. The assessment therefore covers social, environmental, and economic effects.
- Regarding the numbers for EU25, they remain a reference if a European value is sought. The objective of the study from which they were derived is to propose harmonised guidelines for project assessment for transnational projects in Europe. It provides monetary estimates for the values of time saved for an employer's business and for passenger non-work trips (e.g. commuting, shopping and leisure).

42.3 Other possible values

Some additional values, which, although not constituting the perceived key inputs, may be useful for specific purposes of the user of these inputs. These values are presented below.

Value of time of a business aviation passenger

€153 per hour. This value was provided to EUROCONTROL by airline members of the SESAR CBA team in 2012 and is, therefore, adjusted from 2011 prices.

Value of passenger time in the US for high-speed rail passengers

Travel purpose	Time value (€/hour)
Personal	€ 47.2
Business	€ 82.7
All purposes	€ 61.6

Table 64: Passenger value of time for air and high-speed rail travel[137]

Based on US Department of Transport (DOT) guidance on passenger value of time for air and high-speed rail travel by purpose of trip. The numbers are adjusted to inflation from 2015 to 2022 prices and using the exchange rate presented in Table 2.

137 US Department of Transportation, 'Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis', September 2016.

42.4 Further reading

Below are listed some additional sources recommended for consultation:

- *International Transport Forum (ITF), "What is the Value of Saving Travel Time?" Feb. 2019*[138]
- *Economic Development Research Group Inc., "Passenger Value of Time, Benefit-Cost Analysis and Airport Capital Investment Decisions," 2015*[139]
- *University of Leeds, "Values of travel time in Europe: Review and meta-analysis," 2016*[140]
- *University of Leeds, "European Wide-Meta Analysis of Values of Travel Time," May 2012*[141]

When to use the input?

This input is expected to become useful in any study that looks at the opportunity cost of the use of air transport, delays, cancellations, etc. It provides a perspective on the impact that a change in the air transport can have on the passenger.

[138] International Transport Forum (ITF), 'What Is the Value of Saving Travel Time?', 10 February 2019, https://www.itf-oecd.org/what-value-saving-travel-time
[139] Economic Development Research Group Inc., 'Passenger Value of Time, Benefit-Cost Analysis and Airport Capital Investment Decisions', 2015, https://www.ebp-us.com/en/projects/passenger-value-time-benefit-cost-analysis-and-airport-capital-investment-decisions
[140] University of Leeds, 'Values of Travel Time in Europe: Review and Meta-Analysis', 2016, http://eprints.whiterose.ac.uk/104595/1/European meta paper final accepted for publication.pdf
[141] University of Leeds, 'European Wide-Meta Analysis of Values of Travel Time', May 2012, https://significance.nl/wp-content/uploads/2019/03/2012-GDJ-European-wide-meta-analysis-of-values-of-travel-time.pdf

SAFETY

43 Accident/incident statistics

43.1 EUROCONTROL recommended sources

According to ICAO Annex 13:

An **accident** is an occurrence associated with the operation of an aircraft …, in which (a) a person is fatally or seriously injured… or (b) the aircraft sustains damage or structural failure …or (c) the aircraft is missing or completely inaccessible.[142]

An **incident** is an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operations.

The following documents are key sources of the latest statistics on accidents and incidents occurring in the aviation domain, as well as the related fatalities and injuries.

- *EASA Annual Safety Review*[143] provides both, a statistical summary of aviation safety in the EASA Member States and identifies the most important safety challenges faced by European aviation today. The key statistics on accidents and serious incidents in the different aviation domains can be found at the start of each chapter in the Annual Safety Review.
- *EUROCONTROL voluntary ATM incident reporting (EVAIR) safety bulletin*[144] collects low-severity ATM incidents which involve pilots and controllers. The established process and kinds of data provided by airlines and ANSP Safety Management Systems (SMS) allow day to day analysis and, in this regard, identification of the causes of incidents. The data are collected from the entire ECAC region and from neighbouring airspace, such as the Eastern part of the ICAO EUR region, the Middle East, Africa, etc.
- *IATA Annual Safety Report*[145] provides the industry with critical information derived from the analysis of aviation accidents to enable to understand safety risks in the industry and to propose mitigation strategies.

