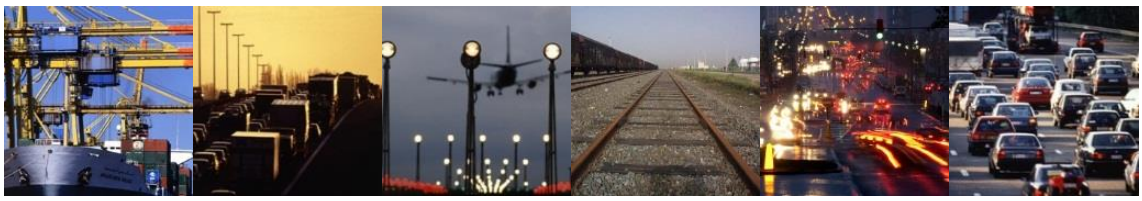
ATM financing study

Report for: Airline for Europe – **A4E**
Rue Du Luxembourg 6
1040 Brussels
Belgium

14th of March 2023

Christophe Heyndrickx, Saskia van der Loo



Transport & Mobility Leuven
Diestsesteenweg 57
3010 Leuven
Belgium
http://www.tmleuven.be

Table of Contents

List of figures

List of tables

List of acronyms and abbreviations

ACE	Air traffic management cost-effectiveness
AATF	US Airport and Airway Trust Fund
ACC	Air Control Centre
ACE	Air traffic management cost-efficiency
ANS	Air Navigation Services
ANSP	Air Navigation Services Provider
ATC	Air traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
CEF	Connecting Europe Facility
CNS	Communication, navigation and surveillance services
CP	Cost recovery pricing
CP–	Cost recovery net of subsidies
CSGI	Core Services of General Interest
DSO	Distribution System Operator
ECA	European Court of Auditors
EEA	European Economic area
EIB	European Investment Bank
EU	European Union
ETD	Energy Taxation Directive
FAA	Federal Aviation Administration (USA)
FAB	Functional Airspace Block
GPS	Global Positioning system
ICAO	International Civil Aviation Organisation
IM	Infrastructure Manager
IMO	International Maritime Organisation
IWW	Inland Water Ways
KPI	Key Performance Indicator

MC	Marginal Cost pricing
MET	Meteorological service for air navigation
MPS	Maritime Pilotage Service
NRA	National Regulatory Authority
NRF	National Regulatory Framework
NSA	National Supervisory Authority
OJT	On the job training
OTC	Over-the-counter
PPP	Public Private Partnership
PRB	Performance Review Board
SAR	Search And Rescue
SARS	Severe Acute Respiratory Syndrome
SES	Single European Sky
SESAR	Single European Sky ATM Research
TANS	Terminal Air Navigation Services
TRS	Traffic Risk Sharing
TSO	Transmission System Operator
TSU	Total Service Units
VHF	Very High Frequency
VTS	Vessel Traffic

Executive summary

In Europe, the financing of ANSPs largely depends on direct user charges paid by commercial aviation[1]. A problem with this type of financing is that it is particularly vulnerable to changes in traffic due to external shocks (Turnbull et al, 2022). This has never been so explicitly revealed as during the pandemic (2020-2021) and the subsequent geopolitical tensions caused by the war in Ukraine (since 2022). The immediate impact of the drop in demand due to COVID-19 was a loss in revenues for the ANSPs of 59% in 2020 and 43% in 2021 compared to 2019 (EUROCONTROL, 2022c). At the same time the ANSPs had to keep the skies open regardless of the number of flights.

ANSPs have high fixed costs and high staffing costs. This meant that it was difficult to reduce costs when income sources collapsed during the COVID crisis. Despite the extraordinary reduction in traffic, European ANSPs were only able to reduce their gate-to gate ATM/CNS cost by 5.2% in 2020 compared to 2019 (EUROCONTROL, 2022c). The gap in revenues that this created will ultimately be recouped through higher user charges when traffic picks up again. In this situation and with the current regulatory framework, en-route navigational charges in the 'SES states'[2] are expected to increase by an average of 13% in 2023 and 2024 when compared to 2019 (PRC, 2022). Airlines will effectively be the only ones to shoulder this financial burden right at a time when they are recovering. As it stands, they have little space to absorb these higher ATC charges.

Facing these problems, rethinking the entire financing system for ANSPs is necessary. This feeling is shared across stakeholders that have been interviewed during this study. Although the main principles governing the current system are seen as sound, the implementation, and the lack of incentives to increase cost-efficiency or to increase collaboration, are problematic. The pandemic has also highlighted the public good nature of aviation and the highlighted that member states should be contributing directly towards the financing of ATM services.

Starting from this premise, we looked for alternatives to the current system and compared funding for ATM in Europe with Canada, the USA, Brazil, Australia and New Zealand. We also examined funding models in other transport sectors, telecommunications, water provision and electricity transmission to see if there were lessons to be learned from these sectors. This study concludes that a fully user-based financing model is found in no other industries within the transport sector. The only other industries with comparable level of user financing are namely the electricity transmission and telecommunications sectors.

Based on our review we propose a number of alternative financing models. They were ranked according to characteristics that were identified as highly relevant during stakeholder interviews including Fairness and Equity, Resilience, Incentives for cost-efficiency etc. Additionally, the ranking takes into account a number of aspects that relate directly to implementation such as transparency, credibility and flexibility.

[1] 74% of the ANSP revenues are coming from en-route charges and 16% form terminal charges. Other revenues include income from airport operators (4%) and 6% are other revenues (mainly from governments) (EUROCONTROL, (2021c)).

[2] The so called 'SES states' refer to the 27 Member States of the European Union (EU) in 2020 plus Switzerland and Norway who are bound by the SES regulations which are described in Section 2.1.2.

We propose two alternatives to the current system: the **Threshold funding model and the Adapted risk sharing mechanism**. Both models keep the existing system of navigation charges in place but introduce public contributions that stabilise funding for navigation charges.

The **threshold funding model** is inspired by Turnbull et al. (2022). In such a model, national governments would be responsible for the funding of the minimum services and staffing levels, so called Core Services of Genera). This would de facto remove any cross-subsidisation that is present in the current system. Costs above the CSGI are covered by user charges. The current cost-recovery system therefore becomes a 'cost-plus minus subsidy' system, similar to other transport modes such as rail. In such a system, there would be a constant flow of public contributions towards air navigation services.

An alternative is to **modify the existing risk sharing mechanism** for traffic and cost deviations. Currently, commercial airlines are liable for almost the entire funding gap in case traffic levels drop below expectations. Under this alternative system, we propose that governments take up half of the remaining liability of commercial airlines in case of downward deviations in traffic of more than 10%. Additionally, such a system could contain a *crisis financing option* in case traffic drops below a critical level (for example 10% of normal traffic). In this case governments could take up an additional share of the liability (for example an additional 25%). This would ensure that the CSGI can still be financed, even with extremely low levels of traffic. While such a situation is very improbable, it is not unthinkable either, as was shown during the first months of the pandemic in 2020.

Both models have advantages and disadvantages. The threshold funding model would imply a steady contribution of the government. This stabilises revenues and increases overall resilience of ATM financing. The adapted risk sharing mechanism on the other hand, limits government involvement to times of crisis. This represents a smaller overall contribution, but it would still imply that public authorities provide funds to air navigation when needed.

Some fundamental questions remain. First of all, the **precise level of any government contribution** needs to be established. Secondly, the efficiency of the model will depend on **how the government contributions are financed**. The impact of such funding will differ depending on whether the contributions are financed with general taxes or air transport specific taxed. We assume that for both models, contributions from the national budget will be made available.

Besides looking at funding options directly, we also reviewed a number of long-term changes in ATM that could deliver improvements in cost-efficiency. While far from ideal, the fragmented and complex system of ATM in Europe provides a unique laboratory for reform (Finger et al, 2017). We review **the unbundling of ANSP services**, **dynamic airspace sharing**, moving towards a **single provider for ANS services** and **tendering all ANSP services within the EU.** For a more flexible and cost-efficient ATM system, a well-designed, credible, and transparent regulatory framework and structural reforms are required. Defragmentation and an increase in cross-border collaboration are needed to increase scale-efficiency of services. Ultimately this should be compatible with any funding model for ANS. Additionally, funding models should respect the mixed public-private character of ANS provision.

We find that one of the more interesting options would be that the EU (or even the entire Eurocontrol area) moves to a model of tendering all ANSP services. This can be combined with the threshold funding model to tender an entire (national) airspace (see Adler et al, 2020). In the long run, this would allow a number of specialised companies providing ANSP services to compete freely on the market. This does not mean that there is no need for government intervention. Any tendering

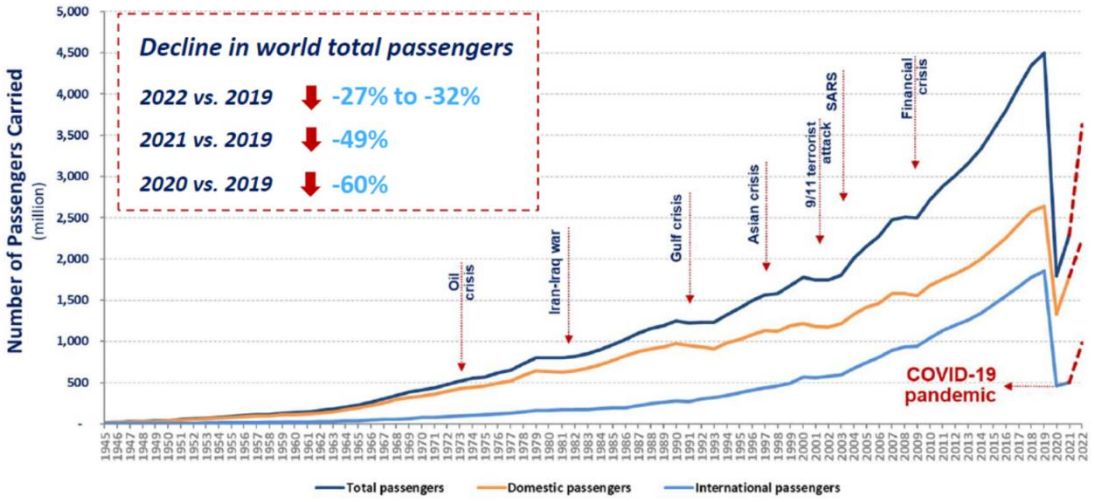
contract should be followed up closely by the contracting authority and put back out to tender after a certain number of years.

1 Introduction

1.1 Context

Air transport demand is strongly linked to the macroeconomic evolution, aggregate income levels, and is subject to government policies. It is also influenced by external shocks. All of this implies that demand can be very variable. As can be seen in the figure below, wars, economic and financial crises and terrorism have all had impacts on global aviation demand. The COVID-19 pandemic, however, has had an unprecedented impact.