43.2 Further reading

The sources listed hereafter are those recommended to consult for further information:

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[142] Full definition of accident: An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which (a) a person is fatally or seriously injured as a result of being in the aircraft; or direct contact with any part of the aircraft, including parts which have become detached from the aircraft; or direct exposure to jet blast (except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers or crew); or (b) the aircraft sustains damage or structural failure which: adversely affects the structural strength, performance or flight characteristics of the aircraft and would normally require major repair or replacement of the affected component (except for engine failure or damage, when the damage is limited to the engine, its cowlings or accessories; or for damage limited to propellers, wing tips, antennas, tires, brakes, fairings, small dents or puncture holes in the aircraft skin); or (c) the aircraft is missing or is completely inaccessible. (ICAO Annex 13)

[143] EASA, 'Annual Safety Review', n.d., https://www.easa.europa.eu/en/document-library/general-publications?publication_type%5b144%5d=144&page=1

[144] EUROCONTROL, 'EUROCONTROL Voluntary ATM Incident Reporting', n.a., https://www.eurocontrol.int/service/eurocontrol-voluntary-atm-incident-reporting

[145] IATA, 'IATA Safety Report', n.a., https://www.iata.org/en/publications/safety-report/

- *EU Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC*[146] contains a definition of accidents and incidents
- *EU Regulation (EU) No 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, amending Regulation (EU) No 996/2010 of the European Parliament and of the Council and repealing Directive 2003/42/EC of the European Parliament and of the Council and Commission Regulations (EC) No 1321/2007 and (EC) No 1330/2007*[147] contains information on the regulatory requirements reporting, analysis and follow-up of occurrences, which include accidents and incidents in civil aviation
- *EU Single Sky Performance Review Body, Annual Monitoring Report*[148] are the Annual Monitoring Reports are prepared by the Performance Review Body (PRB) of the Single European Sky (SES)
- *ICAO safety reports*[149] provides overview of worldwide aviation safety performance and collaborative efforts by international air transport stakeholders to further improve safety in light of the sustained growth of the sector
- *Performance Review Commission (2023) Draft Performance Review Report (PRR) 2023*[150] Annual Performance Review Reports issued by the Performance Review Commission provide an annual review of Europe's ATM safety performance
- *SKYbrary*[151] An electronic repository of safety knowledge related to ATM and aviation safety in general. It contains information about accidents and serious incidents by aircraft type and is also a portal which gives users access to the safety data made available on the websites of various aviation organisations (regulators, service providers, industry).

When to use the input?

This input is recommended to be used in the instances where safety is an important factor, namely in terms of accident reduction.

[146] European Commission, 'Regulation (EU) No 996/2010 on the Investigation and Prevention of Accidents and Incidents in Civil Aviation and Repealing Directive 94/56/EC', n.d., http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:295:0035:0050:EN:PDF
[147] European Commission, 'EU (2014), Regulation (EU) No 376/2014 on the Reporting, Analysis and Follow-up of Occurrences in Civil Aviation, Amending Regulation (EU) No 996/2010 of the European Parliament and of the Council and Repealing Directive 2003/42/EC of the European Parliament and of the Council and Commission Regulations (EC) No 1321/2007 and (EC) No 1330/2007', n.d., https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0376&from=EN
[148] European Commission, 'EU Single Sky Performance', n.d., http://www.eusinglesky.eu/prb-report-library.html
[149] ICAO, 'Safety Reports', n.d., https://www.icao.int/safety/Pages/Safety-Report.aspx
[150] EUROCONTROL, 'Draft Performance Review Report (PRR) 2023', 2024, https://www.eurocontrol.int/publication/performance-review-report-prr-2023-consultation
[151] 'SkyBrary', n.d., https://www.skybrary.aero/

44 Value of a statistical life

44.1 EUROCONTROL recommended values

Value of a Statistical Life (VSL) represents the monetary willingness to pay for a lower risk of instantaneous premature death. It is often used as a proxy to monetise the value of a fatality occurring from transport accidents.

In Europe, based on a study published by the European Commission[152] the **average statistical value of life for EU27+UK is estimated at € 4.3 million.** This value is adjusted to 2022 prices from 2016, based on inflation.

Please note that the value of life differs based on the State, circumstances, age, profession, education, and a number of other parameters. It also differs for different modes of transport. Thus, different sources[153] [154] [155] propose different values and ways to estimate them, depending on specific circumstances.

Related inputs

Accident/incident statistics

Value of a statistical injury

When to use the input?

This input is recommended to be used in studies where the cost of fatalities resulting from safety accidents in aviation needs to be monetised. This is a significant part of an economic impact of a solution, particularly when the solution focuses on safety improvements.

[152] European Commission DG MOVE, 'Handbook on the External Costs of Transport'.
[153] EASA, 'Notice of Proposed Amendment 2013-20. Seat Crashworthiness Improvement on Large Aeroplanes - Dynamic Testing 16g', 2013, https://www.easa.europa.eu/sites/default/files/dfu/NPA%202013-20.pdf
[154] European Commission DG REGIO, 'Guide to Cost-Benefit Analysis of Investment Projects for Cohesion Policy 2014-2020', 2014, https://ec.europa.eu/regional_policy/en/information/publications/guides/2014/guide-to-cost-benefit-analysis-of-investment-projects-for-cohesion-policy-2014-2020
[155] European Commission, '"Better Regulation" Toolbox –November 2021 Edition', 2021, https://commission.europa.eu/system/files/2023-02/br_toolbox-nov_2021_en.pdf

45 Value of a statistical injury

45.1 EUROCONTROL recommended values

The value of a statistical injury represents the **monetary value of an improvement in safety to achieve a risk reduction which would prevent one statistical injury.** It can be used as a proxy to monetise the impact of an injury resulting from transport accidents.

Table 65 shows the estimation of the value of an injury as a fraction of the value of statistical life, following the approach and numbers presented in the Handbook on the External Costs of Transport. This approach assumes six levels of injury, where Maximum Abbreviated Injury Scale (MAIS) 1 and MAIS 2 represent slight injury, MAIS 3 through MAIS 5 represent serious injury and MAIS 6 represents fatality.

Thus, Table 65 presents the levels of injury, the share that the value of injury represents of the value of life and the calculated value of injury in euros, based on these percentages and the estimated Value of Statistical Life (VSL) as presented in section 44.

Injury category	Share of VSL	Value of injury
MAIS 1	0%	€ 12,900
MAIS 2	4%	€ 189,200
MAIS 3	10%	€ 447,200
MAIS 4	26%	€ 1,130,900
MAIS 5	59%	€ 2,541,300
MAIS 6 (fatality)	100%	€ 4,300,000

Table 65: Estimated value of a statistical injury[156]

Note

The above data should be treated with caution as there may be legal implications.

45.2 Other possible sources

Another source to consult in the frame of this input is:

- *European Commission DG REGIO, Guide to Cost-Benefit Analysis of Investment Projects for Cohesion Policy 2014-2020*[157]

Related inputs

Accident/incident statistics

Value of a statistical life

[156] European Commission DG MOVE, 'Handbook on the External Costs of Transport'.
[157] European Commission DG REGIO, 'Guide to Cost-Benefit Analysis of Investment Projects for Cohesion Policy 2014-2020'.