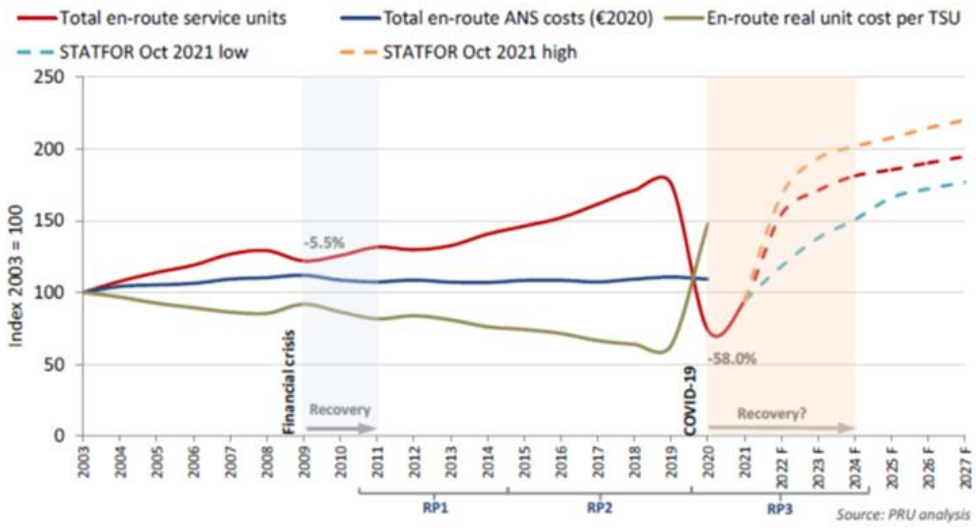
Figure 1: World passenger traffic evolution 1945-2022



Source: ICAO (2022)

The decline in European air traffic due to the COVID-19 pandemic was of the same magnitude, with air traffic in 2020 to be estimated to be 58% lower than in 2019, as depicted in the following figure, which also presents different scenarios for recovery afterwards.

Figure 2 Long term trends in air traffic (2003-2027) and historic ANS costs and cost-efficiency (2003-2020)

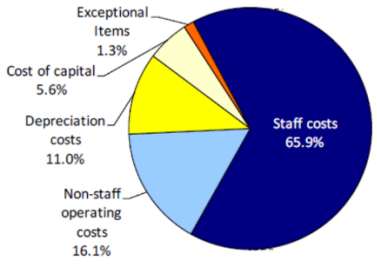


Source: EUROCONTROL (2022c)

The variability of air traffic creates a certain traffic risk for all players of the aviation chain but in particular for commercial airlines and Air Navigation Service Providers (ANSPs). Indeed, the demand for Air Traffic Management (ATM) services provided by ANSPs is directly linked to the demand for air travel.

In Europe, the funding of ANSPs largely depends on direct user charges paid by civil aviation[3]. An immediate impact of the drop in demand due to COVID-19 was a loss in revenues for the ANSPs amounting to a drop of 59% in 2020 compared to 2019 (EUROCONTROL, 2022c). At the same time the ANSPs had to keep the skies open regardless of the number of flights. The specific cost structure of ANSPs, with high fixed costs and high staffing costs, meant that it was very difficult for them to reduce costs when their income source collapsed. Section 2.1.1 depicts the breakdown of the costs for European ANSPs in 2019 before the COVID-19 crisis. The figure only focusses on the Air traffic management (ATM) and Communication, Navigation and Surveillance services (CNS) costs as these are under direct control and responsibility of the ANSPs. As can be seen, in 2019, 65,9% of the en-route ATM/CNS provision costs were staff costs, followed by non-staff operating costs (16.1 %), depreciation costs (11%) and cost of capital (5.6%).

Figure 3: Breakdown of ATM/CNS provision costs in 2019



Source: EUROCONTROL (2021c)

Some of the staff costs are considered to be fixed costs. The breakdown between fixed and variable costs is generally taken to be 85% vs 15% (ter Kuile A., 2002). Despite the implementation of cost containment measures, the European ANSPs reduced their gate-to-gate ATM/CNS costs by only 5.2% in 2020 compared to 2019 (EUROCONTROL, 2022c). The unprecedented drop in revenues lead to liquidity problems for most ANSPs. To alleviate these liquidity problems, some ANSPs (e.g., Skyguide) received government money to overcome this period, others (e.g., LVNL, PANSA, DSNA, NAVE Portugal, …) took loans, often supported by the government, or postponed investments in technology, training, recruitment stops, etc., as can be seen from the table below.

[3] 74% of the ANSP revenues are coming from en-route charges and 16% form terminal charges. Other revenues include income from airport operators (4%) and 6% are other revenues (mainly from governments) (EUROCONTROL, (2021c)).

Table 1: Mitigation Measures Implemented or Planned by European ANSPs, 2020 – 2021

Aid from national government	Loans	Cost-containment measures		
		Staff	Non-staff	Capital expenditure
ANS CR, ANS Finland, Austro Control, DFS[b], LGS[a,b], LPS[b], NATS[a], NAVIAIR, skeyes[a], Slovenia Control				
		Albcontrol, ARMATS, Avinor, BULATSA, Croatia Control, DCAC Cyprus, DSNA, EANS, ENAIRE, HungaroControl, IAA, LFV, LVNL, M-NAV, MUAC, NAV Portugal, PANSA, ROMATSA, Skyguide, SMATSA, UkSATSE		
Skyguide [b] Avinor[b]	Albcontrol[a], ARMATS, Croatia Control, DHMI[a], DSNA, EANS[a], HungaroControl, IAA, LVNL[c], MATS[a], NAV Portugal, Oro Navigacija[a], PANSA, ROMATSA, Sakaeronavigatsia, SMATSA, UkSATSE	ENAV HCAA MATS MOLDATSA	DHMI ENAV MOLDATSA	DHMI HCAA MATS Sakaeronavigatsia

(a) EUROCONTROL Loan. (b) Increase in equity. In the case of Avinor from the parent company, which is a State-owned enterprise. (c) LVNL operates in a specific environment where the balance in its current accounts is ensured by Treasury banking.

Source: EUROCONTROL (2021c)

This reaction now leads to issues, as air traffic is increasing while the necessary investments to cope with this traffic were not made. In addition, ANSPs now need to repay their loans. At the same time when they are recovering their losses, they are expected to invest more in skills and equipment.

In countries where the ANSPs rely on user charges for their financing, the drop in revenues will ultimately be recovered through higher user charges when traffic picks up again. Even though this will only happen after the adoption of the new performance plans for ANSPs (this is, not before 2023) and even though the period in which the losses are recuperated has been increased to 5 to 7 years (this is, until 2027 or 2029) there will still be a massive increase of the unit rates. Indeed, en-route navigational charges in the 'SES states'[4] are expected to be on average 13% higher in 2023 and 2024 compared to 2019 (PRC 2022). This financial burden will effectively be borne solely by the commercial airlines at a time when airlines are just recovering and indicate that they have little room for paying higher charges.

At the same time the question arose (Turnbull et al., 2022) whether ATM is a commercial service for users (a private good) or an essential element in the nation's infrastructure (a public good) of which a minimum level of provision should be funded by the state, such as ATM for essential cargo flights, medical flights, repatriation flights, etc.

Overall, this led the Performance Review Commission to conclude that "the current air navigation services (ANS) charging schemes, whether it be it "full cost recovery" or "determined costs" will become unsustainable in the next few years" (PRC, 2021). It recommends that States consider other options for the current scheme.

[4] The so called 'SES states' refer to the 27 Member States of the European Union (EU) in 2020 plus Switzerland and Norway who are bound by the SES regulations which are described in Section 2.1.2.

1.2 Aim of the study

The principal aim of this study is to analyse interesting new financing models for Air Traffic Management (ATM), based on insights from the economic literature and considering certain desired properties of such a financing model such as fairness, resiliency and economic sustainable. It also aims to provide insights in how to best realise the implementation of such a new financing model.

1.3 Structure of the report

The report is structured as follows. In Section 2 we first give an overview of existing financing models in ATM in Europe and some selected countries: the US, Canada, Australia, New Zealand and Brazil (Subsection 2.1), and discuss the financing models used in some other transport sectors (Subsection 2.2) and other relevant industries such as electricity and telecom (Subsection 2.3). We end the chapter with an overview of the different financing models. This desk research is then complemented with a set of targeted interviews to gather information directly from stakeholders about the benefits and shortcomings of the current European ATM financing system and to collect their views on the desired properties of a future ATM financing model. The findings of the interviews are presented in Section 3. In Section 4 we discuss the existing financing models identified and present some novel financing models for ATM. These financing models are then assessed against the desired properties identified in Subsection 3.4. We conclude the study with a roadmap of implementation of new financing models.

2 Existing financing models – a literature review

UNECE (2017) considers four sources of funding for transport infrastructure and associated maintenance & operational cost: 1) general and earmarked taxation as well as international (EU) grants, 2) operational revenues and user charges, 3) non-user funding, and 4) capital borrowing either by private or public actors.

The degree to which each of these financing methods are dominant depends on:

- The type of sector
- The lifetime of the infrastructure
- Local circumstances
- Political preferences
- The competitiveness of the sector
- The availability of public funds

Before the 1980s most public infrastructure, and in particular transport infrastructure was publicly owned and operated with virtually no user charges. The predominant view at the time was that transport infrastructure is a public service, which should be covered by general tax revenues. Increasing demand for infrastructure services increased the burden on the public budget in times of economic crisis. A narrowing of public funds – in combination with exposed inefficiencies and cumbersome decision processes – accelerated the shift to privatisation of services and infrastructure management. This also led to a broadening of funding sources. Moves were made to increase the share of user charges (user-pays principle) as well as attracting financing of the private sector (with public private partnerships or PPPs).

In the next sections we will take a closer look at different financing systems. We will first present and compare the current financing systems for ATM in some selected countries. Then we will discuss how other transport sectors and industries with related issues have been organising the financing of their infrastructure and services.

2.1 Comparison of different financing models for Air Traffic Management

2.1.1 Introduction

General principles

The international character, the importance of safety and the network characteristics of ATM have led to the need of a strong global oversight. To this means, after the Second World War, the "Convention on International Civil Aviation", known as the "Chicago Convention" was developed. The convention provided for the sovereignty of airspace above the territory of each state together with nine freedoms[5] which establish the freedom of states to operate air transport flights across, into and within the airspace of other states. The Convention also established the basic principles in the area of charges for air navigation services. It states that air traffic control should charge the users on

[5] Freedoms of the Air: https://www.icao.int/pages/freedomsair.aspx (visited 19/01/2023)

a cost-based, non-discriminatory principle. The principles of navigation charges have been largely laid out in the 1967 ICAO conference. They are as follows:

1. Non-discrimination: charges should not differentiate according to nationality.
2. Caution not to introduce charges that overburden operators and the overall economy.
3. Charging based on aircraft weight and distance, combined with other relevant aircraft characteristics.

These principles have been implemented across the world with little exceptions, such that many ANSPs use very similar charging principles. In practice, however, charges vary a lot between countries depending on how much public budget the ANSP receives, its cost-efficiency and regulations.

Regions and countries considered in this study

Although ANSPs share common characteristics such as being natural monopolies and having high fixed and high staffing costs, there are also many aspects in which ANSPs can differ from each other. Firstly, ANSPs range from non-profit government owned entities to fully privatised for-profit corporations (albeit under governmental regulation). Secondly, they also vary widely in size and the airspace they control can vary in complexity (e.g., oceanic vs. high density traffic). Table 2 gives a comparison between the number of ANSPs, air traffic controllers (ATCOs), employees and air control centres (ACCs) as well as characteristics of the airspaces for Europe and some selected countries[6]: the US, Canada, Australia, New Zealand, and Brazil. Each of these cases will be discussed in more detail afterwards.

Table 2: Cases considered in the review of ANSP financing

Country/Region	ANSPs	ATCOs	Employees	ACCs	Airspace (2019)
Eurocontrol region	37	18 490	55 130	62	11.5 million km^2 11 million flights
US	1	14 430	31 647	21	10.4 million km^2 16 million flights
Canada	1	1 870	4 811	7	18 million km^2 3.4 million flights
Australia	1	1 054	4 204	0	51.7 million km^2 4 million flights
New Zealand	1	370	761	1	30 million km^2 1 million flights
Brazil	1	3 126	12 544	5	22 million km^2 (Including oceanic area) 1.6 million flights

Source: EUROCONTROL (2019) & own calculations

Using the figures of Table 2, a high-level comparison can be made between air navigation services in the respective countries and Europe (Figure 4). We use data for 2019 as this is more representative for the actual capacity of each airspace than 2020. Except for Brazil, the high-level indicators suggest that air traffic control in most regions is more centralized (less ACCs) and is performed with a relatively lower number of ATCOs and support personnel than in Europe. However, the

[6] The countries were selected to cover a range of ANSP ownership types and regulatory frameworks. The availability of reliable information was another criterion.

performance of ANSPs in Europe varies strongly depending on local circumstances and organisation (EUROCONTROL, 2021a).

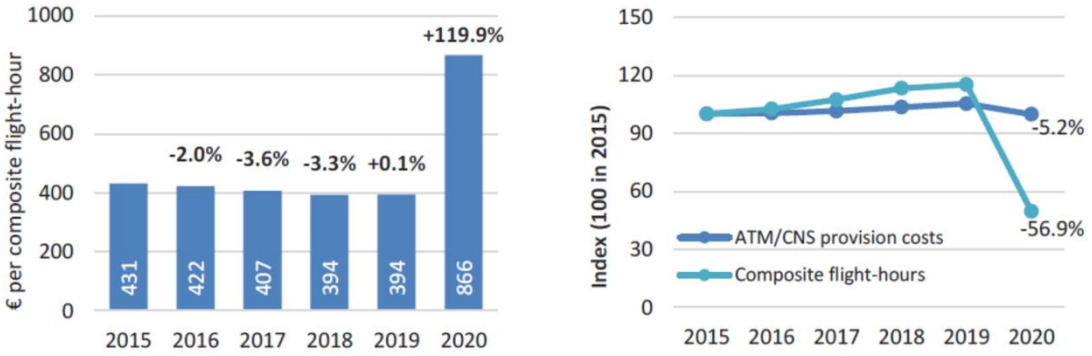
Figure 4: Overall comparison of ATCOs, employees and ACCs vs number of flights controlled in different cases

Source: EUROCONTROL (2019) & own calculations

Impact of COVID-19 crisis on cost-effectiveness of European ANSPs

The COVID-19 crisis led to a quick jump in the average service provision costs per composite flight-hour[7], after a period of gradual decline. In Europe compared to 2019, in 2020 these costs per composite flight-hour more than doubled on average, as can be seen in Figure 5.

Figure 5: Trend of ATM/CNS provision costs and traffic, 2015-2020.



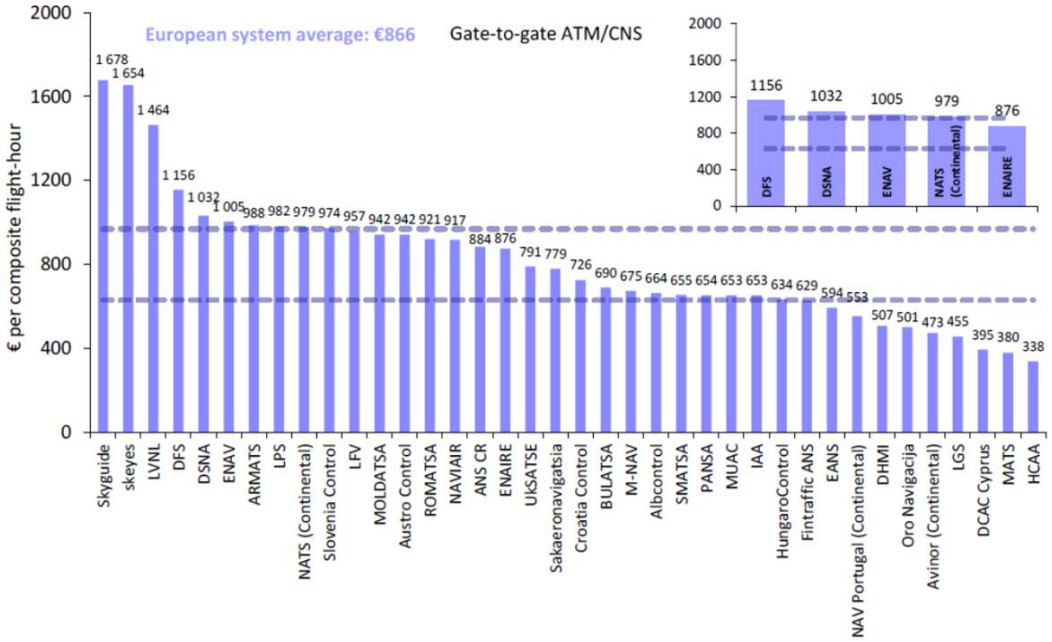
Source: EUROCONTROL (2022a)

A comparison of the economic cost-efficiency of ANSPs reveals striking differences across Europe with costs ranging from EUR 338 to EUR 1716 per composite flight hour in 2020 (Figure 6). The Air traffic management cost-effectiveness (ACE) analysis by EUROCONTROL (see Figure 7) on

[7] The composite flight hour is a weighted average of the time spent en route and the time spent in descent/landing and take-off/climb

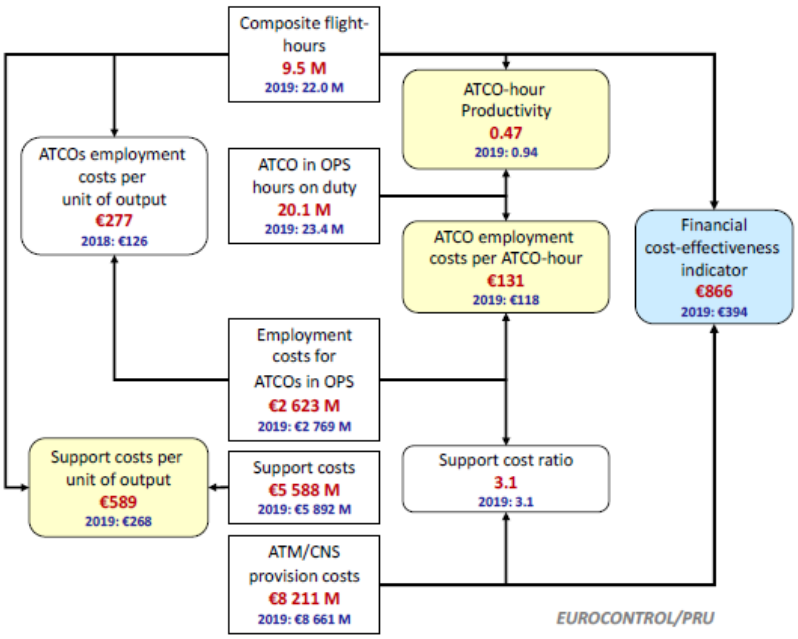
the response of the ANSPs before and after the COVID-19 crisis found that ATCO productivity sharply declined during 2020. As the decline in number of ATCO-hours on duty did not match the decline in the drop of traffic, the overall ATCO-hour productivity was reduced sharply (-49.7%, EUROCONTROL, 2022a).

Figure 6 Comparison of ATM/CNS provision costs per composite flight-hour across European ANSPs in 2020.



Source: EUROCONTROL (2022a)

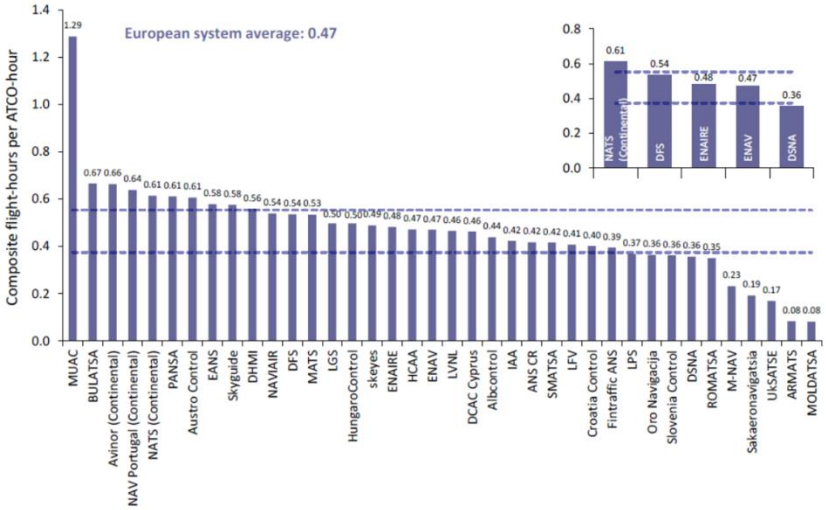
Figure 7: Analytic framework to analyse the breakdown of the cost effectiveness of ATM/CNS provision (comparison 2019 vs 2020)



Source: EUROCONTROL (2022a)

The comparison of ATCO productivity during this period revealed similarly large differences in ATCO productivity across the Europe (Figure 8).

Figure 8: Comparison of ATCO productivity across ANSPs, 2020.



Source: EUROCONTROL (2022a)

As a response to the impact of the drastic reduction in traffic during the COVID-19 pandemic, the European Commission implemented the EC 2020/1627 regulation (EC, 2020) which contained exceptional measures and a revised timeline for the submission of the updated performance plans. It stipulates that the cost efficiency targets should cover determined costs for 2020 and 2021 as a single period and that the unit rate adjustments should be spread over a 5-year period and may be extended to 7 years.

2.1.2 Europe

Current regulation and financing system

Charging airlines for the use of air traffic control (ATC) services is relatively recent. Up to the 1970s *en-route* ATC was free of charge. By 1980 100% of the costs were covered by the airspace users, along cost-plus (full cost recovery) principles. In 2010, under the SES II legislative package European union-wide performance targets were set to improve safety, capacity, environmental performance, and cost-efficiency[8]. Complementary to the performance targets, a charging scheme was set to support the performance scheme together with traffic risk sharing and cost risk sharing between the service provider and the airspace user. Under the charging scheme, the airspace user is charged for services based on the national unit rate, type of aircraft (this is, the weight) and the distance flown. The unit cost rate is determined by dividing the costs of the ANSPs by the forecast demand, with a correction made afterwards. The expected demand is forecast by the ANSPs, based on EUROCONTROL traffic projections which are then approved by the Member States' National Supervisory Authorities (NSAs).

Two risk sharing mechanism are in place. First, if the difference between actual and forecast traffic levels leads to more or less revenue for the ANSP, the difference is shared between airspace users and ANSPs based on a Traffic Risk Sharing (TRS) mechanism. If the deviation between actual and forecast traffic levels is less than 2 per cent, the risk is entirely borne by the ANSP while the risk is shared between the ANSP (30 per cent) and users (70 per cent) for any variation between 2 and 10 per cent. This reflects more or less the share of fixed and variable costs for the ANSPs. If traffic declines by more than 10 per cent, the difference is fully borne by the airspace users through higher charges in the subsequent years[9]. This mechanism seemed to be the answer to the pro-cyclical pattern of air traffic demand and worked during shorter crises such as SARS, and 9/11. However, under the COVID-19 pandemic where traffic was down by well over 10%, the shortcomings of this mechanism became apparent (Turnbull et al., 2022).

In addition to the TRS mechanism, a cost risk sharing mechanism exists. This was designed to incentivise the ANSPs to increase their cost efficiency and to make them accountable for their performance. The European Commission sets the "determined costs" for each year of a performance reference period (which covers a minimum of 3 years and a maximum of 5 years). The determined costs cover the costs of providing air navigation services which are eligible to recover from the airspace users and are in line with the performance plan. The cost sharing mechanism allows for the determined costs to be adjusted within a margin of error. But otherwise, the ANSPs need to cover any additional cost beyond the determined cost and can retain any revenue when costs fall below the

[8] The SES regulations described in this section were adopted by the ANSPs of the EU28+2 States (the National ANSPs of the EU28 states without Luxemburg, plus Norway, Switzerland and MUAC operated by EUROCONTROL on behalf of the states). The other 8 states under control of EUROCONTROL still operate under full recovery where losses are recovered by increasing the navigational charges in the next year. We will not make the difference between these European states for sake of simplicity and refer to European ANSPs in the remainder of the text.