FINANCIAL VALUES

46 Discount rate

46.1 EUROCONTROL recommended values

The discount rate is the annual rate used to discount a stream of cashflows to calculate their Net Present Value (NPV).

The **discount rate recommended to be used for the EU is 3%.**[158]

A nominal discount rate has three components:

- a basic, risk-free, time value of money (TVM) – traditionally of the order of 2.5%
- compensation for the erosion of the principal by inflation
- a premium for risk

The inflation element should only be included if the cash flows are expressed in 'money of the day' and should be excluded if the cash flows are expressed at constant price levels. The recommended value is inflation-free and only takes into account TVM and the risk premium.

The assessment of the risk premium depends on the judgment of the investor and can only be analysed over a portfolio of investments. In the case of investment in an air traffic management system, the risk being evaluated is the risk that the system will operate successfully and generate the benefits expected. It is not related to the commercial viability of aircraft operators using the system.

Values differing from the 3% benchmark can, however, be justified on the grounds of local and individual conditions which affect the requisite risk premium.

For instance, the value used as an indicative benchmark in (EUROCONTROL) business cases for ATM investments is often 8%, and it is applied to costs incurred and benefits achieved by air navigation service providers, aircraft operators and any other parties involved.

46.2 Other recommended values

Another way to calculate the discount rate is by using the Weighted Average Cost of Capital (WACC) metric. According to Implementing Regulation 2019/317 art. 22 (4),[159] WACC is defined as the average of the return on equity and the interest rate on debt, weighted by the capital structure. According to the same source, the WACC relevant for the assessment of performance plans is the cost of capital pre-tax rate.

In their 'Study on cost of capital. Methodology review and update' report,[160] the Performance Review Body (PRB) of the Single European Sky performed an assessment of the cost of capital for the ANSPs of the Single European Sky Member States.

[158] European Commission, 'Better Regulation Toolbox', July 2023, https://commission.europa.eu/system/files/2023-09/BR%20toolbox%20-%20Jul%202023%20-%20FINAL.pdf
[159] European Commission, 'Implementing Regulation 2019/317 Art. 22 (4)', n.d., 317, https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2019%3A056%3ATOC&uri=uriserv%3AOJ.L_.2019.056.01.0001.01.ENG
[160] Performance Review Body (PRB), 'Study on Cost of Capital. Methodology Review and Update', 2021, https://wikis.ec.europa.eu/download/attachments/54034648/prb_cost_of_capital_report_2021_published.pdf?version=1&modificationDate=1650978083175&api=v2

The methodological approach taken by PRB calculates efficient costs of capital and combines them with a check on the maximum exposure due to the traffic-risk sharing mechanism.[161] The cost of capital is assessed according to four options[162] that are summarised as follows:

- **Option 1** should be used when the WACC of an ANSP is based on an actual capital structure that is not aligned to the optimal capital structure
- **Option 2** should be used if it is lower than Option 1 for an ANSP that is subject to a government-specified equity return
- **Option 3** should be used if it is lower than Option 1 for an ANSP that has access to loan finance on favourable terms but is not subject to a government-specified equity return
- **Option 4** is an additional sense check of the cost of capital (the WACC times the asset base) and the maximum risk exposure of the ANSP (4.4% of revenues)

Option 1 is used as a reference here because it constitutes the baseline value in the study, while the remaining three options are subject to specific circumstances described above.

As a result of this assessment, the **average estimated pre-tax WACC in 2022 for all Member States' ANSPs for option 1 amounts to 4.6%.**

According to the PRB, Options 2-4 of the methodological framework may result in lower numbers than Option 1 if the ANSP is subject to a lower government-specified return on equity (Option 2), if the ANSP obtains loan finance on more favourable terms (Option 3), or if the WACC implied by the maximum exposure of the ANSP is lower (Option 4).