[9] Article 27 § 3 of Commission Implementing Regulation (EU) 2019/317 of 11 February 2019 laying down a performance and charging scheme in the single European sky and repealing Implementing Regulations (EU) 390/2013 and (EU) 391/2013. The TRS is calculated at the end of each year and is recovered 2 years later through Unit Rate adjustments.

determined costs. In other words, the ANSPs are left with two options to raise more net revenues: either by attracting more airline traffic or by reducing their costs below the target level.

Beside the risk sharing mechanisms the Member States are allowed to apply financial incentives in the form of bonusses or penalties in the areas of capacity and environment. They may also modulate charges to improve the performance of air traffic, such as reducing the environmental impact or reducing overall costs of air navigational services and improving their efficiency. The modulation may, however, not change the overall revenues of the ANSPs and needs to be revenue neutral.

The financing system is supplemented with a regulatory framework. This framework sets binding performance targets on safety, environment, capacity, and cost-efficiency on the ANSPs which are defined through several key performance indicators (KPIs). A performance plan must be drawn for the next 5 years, which needs to be approved by the National Safety Agency (NSA) and the Performance Review Board (PRB). This plan determines the unit rate (and thus the navigational charges) for the following reference period.

Market structure and recent developments

The European airspace is one of the busiest and most complex in the world. With 37 ANSPs and 62 en-route ACCs it is a fragmented market consisting of ANSPs that mostly control airspaces that coincide roughly with national borders. Recent decades saw a limited move towards a privatisation of ANSPs to either fully private or mixed public companies. However, the sector remains heavily regulated and mostly state-owned as ANSPs are natural monopolies, especially those that are centrally located. ANSPs appear to benefit both from increasing their level of corporatisation and outsourcing (Buyle et al., 2021).

It is argued that the current fragmentation of the system leads to low economies of scale, weak incentives for cost efficiency and low uptake of technological innovation (Baumgartner et al., 2022; Finger et al., 2017). Commercial airspace users are currently contributing up to EUR 9 billion in navigation charges. As part of the Single European Sky (SES) initiative in 2004 (EC, 2004), functional airspace blocks (FABs) were established to enhance cooperation between ANSPs. FABs are established regardless of State boundaries and are based on operational requirements. The aim of the EC is that ANSPs would eventually operate effectively as one company within each FAB. This requires new technologies and more digitalisation. To coordinate EU research and development activities in ATM, the SESAR research program was launched. The agreed roadmap to achieve the targets set in the SESAR deployment plan are described in the European ATM Master Plan. Ex-post analysis by the EC found partial success of the SES I and SES II packages. While not all targets were met, ANSPs in Europe did realise small and consistent cost reductions while increasing capacity. The role of the PRB (Performance Review Board) was evaluated quite positively, but both airlines and ANSPs found issues with the existing KPIs (EC, 2017).

A new package of reforms is under review at the time of writing called SES2+. This would entail a number of reforms. However, as the legislation is still pending with uncertain outcome, this study does not take into account potential reforms topics of the SES2+ proposal. In addition, the SES2+ proposal does not contain a general new approach on ATM financing.

EU financing and grants

Realising the ATM masterplan in which the roadmap is set to achieve the targets of the SESAR deployment plan is estimated to require an investment between EUR 18 and 26 billion by 2035 (EC,

2018). There are numerous EU financing sources available for innovation in ATM and realising the SES objectives. In particular:

- Overall, the EU has committed EUR 3.8 billion to SESAR between 2005 and 2020 (ECA, 2019). The CEF funding rates were: 50% of overall costs for studies and implementation of infrastructure, 50% for ground equipment, 20% for airborne equipment.
- The European Fund for Strategic Investment (EFSI) committed EUR 315 billion for the period 2015-2018.
- It is possible to cumulate CEF funding and European Investment Bank (EIB) loans up to 70% of total costs.

In its assessment of the effectiveness of SESAR funding the European Court of Auditors expressed criticism (ECA, 2019). EU funding in support of ATM modernisation was deemed largely unnecessary, and the management of funding was found to be affected by shortcomings. The ECA expressed 5 recommendations

1. Improve the focus of common projects.
2. Reinforce the effectiveness of common projects.
3. Review EU financial support for ATM modernisation.
4. Review and formalise preparation and submission of applications for funding.
5. Ensure adequate monitoring of performance benefits.

2.1.3 The United States

There are critical differences between the US and Europe. In the US, air navigation services are provided by a single ANSP: the FAA (Federal Aviation Administration). This contrasts with the fragmented EU market where different ANSPS are largely organised within State boundaries (Table 3).

Table 3 Comparison of US and European Air Traffic Management

Year 2016/2017	US*	Europe**	US vs. Europe
Geographic Area (million km²)	10.4	11.5	≈ -10%
Nr. of civil en-route ANSPs	1	37	
Nr. of Air Traffic Controllers (ATCOs in Ops.)	12 170	17 794	≈ -32%
Nr. of OJT/developmental ATCOs	2 260	696	≈ +225%
Total ATCOs in OPS plus OJT/developmental	14 430	18 490	≈ -22%
Total staff	31 647	55 130	≈ -43%
Controlled flights (IFR) (million)	15.3	10.4	≈ +47%
Flights hours controlled (million)	23.8	16.0	≈ +48%
Relative density (flight hours per km²)	2.3	1.4	≈ x1.6

* Area in flight hours refer to the Continental United States (CONUS) only. Centre count and staff numbers refer to the National Airspace System (NAS) excluding Oceanic.

** Area and flight hours refer to EUROCONTROL States, excluding Oceanic areas, Georgia and the Canary Islands. European staff and facility numbers refer to EUROCONTROL States excluding Oceanic and Georgia and represent 2016.

OJT: on the job training; IFR: instrument flight rules

Source: EUROCONTROL (2019).

While the European airspace is only 10% larger than that of the US and is less dense in terms of traffic, it is more costly for airlines to operate in. The US operates with 32% less ATCOs (22% less

if ATCOs in training and "on the job training" (OJT) are included), but control 48% more traffic hours. EUROCONTROL (2017) estimates that staff costs for the FAA are 16% lower, but other operating costs are more than 80% higher than in Europe. While the total costs of ATM/CNS provision are remarkably similar (around EUR 8 billion), the FAA controls more than 5 million additional flight hours compared to the European ANSPs.

The US Airport and Airway Trust Fund (AATF) provides the primary source of funding for the FAA. The funding comes principally from a variety of excise taxes on users of the airspace. Travellers pay some of the costs via an excise tax based on the value of the ticket. In addition, revenues from excise taxes on cargo and general aviation fuel are also included. Each year expenditures are authorised by Congress and money is transferred to the FAA. By far the largest component (70%) of the income of the trust fund is coming directly from the passenger market. The role of the trust fund is to create a stable source of revenues for the FAA and provide a buffer for negative downturns in the air transport market. A few examples here are the strong reductions in demand after 9/11 (2001) the SARS epidemic (2003), the recession in 2009 and more recently COVID-19.

On October 1, 2020, following the drop in the revenues from aviation taxes and surcharges that support the AATF, the U.S. Congress approved a USD14 billion (EUR 12 billion) transfer from the Treasury's General Fund to the AATF. This transfer is used to support the entire FAA budget, of which ATM is only one part. The FAA also reported cost savings, primarily related to travel and overtime. Still, it is notable that some costs also grew - especially in the areas of cleaning and custodial services, a trend which is also expected to be observed for some European ANSPs (EUROCONTROL, 2021b).

2.1.4 Canada

The Canadian domestic airspace is controlled by a single ANSP, named NAV CANADA. NAV CANADA is a privately run, non-for-profit cooperation which recovers its costs through charges. Before 1996, air navigation services were provided by the Canadian government and were funded through the Air Transportation Tax charged to airline passengers. In 1998, this tax was retracted and now, charges are levied on aircraft operators. Similar to the EU charging scheme, the charges are equal to the product of the unit rate, the weight factor, and the distance. The charges are set at a level sufficient to cover NAV CANADA's costs, based on a "*reasonable and prudent*" projection of costs and air traffic.

During the COVID-19 crisis, NAV CANADA experienced similar problems as the European providers, respectively a sharp drop in revenues from navigation charges in combination with requirements to sustain minimal operations in the airspace. As a result, NAV CANADA decided to increase navigation charges by about 30% compared to 2019. This was not accepted by the airlines and led to legal conflict. NAV CANADA was however allowed to go through with the increase in charges.

2.1.5 Australia and New Zealand

In Australia, under the Air Service Act (1995), Air services Australia is responsible for the provision of air navigation services. This is a state enterprise. The primary objective is not to maximise profits but to "balance shareholder value with customer value". Prices are set in consultation with customers. Any increase needs to be communicated to the Australian Competition and Consumer Commission (ACCC). The ACCC is then responsible for assessing the proposed price increases and can either object or not. It may also suggest lower prices but has no power to impose any such prices. In reaction

to the COVID-19 crisis Air services Australia received government assistance. No increase in charges is foreseen until 2024, when a 1% increase is planned.

In New Zealand Airways provides air navigation services. It is a corporatised entity owned by the government and was established under the State-Owned Enterprises Act 1987. There is no share capital or private ownership of Airways stock, which remains a fully government-owned enterprise, owned by the Ministry for State-Owned Enterprises and the Ministry of Finance on behalf of the State. It is managed by an independent commercial Board of Directors. Airways is thus a limited liability company governed by the same legislation that applies to all corporations in New Zealand. It is legally bound to operate on a commercial basis, including the requirement to make a profit and is regulated by the New Zealand Commerce Commission (NZCC). Airways uses Ramsey pricing. This is a price principle that allows a natural monopoly to charge for goods/services above marginal cost. It requires the operator to apply a markup to marginal cost inversely to the price sensitivity of demand (the more elastic the product's demand, the smaller the markup). Such a markup enables the natural monopoly to earn a profit, but not at a rate comparable to full monopoly pricing.

Finally, Airways is completely separated from the Civil Aviation Authority, which is the regulatory entity responsible for safety. Airways was the world's first fully commercial ANSP, meaning that it is funded entirely by its users. It generates its revenues from charges to aircraft operators, offshore training, international project management and consultancy services. It self-regulates the returns from its services under the form of a rate-of-return regulation.

In 2020, after air traffic volumes declined with 95% in March, Airways received a $70 million equity injection, followed by a $95 million capital facility made available by the government. In 2021, air traffic resumed to 73% of 2019 values (OECD 2021).

2.1.6 Brazil

Air navigation services provision in Brazil is provided by a single ANSP namely, the Departamento de Controle do Espaço Aéreo (DECEA). The provision of ANS has not been privatised nor commercialised in Brazil. The DECEA is a government organisation subordinate to the Ministry of Defence and the Brazilian Air Force and thus operates as a fully integrated civil-military system. Although the DECEA has not been commercialised, it is nevertheless subjected to the Law of competitive bidding (ICAO 2013). The financing is a combination of governmental funding and revenues coming from navigational charges which are the product of a unit rate, a weight factor and distance. They apply a different level of charging for domestic and international flights.

The impact of COVID-19 on Brazilian air operations was similar to that in other countries. DECEA (2021) indicates that domestic flight movements in 2020 dropped by 90% in April and May 2020, and only slowly recovered to 80% of 2019 values by December 2021. International air traffic recovered even more slowly and was below 50% of 2019 values in December 2021. Notable is that the number of effective ATCOs increased consistently from 2017 (3538) to 2021 (4190) (DECEA 2021). The share of inactive ATCOs even fell during the 2020 pandemic: ATCO activity increased from 80.8% to 84.7% during and after the pandemic. This happened in every region under DECEA control (DECEA 2021).

While ATCOs remained on duty, there was a notable shift in the number of active ATCO hours, which are measured as hours '*logged in*' to the flight control system. Variations between 2019, 2020 and 2021 were measurable here. While the value of the indicator varied around 50-60% before the crisis, it reduced to 40% or lower in some localities during the crisis (DECEA 2021). Interesting to

note is that the level of delays and other efficiency indicators hardly changed during the years of the pandemic. With the exception of a number of highly congested regional airports, there was no significant change in capacity nor a significant change in delays within the Brazilian airspace.

Overall, we can note the following. The Brazilian ANSP hardly reacted to the drop in flights in Brazil. On the contrary, new ATCOs were trained and employed, even when overall activity dropped. As a consequence, there was very little change in capacity in the Brazilian airspace and almost no change in flight efficiency. It should be noted that the Brazilian airspace is significantly larger and less congested than the European one. Also, air transport in Brazil recovered to its 2019 volume already by 2022.

2.1.7 Overview of current ATM financing systems

In the next table we summarise the different ways in which air traffic services are organised and financed in Europe and the five countries we considered.

Table 4: Overview of financing / ownership and charging principles

Country/ Region	Charging	Ownership	Reaction to COVID-19 pandemic
Europe (37 ANSPs)	100% paid by users on cost recovery (cost plus) principles. EUROCONTROL collects all navigation charges. Navigation charges as sum of en-route charge + terminal charges. Regulation by multi-year performance plan, price caps and risk sharing for traffic and cost.	National regulated government corporations or private.	Small cost reductions as reaction to COVID-19 pandemic, with varying response across different ANSPs. Small reductions in staffing. Navigation charges expected to rise to recover losses.
US (FAA)	No direct charging of user fees to airlines except for overflight charges. Paid by AATF: a government trust fund financed by charges on air tickets and excise taxes.	National (US level) public monopoly. Congress regulates cost and approves budget.	Increased government contribution to FAA during pandemic. Tax holiday for passengers paying into AATF. Limited change to ATCO employment/activity.
Canada (NAV CANADA)	100% paid by users largely on cost plus principle. Before 1996 similar to US. Unitary rate across Canada with some differentiation across weight type and for aircraft use. Revenues should not exceed (reasonable) financial requirements to provide navigation services. Billing of navigation services can be set annually, quarterly or daily.	Privatised regulated monopoly.	Depleted rate stabilisation fund during pandemic. Year-on-year increase of navigation charges by 30%. Reduction in staffing and employment after crisis.
Australia (Air services Australia)	In principle 100% cost recovery, but more government support than in Europe. Charges regulated by the ACCC that can approve or disapprove increases.	Government owned public monopoly.	During pandemic the Australian government decided to pay out the losses for the ANSP. Navigation charges are stable until 2024.
New Zealand (Airways)	100% paid by users with a minimum profit requirement. Charges regulated by NZCC. Similar rules as Australia, but Airways New Zealand more independent. Ramsey pricing principle.	Government owned corporation providing services on commercial basis.	Substantial government support during Covid-19 in the form of loans, payment deferrals and subsidies.
Brazil (DECEA)	Public funding & navigational charges Charges as product of unit rate, weight factor and distance. Different charging for domestic and international flights.	Government department. Integrated civil and military oversight. No commercialisation or privatisation.	Limited to no reaction of ANSP to COVID-19 pandemic. ATCO employment increased during pandemic.

2.2 Comparison of different financing models for other transport sectors

In this section we discuss pricing in other transport sectors: rail, road, inland waterways and maritime transport. The nature of these sectors and the approach to traffic control is different from that in aviation. Therefore, we take a broader view in this section, covering also charging for the use of infrastructure, which may or may not involve charging for traffic control. The aim is to see whether lessons can be drawn for ANSP charging.

2.2.1 Rail

Until 1991, rail services in Europe were provided by single vertically integrated state-owned companies. Since 1991, starting with the Directive 91/440 (EC, 1991), the European Commission has reformed the sector to enhance within-mode competition by opening access to new operators. To facilitate this, vertical separation between infrastructure and operational services was imposed. This could be a fully vertical separation such as in the UK or Sweden or via a holding company model (Germany and France). With the separation of infrastructure managers (IM) and train operators, legislation around access and access charges became necessary to ensure new entrants were not discriminated against.

User charges are regulated by Directive 2001/14 (EC, 2001) and the railway packages. The general charging principle is marginal cost (including scarcity of capacity during periods of congestion and environmental costs), but there are allowances for markup pricing and multi-part charging schemes. In most European countries rail track charges do not cover more than the running cost and wear & tear (5-30% of overall cost), reflecting the fact that governments support IMs through subsidies. Indeed, governments generally cover the cost of railway infrastructure investments. New rail infrastructure is predominantly financed from national budgets with EU grants. On average, 50% of railway infrastructure investments have been funded by national budgets (IRG-Rail 2020), EU co-funding added an average 12%. The remainder is financed by concessions, PPPs, loans, equity capital and to a lesser extent rail track charges (Doll et al., 2015). For some options PPP financing has been considered (generally as Design-Build-Finance-Operate or DBFO) schemes. However, the implementation of such schemes across Europe has often resulted in negative experiences, due to low and risky revenue streams and conflicts with infrastructure management.

High-speed rail generally uses dedicated rail infrastructure for its operations. Operating and management of this infrastructure is often vertically integrated in the main company. In general financing schemes for high-speed rail have been politically sensitive due to high infrastructure costs and overestimated travel projections (de Rus & Nash, 2007).

Similar to aviation, rail suffered from large reductions in demand during the COVID-19 crisis. In Europe, passenger revenues were down by 44% in 2020 representing a loss of EUR 24 billion. Losses in the freight sector were less pronounced at 30% representing a loss of EUR 7.4 billion (UIC, 2020). Consequently, the EU has allowed Member states to waive or defer payments of infrastructure charges to reduce the financial burden of railway undertakings. In addition, the EU has approved financial aid from governments directly to the infrastructure managers. In Germany, a government support measure compensating German Rail (DB) was approved which will take the form of an equity injection. In addition, a scheme to support the sector by reducing access charges was set up.

In summary, although the comparison between the rail infrastructure manager and ANSPs is not perfect, they do share some similarities. Both are responsible for the investment and maintenance of

the network infrastructure and both the IM and the ANSP will charge the users for their use of the infrastructure and for the provision of traffic management services. Moreover, due to the costly infrastructure with a long-life cycle, both sectors are natural monopolies and necessitate some form of regulation. Interestingly, while ANSPs need to cover the costs of investment through user charges, rail infrastructure managers can rely on government funding and grants and are more perceived as providing a public good.

2.2.2 Road

Users generally do not pay a separate charge for traffic control services in the case of road transport. Road networks can be funded by general taxation, by earmarked taxes (e.g., fuel taxes) and/or road tolls covering the marginal costs. These are often defined narrowly as the cost of maintenance and renewal. While several unsuccessful attempts have been made to introduce kilometre charging on all motorised road users in Belgium and the Netherlands (Heyndrickx et al., 2021) we can consider the following types of actual road tolling in Europe.

1. Toll charges for the use of a specific infrastructures (examples: Oresund fixed rail-road link, Oosterweel connection, Belgium)
2. Tolls to use motorways (example: Péage)
3. Zone charges for accessing or driving in inner city roads (examples: Milan, Stockholm, London)
4. Kilometre charging for trucks on specific roads (motorways and national highways); the revised Directive 2022/362 (EC, 2022) also sets the rules for Member States wishing to introduce this for light duty vehicles.

Tolls for the use of a specific infrastructure are common and mainly involve strategic infrastructure that offers large user benefits. A good example is the Oresund bridge which was completely loan financed by the Danish and Swedish government. The Oresund fixed rail-road link was projected to be user financed with a projected repayment of debts in 30 years. The financing of the bridge is subject to in-depth EC investigation, due to State guarantees that were made to the consortium building the link. These guarantees would have given a selective advantage to the consortium operating the link.

Motorway tolls are common in several European countries, e.g., France, Portugal, and Italy. The experience of France with motorway tolling is especially long, with motorways constructed by public concessions since 1950. In total 75% of French motorways are operated through private concession contracts and are funded by toll revenues. Large groups are: SANEF, SAPRR and the Vinci group (ASF, Escota, Cofiroute and Arcour). The provision of motorways was built on two principles (Fayard et al., 2012):

1. Build-Operate-Transfer. The government remains the principal owner of the motorway.
2. The State decides where links are built.

The French government has always regulated tolling on the motorway to some extent. The distance between the government and private concessionaires has increased, however. The French government has moved to a system of auctioning within time periods of 5 to 10 years, with periodic renegotiation of tolling and allowances for more differentiation in tolling. Contracts with concessionaires like SANEF include performance targets, in particular minimum travel speeds. Performance of concessionaires is overseen by ARAFER.

Overprediction of traffic and underprediction of cost (Flyvberg et al., 2013; 2004) remain an important problem for financing road infrastructure. It is nearly impossible to gain a financial

advantage from an ill-planned road link. This is even independent from external shocks to the economy such as a pandemic (COVID-19) or the current energy crisis. To make the system more resilient, mechanisms for risk sharing have been proposed. For example, a fund where all concessionaires need to contribute to with a fixed percentage of toll revenues. This fund can then be used in periods of economic downturns to avoid bankruptcy or government intervention (Fayard et al., 2012). It is important to note here that on French motorway concessions with traffic far below expectation, the government stepped in and in some cases renationalised the motorway.

Kilometre charges for trucks heavier than 3.5 tons (HGV) have replaced the former Eurovignette system in many EU countries. Currently, Eurovignette is only used in the Netherlands, Luxemburg, Denmark, and Sweden. The Netherlands has plans to introduce a Dutch version of the kilometre charges for trucks in 2026 where the charge is dependent upon the environmental characteristics of the truck, the type of road and weight, similar to other countries.

There is a clear move in the road sector to have the users pay for infrastructure. Although the comparison is imperfect as road traffic management differs substantially from ATM. The move to concessions for motorways is, however, interesting.

2.2.3 *Inland waterway transport and Maritime transport*

The EU network of inland waterways extends for around 37.000 kilometres and connects hundreds of European cities, as well as important industrial regions. About 15.000 kilometres of inland waterways are included in the trans-European transport network (TEN-T) of key EU transport connections. In total, 13 EU countries share an interconnected waterway network, which is relatively dense in Germany, the Netherlands and France. The largest seaports, Rotterdam and Antwerp are well connected to their hinterlands and their terminals and inland ports.

The EC is actively promoting inland waterways to reduce road freight. Inland waterways represent a large, underused capacity that can provide an alternative for costly new road infrastructure. In particular, it offers an environment-friendly alternative in terms of both energy consumption and noise emissions. Its energy consumption per km/ton of transported goods is approximately 17% of that of road transport and 50 % of rail transport.