46.3 Further reading

The sources listed below are those recommended for further information about discount rates:

- *European Commission (2023), Better regulation toolbox*[163]

  Has been created to support designing EU policies and laws so that they achieve their objectives at minimum cost. The Guidelines explain what better regulation is and how it should be applied in the day-to-day practices of Commission officials preparing new initiatives and proposals or managing existing policies and legislation.

- *European Commission (2014), Guide to Cost-Benefit Analysis of Investment projects, Economic appraisal tool for Cohesion policy 2014-2020*[164]

  Offers practical guidance on major project appraisals, as embodied in the cohesion policy legislation for 2014-2020 and takes into account the specific requirements for the European Commission.

[161] Please refer to the source document for further details
[162] See table 2 of the source document
[163] European Commission, 'Better Regulation Toolbox'.
[164] European Commission DG REGIO, 'Guide to Cost-Benefit Analysis of Investment Projects for Cohesion Policy 2014-2020'.

- *European Commission (2022), Economic Appraisal Vademecum 2021-2027 – General principles and sector applications*[165]

  Further promotes and simplifies the voluntary use of Economic Appraisal for EU co-financed investments in the 2021-2027 programming period.

- *GOV.UK, HM Treasury (2018), The Green Book: Central Government Guidance on Appraisal and Evaluation*[166]

  The EUROCONTROL recommended value of 3% is not necessarily suitable for discounting intergenerational projects, especially the projects dealing with environmental matters. A declining long-term discount rate approach may be used following the example on p.104 of this document.

46.4 Comment

Different approaches to determining discount rates can be used (social rate of time preference, marginal social opportunity cost of capital, weighted average cost of capital, shadow price of capital). A description of these approaches goes beyond the limits of this document.

The choice of an appropriate social discount rate for the cost-benefit analysis of public projects has long been a contentious issue and subject to intense debate by economists.

Since the choice of discount rate is a matter of judgment, it is recommended that in project appraisals the sensitivity analysis should include a consideration of the effect of differing discount rates. Note that the Internal Rate of Return (IRR) is the discount rate which will give an NPV of zero and thus gives the effective overall return on an investment over the period under consideration.

[165] European Commission DG REGIO, 'Economic Appraisal Vademecum 2021-2027 General Principles and Sector Applications', 2022, https://op.europa.eu/en/publication-detail/-/publication/cf2c28fe-484e-11ed-92ed-01aa75ed71a1/language-en

[166] GOV.UK, HM Treasury, 'The Green Book: Central Government Guidance on Appraisal and Evaluation', 2018, https://www.financeministersforclimate.org/knowledge-center/green-book-central-government-guidance-appraisal-and-evaluation

47 Exchange rate

47.1 EUROCONTROL recommended sources

An exchange rate represents the price or rate at which the currency of one State can be exchanged for another State's currency.

In order to obtain the latest exchange rate information it is recommended to visit the website of the European Central Bank.

The website contains information on the yearly, half-yearly, quarterly, monthly, and daily exchange rates of 40 currencies.

As an alternative, the European Commission InforEuro Exchange rate provides the European Commission official monthly accounting rates for the euro, the corresponding conversion rates for other currencies, and historic conversion rates from 1994.

Acronyms and definitions

AAGR	Average Annual Growth Rate
ACARS	Aircraft Communications, Addressing and Reporting System
ACC	Area Control Centre
A-CDM	Airport CDM
ACE	ATM cost-effectiveness
ACI	Airports Council International
ACMG	Airline Cost Management Group
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic dependent surveillance-contract
AEM	Advanced Emission Model
AFIS	Airport/Aerodrome Flight Information Service
AIBT	Actual In-Block Time
AIRAC	Aeronautical Information Regulation and Control
AIRIAL	Air Navigation Inter-Site Acronym List
AIS	Aeronautical Information Services
Albcontrol	Albanian ANSP
ALDT	Actual Landing Time
ANS	Air Navigation Services
ANS CR	Cech ANSP
ANSP	Air Navigation Service Provider
AOBT	Actual Off-Block Time
AOC	Air Operator Certificate
APCH	Approach
APM	Aircraft Performance Model
APP	Approach Units
APV	Approach Procedures with Vertical Guidance
ARMATS	Armenian Air Traffic Services (Armenian ANSP)
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management