RIS (River Information Services) are the harmonised information services to support traffic and transport management in inland navigation, including interfaces with other transport modes. RIS may interface with commercial activities other than those happening internally between companies. RIS comprise services, such as:

- geographical, hydrological, and administrative information about the waterway (fairway information)
- traffic information
- traffic management
- calamity abatement support
- information for transport management
- statistics and customs services
- waterway charges and port dues

Waterway use charges generally take the form of a license, permit or vignette. These licenses can have a daily, monthly or longer (yearly) validity. The cost varies with vessel size (in meters) and type, sometimes with additional variation for the speed of the vessel. Vessels below a certain size (generally

five or six meters) or of limited speed do not require a permit. Actual rules vary strongly by country, but also within specific regions each country.

Operation and management of inland waterway infrastructure as well as providing navigation information is (with little variation) up to specific government departments. These departments have varying degree of independence from the government and are increasingly set up as corporations or privatised. Examples are 'De Vlaamse waterweg', 'Rijkswaterstaat' or 'Via Donau'.

Vessel traffic services (VTS) are a maritime (or in some cases) inland waterway traffic monitoring system established by harbour or port authorities, similar to air traffic control for aircraft. The International Maritime Organisation (IMO) defines vessel traffic service as a service implemented by a competent authority designed to improve the safety and efficiency of vessel traffic and protect the environment. The IMO prescribes that the service shall have the capability to interact with the traffic and to respond to traffic situations developing in the vessel traffic service area. Typical vessel traffic service systems use radar, closed-circuit television, very high frequency or VHF radiotelephony and automatic identification systems to keep track of vessel movements and provide navigational safety in a limited geographical area.

Unlike air navigation services, VTS are generally advisory. While ATCOs can give commands to pilots, VTS controllers cannot force a captain to follow orders. In limited cases, VTS controllers can give traffic recommendations of an urgent nature. In this case the captain is required to follow the order. VTS controllers however cannot be held responsible for incidents. Maritime traffic is not charged directly for vessel traffic services. However, these services could be seen as being implicitly included in port dues.

Maritime pilot services (MPS) are used to lead a ship when entering or leaving a port or is moving within a port's water or dangerous or congested waters to ensure the safety of the ship, crew, and cargo. In some maritime areas near ports or offshore oil and gas exploitation it is mandatory to use a maritime pilot to navigate. In 2003, the IMO assembly adopted a regulation encouraging the use of pilots on boards in certain areas such as the Euro-Channel or the entrance to the Baltic Sea. Locally these recommendations are set out in Pilotage Acts issued by the Maritime Authority of the relevant country. Maritime pilots are skilled professionals licenced or authorised by a recognised pilotage authority. The organisation of maritime pilotage differs from country to country. Most qualified pilots are employed by the local port or maritime authorities and provide services to ships for a fee, calculated in relation to the ship's tonnage, draught (vertical distance between the waterline and the bottom of the hull) or other criteria.

In countries such as Canada, a single service provider exists, the Atlantic Pilotage Authority. This is a crown corporation and acts as service provider and regulator. The charge levels are determined in the Pilotage act which requires that pilotage charges "be fixed at a level that permits the Authority to operate on a self-sustaining financial basis, and that those charges be fair and reasonable." Charges are differentiated across ports in order to avoid cross-subsidisation among ports. Other countries such as the Netherlands have privatised their maritime pilotage service provider. In 1988, the Dutch "Loodswezen" became an independent private organisation. Due to the monopolistic position of the organisation, it is regulated by the competition regulator in the Netherlands. Charges depend on the draught of the ship and the number of sea miles during which the service is needed. Since 2014, charges are prohibited to differ across ports. In Denmark, pilotage has been open for competition since 2006 and several companies offer pilotage services in the Danish waters. All need to comply with the Pilotage act issued by the Danish Maritime Authority. In the UK, pilotage is seen as a public

service, but as local knowledge is key, the responsibility to provide pilotage is left to the harbour authorities. After the privatisation of ports in the 1980s, most port authorities were given statutory powers relating to the provision of pilotage in their waters.

The charging of MPS exhibits similarities with the charging of ATM, i.e., both are based on weight/draught of the aircraft/vessel and distance over which the service is provided. The main difference is the proportion of the full trajectory where the service is needed. MPS is only needed for a very limited part of the vessels' journey and thus might be closer to the landing and take-off ATM provision.

2.2.4 Overview of financing systems in the transport sector

In the following table, we summarise the findings of previous subsections and compare the different non-air transport sectors with ATM. We compare the market structure of the different sectors, their financing systems and finally we see which lessons could be learnt for a future ATM financing system.

Table 5: Comparison of air transport with non-air transport sectors

	Rail infrastructure manager	Road: case of motorway tolling	IWW and Maritime transport
Market structure	Either independent public monopolies or regulated private corporation	Many local and national infrastructure managers that bid for road concessions	Vessel Traffic Services (VTS) and Maritime Pilot Services (MPS) are often under the harbour authority. In the case of MPS there is a move to independent, private providers. Port Authorities are generally government or mixed-ownership organisations that are moving towards fully privatised companies independent from government.
Financing	Large part of infrastructure is financed through public budgets and EU grants. Some countries aim to move towards a 100% user-pays principle after subsidies. Marginal cost pricing principles were introduced in some countries, but often limited to wear & tear.	Tolls generally finance about 50% of the infrastructure cost in countries with motorway tolling.	Payments to use port facilities are generally not covering all costs. Governments provide substantial support for ports, especially in developing hinterland and managing access to ports (dredging, widening, construction of canals). National interest and competition play a significant role in developing ports. The charges of MPS are based on cost recovery.
Lessons learned?	Most countries use marginal cost pricing, but different mechanisms are applied across Europe. In general infrastructure managers have access to government subsidies for renewal and investments.	Motorway tolling has moved towards auctioning of links to concessionaires. This same idea could be applied to ANSPs.	MPS charging system exhibit similarities with the charging for ATM. MPS is, however, only needed for a very limited part of a vessel's trajectory and is probably closer to landing and take-off fees.

2.3 Comparison of financing models in non-transport sectors

In this section we discuss financing models for a number of non-transport sectors: electricity, telecom and utilities in the water sector. The aim is to see whether we can draw lessons from them that are relevant for aviation, while recognising the different nature of the sectors.

2.3.1 The electricity sector

The electricity market consists of: (i) electricity generators, (ii) producers of electricity, which can either be small local producers or larger (inter)national companies that manage multiple generators, (iii) electricity suppliers, (iv) transmission system operators (TSOs) and (v) distribution system operators (DSOs). Electricity suppliers buy electricity from the generators to sell to consumers. A peculiar aspect about the market is that a company providing (generating) and supplying (buying) the electricity can coincide. Which means that a company is effectively buying its own energy back from the market. The TSOs are in charge of the long-distance transport of electricity and are responsible for ensuring system stability and the DSOs distribute electricity locally to consumers. The electricity market is regulated in general by national regulators that cooperate within the framework of ACER (Agency of cooperation of Energy Regulators).

There are basically two ways how electricity markets balance supply and demand. The first is through Over-the-Counter (OTC) market that offers electricity contracts approved by the regulator. Suppliers offer contracts that offer a volume, price, and period in bilateral agreements. About two-thirds of the market consists of these transactions. The second mechanism is via a wholesale EU wide energy market that is anonymous and digital. The main EU platform is APX.

There are some similarities between TSOs and ANSPs, in terms of organisation and financing strategies. First of all, TSOs consist primarily of national service providers which are regulated public monopolies, similar to how ANSPs are organised (Henriot, 2013; EC, 2019). Unbundling of electricity generation and transmission has generally led to improvements in cost efficiency. Investments were negatively affected if regulation was oriented to the incumbent, rather than to facilitate the electricity market (Gugler et al., 2013). Another similarity is that the TSO costs are attributed via electricity suppliers to the final users (either households or industry) along cost recovery (cost plus) principles. This means that cost recovery is generally the rule, as with ANSPs in Europe. Which costs are recoverable is assessed by the National Regulatory Framework (NRF). The rules along states may however differ and the NRF is implemented by an independent regulatory authority (NRA) which is somewhat similar to the NSA in ATM. In contrast to the ATM sector, regulations on gas & electricity transmission appear to be more harmonised and less fragmented and there is a high level of consistency (EC, 2019). This can be traced back to the Third Energy Package which sets provisions such as 'security of supply' together with congestion management requirements and duties to promote TSO and NRA cooperation. This is especially true for cross-border and market integration. NRAs and TSOs are generally satisfied with the regulatory framework. They have a guiding framework in securing supply and do not perceive notable barriers in implementing projects to increase supply. Where ANSPs are strongly focused on safety, TSOs have a strong focus on security of supply. These focuses are somewhat comparable as it may create a tendency towards technological conservatism and against cost efficiency.

Due to their organisation TSOs exhibit several similar problems as the ANSP market. Firstly, the EC notes underinvestment in transmission infrastructure, especially in line with EC objectives in deploying renewables in the EC. The IEA estimates that 21% of the network should be replaced between 2016-2025 and an additional 15% between 2026 and 2035 (EC, 2019). Underinvestment in

the network is a critical danger for electricity transmission due to pressure on transmission charges and complex decision-making processes. Too stringent regulation may stifle innovation. At the same time discussions arise on cross-border cooperation. Secondly, EC (2019) considers several strategies to increase investment and improve financing in electricity transmission. In particular, they propose to (i) impose requirements to introduce innovative solutions and (ii) to require Social Cost Benefit Analysis (SCBA) for new projects.

2.3.2 The telecommunications sector

Until the early 1990s most European telecom markets were organised around state-owned utility companies with one fixed-line incumbent. Liberalisation of the telecom sector in the last 25 years can be considered to be one of the principal success stories of the EC driven market liberalisation (Cave et al., 2019). Initially, the incumbent operator was mandated to offer access to its network, also known as access-based competition. Later competition was also introduced into the network infrastructure. The difference in coverage of the legacy network owned by the incumbent provider led to very different situations across Europe. Liberalisation of the market initially led to an increase in competition, lower prices, increase in investments, and technological innovation. The new investments were mainly driven by the new entrants as they could directly switch to more advanced technologies such as fibre. However, challenges remain. The first is to guarantee effective investments in new infrastructure under current oligopolistic market regimes with low margins and less access to government funding. This is illustrated by the fact that the European telecommunications sector is lagging behind Asian countries and the US in terms of adopting the latest technologies. The second is to increase harmonisation and integration in the European market (Cave et al., 2019). As networks remain largely local or national infrastructure, international competition is limited. There are concerns that the market is currently too fragmented to allow for large infrastructure investments. Genakos et al. (2018) claim that an increase in market concentration would increase cost to consumers, but also generate momentum for larger investments.

These challenges are not unsimilar to the challenges encountered in the ATM sector with national service providers and a legacy infrastructure which is very costly to modernise. A major difference is that in the telecommunications sector it is possible to have multiple network infrastructures and a vertical integration of operator and network provider often remains, whereas in the ATM sector there is an unbundling between infrastructure (ANSPs) and operators (airlines).

2.3.3 The utilities (drinking water) sector

Drinking water is widely seen as one of the most important public goods. While in theory abundant in most EU countries, there are concerns that water scarcity will increase in the future. Problems are exacerbated due to insufficient financing and climate change (OECD, 2018). In general drinking water is not fully financed by charges. In the EU we observe various approaches:

- Financing through national budget with water supplied at very low or zero charges.
- Water charges as part of local or municipal taxes, with either low or zero charges.
- Public utility companies that charge users directly for water use, but not at full cost recovery.
- Privatised utility companies responsible for charging users, subject to government regulations.

As in other sectors, financing has become an issue, with increased privatisation of supply. This has led to cost efficiency gains and innovation in the sector (OECD, 2018). Privatisation is politically sensible however, as drinking water is commonly seen as a public good. Due to its position as a natural monopoly and drinking water as primary necessity of human beings, government regulation

in this sector probably is unavoidable. Besides this, water infrastructure has a very long lifetime, which may complicate payback of investments in a reasonable time span. Therefore, full cost recovery is generally not possible.

2.3.4 Overview of financing systems in non-transport sectors

As was done for the non-air transport sectors, the following table summarises the findings of previous subsections and compare the electricity, telecom, and utilities sectors with ATM. We compare the market structure of the different sectors, their financing systems and finally we see which lessons could be learnt for a future ATM financing system.

Table 6: Comparison of ATM with non-transport sectors

	Electricity transmission	Telecom	Drinking water
Market structure	Either public or mixed-public companies on Member State level with service obligations under National Regulatory Framework Focus on security of supply.	Large private companies (often former state monopoly) and many small providers.	Public companies on national or local level.
Financing	User-pays principle. Cost-plus recovery through unitary tariff. Government support for large infrastructure investments. EU grants for cross-border investment.	Infrastructure managers manage and maintain own network and are obliged to open up network for other providers.	Only partially paid by user Cost-plus – subsidy recovery. Financing of network through general taxation or tariffs imposed on water users.
Lessons learned?	Electricity transmission suffers from underinvestment. Possible solution is to avoid overregulation of cost, increase the use of Social Cost-Benefit Analysis and technological mandates.	Liberalisation of telecom sector is exemplary for the benefits of a more competitive ATM in Europe. On the downside the current telecom market does seem to structurally underinvest in new infrastructure. Most gains were made on the basis of improving use of existing (state funded) infrastructure.	Drinking water is considered to be a public good but charging for its use is becoming more common. Long lifetime of infrastructure leads to very long payback period (100 years) which makes economic case unrealistic.

3 Desired properties of ATM financing models

In this section we discuss the views of stakeholders on the following topics: the advantages and disadvantages of the current ATM financing system, the desired properties of a future ATM financing system and the ranking of these desired properties. Their views were collected by means of structured interviews and surveys.

3.1 Set up of the interviews and surveys

The main purpose of the interviews and surveys was to collect the views of different types of stakeholders about the current ATM financing system and the desired properties of a future system. The interviews and the surveys followed the same structure and covered the same questions. After collecting some general information, they were structured in three parts:

- Part 1: Open questions regarding the advantages and disadvantages of the current ATM financing system in Europe.
- Part 2: Open question about which properties are deemed important for a future ATM financing system in Europe.
- Part 3: Ranking of the desired properties.

We conducted in total eight interviews and in addition received five completed surveys from airline representatives. Moreover, a meeting was held with airline representatives to discuss the outcomes of the surveys. Among the participants in the consultation are six representatives of European ANSPs (of which three are considered as small while the other three are larger ANSPs), five representatives of airlines (European and non-European, three legacy airlines and two low-cost), a regulatory organisation and a non-European ANSPs (denoted as "others").

3.2 Stakeholders' views on the advantages and disadvantages of the current European ATM financing system

The following table summarises the stakeholders' views on the perceived advantages of the current ATM financing system.

Table 7: Number of participants mentioning a specific advantage of the current European ATM financing system

Type of organisation	User-pays principle: reflects service cost	Robust in normal circumstances	Transparent	Predictable/ simple	Economic regulation on top of charging	Non-discriminatory/ coherent
Airline (5)	5			3	1	1
ANSP (6)	6	4	4	2	3	3
Other (2)	2	1	1		2	

The stakeholders' responses indicate that the major benefit of the European ATM financing system is that it is based on the "user-pays principle". This guarantees that the financing is directly connected to how often a user uses the service and this is seen as a good principle across all stakeholders. The simplicity (only one invoice and one contact point), the coherence (same system across all of Europe) and the non-discriminatory nature (same for national and international airspace users) of the system are mentioned several times as an advantage both by airlines and by ANSPs. Airlines also appreciate the predictability and simplicity of the system where fees are collected by a single entity. Although the dependence of the unit rate on distance is perceived as just, the dependence on the weight is not always considered to be fair and even seen to be discriminatory, especially by the airlines.

In general, the system is seen as robust in normal circumstances, i.e., when traffic is stable. The need for economic regulations on top of the pricing mechanism is essential to mimic market conditions and counterbalance the monopolistic nature of the ATM provision. There is, however, a discrepancy between airlines and ANSPs about the degree of transparency of the system. The ANSPs perceive the system as transparent in the sense that all data to compute the determined costs and traffic forecasts are included and justified in the performance plan and consultations take place with the airlines. As will be discussed further on, this point of view is, however, not shared by the airlines.

Next, the following table summarises the stakeholders' views on the perceived disadvantages of the current ATM financing system.

Table 8: Number of participants mentioning a specific disadvantage of the current European ATM financing system

Type of organisation	Performance plan: too long and complex	No incentive for cost-efficiency	No incentive for collaboration / defragmentation	Does not increase competition	Performance targets not adequate	Lack of enforcement	Risk mechanism not robust in crisis	Too political	No flexibility for ANSPs to react to changes
Airline (5)	3	3	4	3		1	5	3	
ANSP (6)	5	5	1		4	1	4	1	5
Other (2)			2			1	1		

Although most participants are of the opinion that the principles behind the European system are sound, several drawbacks and problems with the implementation are pointed out. It is important here to make the difference between the performance of the system in normal circumstances and the robustness of the system in crisis. We will first discuss the disadvantages during non-crisis situations as they were put forward by the participants.

Most participants mention that the system, and especially the drafting of the **performance plan, is too complex and too time consuming**. All but one ANSP mention the 5-year period of the performance plan as an obstacle for the ANSPs to react to new developments (new users, deviations from traffic forecasts). There may also be planning inaccuracies as the situation might have changed between the drafting of the plan and the final approval. The lack of flexibility to revise an active

performance plan is another major drawback that is mentioned. Although the performance plan should ensure transparency from the side of the ANSPs regarding their costs and business plan, the airlines find the system not to be transparent due to its complexity and the large amount of data. Airlines point out that the large number of ANSPs make it difficult for the airlines to absorb all the relevant data. Communication between the airlines and the ANSPs does not seem to be always optimal, there is a lack of transparency regarding cost benefit analysis. Furthermore, justification of investments are not always clear according to some airline representatives. Some ANSPs would like to see a more centralised regulatory organisation (as opposed to the advisory role of the PRB currently), in addition it is suggested that there is a need for a clear Master Plan. The need for a regulatory body with more enforcement powers has also been hinted upon by several participants when discussing the lack of strong enforcement of the performance plans and as a means to react more swiftly in case of emergencies.

According to the participants the current system does **not give the right incentives to the ANSPs in terms of cost-efficiency and innovation.** Three out of the five airlines and all but one of the ANSPs mention this issue. The long performance plan period is one of the reasons given for this, since the predicted costs are fixed for the duration of the planning period, ANSPs will in general be wary to underestimate them. All but one participating ANSPs mention that the lack of freedom to deviate from the determined costs gives the ANSPs little margin to react to a changing environment by making new investments or to innovate. Desirable investments to enhance the operational efficiency and/or capacity are therefore sometimes not been made.

Related to this, many participating ANSPs mention that the **performance targets need to be revised**. Some of the ANSPs mention that the emphasis is put too much on economic efficiency rather than on operational efficiency and that interdependencies are not well considered. A couple of the ANSPs suggested that there is a need to differentiate between the different categories of costs (capacity, environmental, safety etc.) and less emphasis should be put on the total costs due to the interdependencies (increasing capacity or reducing environmental impact will increase costs). Moreover, some argue that the targets are not differentiated enough across ANSPs and do not consider intrinsic differences such as the scalability or complexity of the airspace. For example: providing more capacity in a saturated airspace will be proportionally more costly than in a less saturated one. A "one size fits all" approach does not work since there are different local circumstances to be considered. There are not only geographical and traffic differences, but also large differences in the way ANSPs are organised (limited companies vs. public authority), cost of staffing and other macro-economic inputs. Some ANSPs think that historical performances should be recognised and incorporated in the targets. In general, the ANPS feel that too much emphasis is put on cost reduction rather than improving service (operational targets). Having the right set of targets is believed to be essential to trigger the right incentives.

Another factor that contributes to the inefficiency of some ANSPs, according to three of the participants, is the **lack of enforcement.** There is little or no consequence for the ANSPs that fail to deliver the required quality of service. The current system is **not seen as encouraging competitive** behaviour from the ANSPs according to most airlines. Although the lack of competition has not been mentioned by non-airlines, **the lack of collaboration** between ANSPs or lack of technological harmonisation has been recognised by ANSPs, airlines and others alike. Fragmentation of the European airspace is seen to be a major source of inefficiency as it leads to duplication of equipment on the ground and aircraft need to be equipped with several systems. Currently the system does not reward enough collaborative initiatives between ANSPs.

Coming back to the lack of transparency and complexity of the system, some of the participants raise the concern of the system being **too political**. From the airlines point of view, this adds to the opacity of the system and raises questions about conflict of interest. For some ANSPs the involvement of the states in the approval of the performance plan is sometimes counterproductive and seen to work to the disadvantage of smaller states who lack the political power during negotiations. Most ANSPs interviewed (and airlines agree) are of the opinion that ANSPs need to be independent entities and more state involvement in investment decisions or other is not seen as desirable.

All of the European participants recognise that the current system is **not robust in times of crisis** or when air traffic demand drops drastically as seen, for example, during the COVID crisis. The current risk mechanism is considered not to be financially sustainable, as was demonstrated by the fact that "exceptional measure regulations" needed to be adopted. In this context, the ability of the US to be able to use the reserves it had built was brought up as an advantage. The ability for ANSPs to build up some reserves by allowing them to keep a positive margin was one of the options mentioned by one of the ANSPs. It is worthwhile noting that some ANSPs did have some reserves that they could use. It must be noted, however that in general, there is little enthusiasm among the participants to change the financing system to resemble the US system. The reason is that the latter is not based on the user-pays principle, which is generally deemed as the building block of any fair financing system.

A recurrent discussion during the interviews was whether **the state should be responsible for maintaining a minimum level of ATM.** Or with other words, to what degree ATM provision can be seen as a public good. Opinions are very much divided among the participants. The airlines' point of view is that all (including military, drones etc.) should be paying for ATM. They see it as unfair that all costs are being borne by commercial providers. To this end, they argue that the states should at least contribute for their costs. The provision of a minimal service is seen as a state responsibility by the airlines and the provision of ATM services is seen as a core service of general interest that must be co-financed by the state. Some smaller ANSPs however argue, that when most of the air traffic consists of overflights, this argument does not keep up since overflights do not contribute to the local economy. Most participating ANSPs are wary of more state involvement as stated previously, and do not support the idea of ATM as a public good. They do agree that in a crisis there is a need to access some external funds but argue that the costs they incurred during the COVID-19 pandemic did benefit the airlines as it enabled them to be functional as soon as air traffic was bouncing back.

3.3 Stakeholders' views on the desired properties of a future ATM financing system in Europe

After discussing the advantages and disadvantages of the current European financing system, we asked the participants which properties a new ATM financing system should have and asked them to rank the properties mentioned. Table 9 summarises the desired properties according to the participating airlines and non-airlines and their ranking[10]. Most participants found it difficult to give a complete ranking as they deemed some properties to be equally important. For this reason, some of the properties have received the same ranking.

[10] The final ranking has been obtained by associating a point system to the individual rankings which are then summed.