ATN	Aeronautical Telecommunications Network
ATOT	Actual Take-Off Time
Austro Control	Austrian ANSP
AVINOR	Norwegian ANSP
BADA	Base of Aircraft Data
bbl	Barrel
BHANSA	Bosnia and Herzegovina Air Navigation Services Agency
BULATSA	Bulgarian ANSP
CAA	Civil Aviation Authority
CBA	Cost-Benefit Analysis
CDM	Collaborative Decision-Making
CIS	Commonwealth of Independent States
CNS	Communication, Navigation and Surveillance
CO	Carbon monoxide
CO_2	Carbon dioxide
CODA	Central Office of Delay Analysis
CP1	Common Project 1
CPDLC	Controller Pilot Data Link Communication
CRCO	Central Route Charges Office
Croatia Control	Croatian ANSP
CRS	Central Reservation System
DAIO	Departures, Arrivals, Internal, Overflight
db(A)	Equivalent continuous level
DCAC Cyprus	Cypriot ANSP
D-FIS	Data Link Flight Information Service
DFS	Deutsche Flugsicherung (German ANSP)
DGAC	Direction Générale de l'Aviation Civile (FR)
DHMI	Devlet Hava Meydanları İsletmesi (Turkish ANSP)
DME	Distance Measuring Equipment
DOT	Department of Transport
DSNA	Direction des services de la navigation aérienne (FR)
EAD	European AIS Database
EANS	Estonian Air Navigation Services (Estonian ANSP)

EAO	EUROCONTROL Aviation Outlook
EASA	European Aviation Safety Agency
ECAC	European Civil Aviation Conference
EEA	European Environment Agency
EFTA	European Free Trade Association
EMEP	European Monitoring and Evaluation Programme
ENAIRE	Spanish ANSP
ENAV	Ente Nazionale di Assistenza al Volo S.p.A. (Italian ANSP)
ESSIP	European Single Sky Implementation
ETS	Emissions Trading Scheme (of the European Union)
EU	European Union
Eurostat	Statistical Office of the European Union
EVAIR	EUROCONTROL voluntary ATM incident reporting
FANS	Future air navigation systems
Fintraffic ANS	Finnish ANSP
FIR	Flight Information Region
FMC	Flight Management Computer
FOCA	Swiss Federal Office of Civil Aviation
FPL	Flight Plan
FTE	Full Time Equivalent
GA	General Aviation
GAT	General Air Traffic
GBAS	Ground Based Augmentation System
GDP	Gross Domestic Product
GDS	Global Distribution System
GLS	GNSS Landing System
GNSS	Global Navigation Satellite System
H_2O	Water (chemical compound)
HASP	Hellenic Aviation Service Provider (Greek ANSP)
HC	Unburnt hydrocarbons
HEATCO	Developing Harmonised European Approaches for Transport Costing and Project Assessment
HF	High Frequency
HF RTF	High Frequency Radiotelephony

HFDL	High Frequency Data Link
HICP	Harmonised Index of Consumer Prices
HungaroControl	Hungarian ANSP
IAA	Irish Aviation Authority (Irish ANSP)
IATA	International Air Transport Association
IC	Interrogator Code
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INMARSAT	International Maritime Satellite
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
ITF	International Transport Forum
kg	Kilogramme
LBS	Pound (weight)
Lden	Perceived noise level weighted over day/evening/night
LFV	Luftfartsverket (Swedish ANSP)
LGS	Latvijas Gaisa Satiksme (Latvian ANSP)
LNAV	Lateral Navigation
LPS	Letové Prevádzkové Služby Slovenskej Republiky (Slovak ANSP)
LPV	Localizer Performance with Vertical Guidance
LSA	Light Sport Aeroplanes
LSSIP	Local Single Sky ImPlementation
LTO	Landing and Take-Off Cycle
LVNL	Luchtverkeersleiding Nederland (Dutch ANSP)
MAIS	Maximum Abbreviated Injury Scale
MATS	Malta Air Traffic Services Ltd. (Malta ANSP)
MLAT	Multilateration
MLS	Microwave Landing System
M-NAV	Air Navigation Services Provider of the Republic of North Macedonia
MOLDATSA	Moldavian Air Traffic Services Authority
MPL3	Master Plan Level 3
MTSAT	Multifunction Transport Satellite

MUAC	Maastricht Upper Air Control Centre
N_2O	Nitrogen dioxide (chemical compound)
NATS	National Air Traffic Services Ltd. (United Kingdom ANSP)
NAV Portugal	Portuguese ANSP
NAVIAIR	Air Navigation Services – Flyvesikringstjenesten (Danish ANSP)
NCC	Non-commercial operations with complex motor-powered aircraft
NM	Nautical Miles
NM	Network Manager
NMD	Network Management Directorate
NMVOC	Non-methane volatile organic compound (chemical compound)
NOP	Network Operations Plan
NOx	Nitrogen Oxides
NPV	Net Present Value
OAT	Operational Air Traffic
Oro Navigacija	Lithuanian ANSP
PANSA	Polish Air Navigation Services Agency
PAX	Passengers
PBN	Performance-Based Navigation
PCP	Pilot Common Project
PDC ACARS	Pre-Departure Clearance ACARS
PM volatile	Particulate Matter volatile
$PM_{2.5}$	(Atmospheric) Particulate matter
Ppm	Parts per million
PRB	Performance Review Body
PRISME	A EUROCONTROL database
PRR	Performance Review Report
PRU	Performance Review Unit
PSR	Primary Surveillance Radar
RNAV	Area Navigation
RNP	Required Navigation Performance
ROIC	Return On Invested Capital
ROMATSA	Romanian Air Traffic Services Administration
RPAS	Remotely Piloted Aircraft System

RPK	Revenue passenger kilometre
SAF	Sustainable Aviation Fuel
SAKAERONAVIGATSIA	Georgian ANSP
SATCOM	Satellite communications
SBAS	Space Based Augmentation System
SDP	SESAR Deployment Programme
SES	Single European Sky
SESAR	Single European Sky ATM Research
SID	STATFOR Interactive Dashboard
SJU	SESAR Joint Undertaking
skeyes	Belgian ANSP
Skyguide	Swiss ANSP
Slovenia Control	Slovenian ANSP
SMATSA	Serbia and Montenegro Air Traffic Services Agency
SMS	Safety Management System
SO_2	Sulphur dioxide (chemical compound)
SOx	Sulphur Oxides
SPO	Special Operations
SSR	Secondary Surveillance Radar
STATFOR	EUROCONTROL Statistics and Forecasts service
STD	Scheduled Time of Departure
TACAN	Tactical air navigation
TMA	Terminal Manoeuvring Area
TNSU	Terminal Navigation Service Units
TSU	Terminal Service Units
TVM	Time Value of Money
TWR	Tower
UAS	Unmanned Aircraft Systems
UHF	Ultra-high frequency
UkSATSE	Ukrainian State Air Traffic Service Enterprise
UoW	University of Westminster
US gal	US gallon
VDL	VHF digital datalink

VFR	Visual Flight Rules
VLA	Very Light Aeroplanes
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Ranging
VOR/DME	VHF Omnidirectional Ranging/Distance Measuring Equipment
VORTAC	Combined VOR and TACAN
VSL	Value of Statistical Life
WACC	Weighted Average Cost of Capital
WAM	Wide-Area Multilateration
WPR	Waypoint Position Report

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