Table 9: Desired properties of an ATM financing system

Property	Ranking airlines	Ranking non-airlines
Fair	1	1
Equitable	1	1
Non-discriminatory	1	1
Resilience to shocks	1	2
Credible enforcement	2	4
Incentives for cost-efficiency	2	2
Transparency/consultation with stakeholders	2	2
Simplicity of system	3	3
Flexibility to adapt to changes		3
Earmarking of revenues		5

There are several properties that all participants agree upon. Firstly: any ATM financing system should be based on the user-pays principle as this is seen as **fair**, **equitable** and **non-discriminatory**. These are all properties that are deemed essential for any financial system. Secondly, the system should be **resilient** to large shocks in demand. The system should **incentivise cost-efficiency**. Increasing cross-border collaboration or harmonisation is a way to make use of the economies of scale in ATM and should be encouraged. The importance of **transparency** is also recognised as a means to control the monopolistic nature of ANSPs. Proper consultation with all the stakeholders is part of this, together with sound cost-benefit analysis to justify investments. The system should remain **simple** to understand and to implement to ensure that all stakeholders can make informed decisions. A good system also needs to be complemented with an independent regulation and adequate enforcement to be **credible**.

Most participating airlines believe that a completely fair and equitable financing system implies some state co-funding, as ATM services are core services of general interest. At the same time, the system should simulate perfect market conditions, stimulate competition, and encourage cross-border collaboration. This is expected by the airlines to ultimately lead to more cost-efficient service provision. They argue that in time of crisis shareholders should be the one contributing to the losses rather than the customers. They mention that the user-pays principle entails that there must be transparency on the costs of the service and a more efficient consultation process is needed. Important for the airlines is also that all users of the airspace pay their share. The system, moreover, needs to stay simple and predictable.

The participating ANSPs put more emphasis on the shortcomings of the current performance targets which are considered not to encourage cost-efficiency nor collaboration (see discussion in previous section). The targets are said to be too rigid or not **flexible** enough due to their long planning period which does not allow to adapt to new developments. The ANSPs emphasise that more involvement of the state is not the way forward. Also, any system should recognise that ANSPs legally need to maintain a minimum service even without air traffic and that this needs to be financed. The importance of **earmarking** the revenues to ensure that the revenues from ATM services are put back into the system is also mentioned (only by the ANSPs), as is the need for an equitable system where no users are discriminated against.

3.4 Desired properties of a new ATM financing model

When merging the ranking of the airlines and the ANSPs together we arrive at the ranking (see also footnote 10) presented in Table 10.

Table 10: Ranking of desirable properties of an ATM financing system

Property	Ranking
Fair	1
Equitable	1
Non-discriminatory	1
Resilient	2
Incentivises cost-efficiency	3
Transparent	3
Credible (enforcement)	4
Simple/predictable	4
Flexible (to be able to adapt to changes)	5
Earmarking	6

When using the properties to rank existing financing systems for ATM and to assess proposals for future ones we will use a simplified list of properties. We will omit those properties that are more linked to the way the system is implemented. Since the properties "fair", "equitable" and "non-discriminatory" are all very much related and furthermore received the same ranking, we will group these properties and use "Fair" as a general property. As the properties "transparent" and "credible" and flexibility are more related to how the system is implemented, we will keep them separated. We will first assess the financing systems on their intrinsic properties, keeping in mind that a sound financing model which is poorly implemented can result in an overall poorly performing system. This leads us to the following final list of properties against which we will assess existing and new financing models and implementation requirements.

Table 11: Final list of desired properties

Property	Description	Ranking
Fair/equitable/non discriminatory	All users of the service should only pay for the service they receive (no cross-subsidisation nor discrimination)	1
Resilient	Able to withstand and quickly recover from large shocks in demand	2
Incentivises cost-efficiency	Should encourage ANSPs to provide the service at lowest cost possible	3
Simple / predictable	Easy to implement, minimal administrative burden for all parties	4
Earmarking	Revenues from ATM charges should be used to cover costs of ATM services	5

In addition, when implementing the financing system, the following requirements are desired.

Table 12: List of implementation requirements

Property	Description	Ranking
Transparent	Recovered costs are justified and sufficient stakeholder consultations	1
Credible	Existence of an authority that can enforce rules	2
Flexible	Possibility to quickly adapt to changes in market conditions	3

4 Assessment of existing and future ATM financing models

4.1 Objective and structure

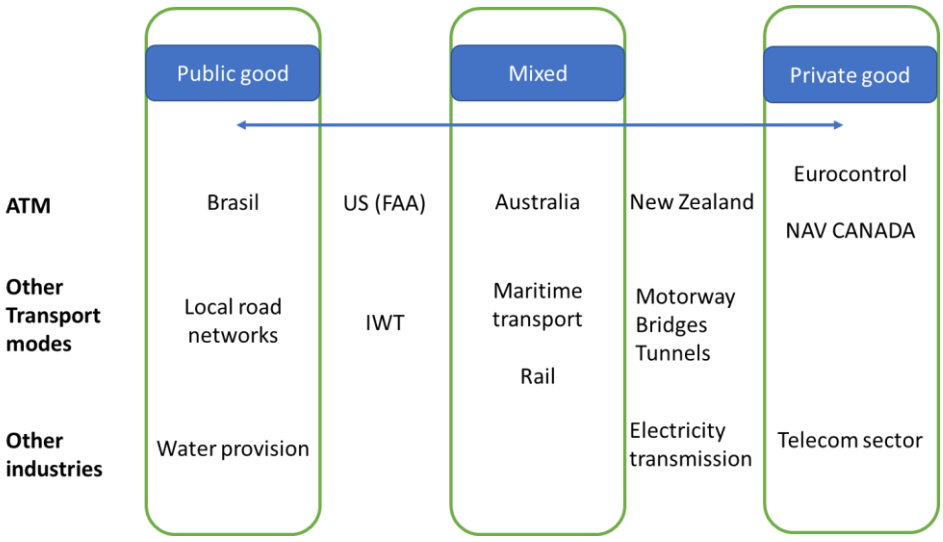
In this part of the report we discuss alternative financing models, starting from existing financing models in different transport and other sectors. Our objective is to propose alternatives to the current model of ATM financing, which is largely user financed in Europe. We give an overview of alternatives to the current system. We discuss advantages and disadvantages of the new financing models.

The new financing models are then ranked according to their possible contribution in terms of resilience, cost-efficiency, fairness and simplicity. In a step beyond financing alone, we discuss the compatibility of the financing model with possible long-term improvements in ATM structure and organisation. The objective is to check the compatibility of structural changes in ATM provision with the proposed financing model.

4.2 Assessment of existing financing models

The existing financing models that we have discussed in Section 2 can be categorised by the degree to which they are considered as public or private good, as shown in Figure 9. We see that there is a wide variety within ATM and across industries on how services are perceived.

Figure 9: Public good nature of ATM, other transport modes and industries



One of the consequences is that even within one sector, a variety of financing systems can be observed. In practice this comes down to the following types of charging and financing for transport and other public and semi-public services:

- **General budget** financing: the costs are entirely funded by the general budget without any payments by the users.
- **Fund**: the costs of the service are covered by a fund financed by either excise taxes, fuel taxes or other taxes.
- **Marginal cost pricing** (MC): the users pay for the cost of providing additional services.

- **Ramsey pricing**: the users pay a charge above marginal cost to avoid losses for a public monopoly. The markup over marginal cost is inverse to the price elasticity of demand.
- **Cost recovery pricing** (CP): the costs (including the fixed and investment costs) are recovered through user charges.
- **Cost recovery pricing net of subsidies** (CP–): direct government financing in the form of subsidies or grants is combined with user charges to recover the costs of providing the service, including the fixed and investment costs.
- **Vertical integration**: Fully privately owned infrastructure is vertically integrated with operator. Infrastructure needs to be provided to competing operators.

In Table 13 we summarise the different ways in which the services discussed in Section 2 are financed.

Table 13: Financing systems for different services

	ATM						Other transport modes				Other industries		
Financing source	**EU**	**US**	**NAV CANADA**	**Australia**	**New Zealand**	**Brazil**	**Rail**	**Local roads**	**Motorways**	**Maritime**	**Electricity**	**Telecom**	**water**
General budget		√				√	√	√	√				√
Fund		√											
MC							√						
Ramsey					√								
CP–						√	√		√		√		√
CP	√		√	√						√			
Vertical Integration												√	

Notes: MC = Marginal Cost pricing; CP– = cost recovery pricing minus subsidies; CP = cost recovery pricing

To assess the existing financing systems, we have used the properties identified in Section 3 and have compared them to the current European ATM financing system. This is a rough assessment only, as specific characteristics of each model could alter the assessment. For example, in case of Fund based financing, a lot depends on where the revenues are collected. Table 14 should be interpreted as an assessment of the potential of the different financing systems rather than a thorough analysis.

Table 14: High-level assessment of existing financing systems and current EU ATM financing systems

	Fair	Resilient	Incentivises cost-efficiency	Simplicity	Earmarking
General budget	–	+	––	+	–
Fund	–	+/–	––	+	+
MC	++	––	++	–	+
Ramsey	+	+/-	+	–	–
CP–	+	+	–	+	+
CP	++	––	–	+	+
Vertical integration	+/–	+	+	+	–
Current European ATM financing system	+	––	+/–	+/–	++

Notes: MC = Marginal Cost pricing; CP– = cost recovery pricing minus subsidies; CP = cost recovery pricing

Fair and equitable: In general terms, the more the financing relies on the user-pays principle the higher it will score on fairness as defined in this study. Both marginal cost pricing and cost recovery are based on the user-pays principle. In the case of marginal cost pricing, the user only pays for the extra cost to supply an additional unit of service, while in the cost recovery system, the user also pays for the fixed costs of the service provider. The current European system is seen as fair and equitable as it is based on the user-pays principle: the user pays for the service received. However, the fact that some users, such as the military, are exempt goes against the fairness principle. A simple way to increase the fairness of the European system is therefore to abolish any exemptions, as is done in Australia. The discussion of ATM as a public versus private good can alter the assessment. If it is deemed that ATM services are a public good, then more government funding would be seen as desirable. We will come back on this further on in the study.

Resilience: Sectors with large, fixed costs will be more resilient if their financing system relies more on government intervention. This is the case for ATM in the US or the rail sector. One possibility to increase the resilience of the European ATM system is to increase governmental subsidies or to have a fund that can be used to cover unexpected losses.

Incentivising cost-efficiency: According to economic theory, lump sum subsidies do not incentivise cost-efficiency. It advises to have a direct link between charges and the cost of the service. Generally, the economic literature advises that users pay the marginal cost and not the average cost of service provision in transport. Vertical integration encourages the minimisation of the costs of the whole system, whereas unbundling of services can lead to each party minimising its costs without considering the impact on the other and can therefore be less cost efficient. Other factors, such as regulation, monopoly power and fragmentation of the market have, however, a big influence on the cost-effectiveness of a service. The implementation of the financing system is therefore critical to ensure that the right incentives are given.

Simplicity: Whenever charges depend on costs (whether marginal, average, or total), determining which costs are eligible and the true level of these costs will add complexity to the system. The current European financing system is simple and predictable in the sense that there is only one invoice, one contact point and the system is the same across Europe. However, the large variation between the ANSPs' unit costs and the justification of these, makes the system more complex.

Earmarking: the use of general taxation to cover the costs of a specific service, in general, goes against the concept of earmarking.

In general, we can see that the financing models that combine the user-pays principle with some general funding such as MC pricing, Ramsey pricing and cost recovery net of subsidies (CP–) have a good overall score, together with the vertical integration model that requires a fully privatised infrastructure manager.

4.3 Problems with the current European ATM financing model

4.3.1 Resilience

The first major problem with the current financing model is resilience. More specifically, it is ill equipped to handle traffic downturns.

The ICAO recommends contracting states to introduce a financing system that requires users to pay allocated costs. Under that recommendation, the cost of providing services should be borne directly by the users of the infrastructure (airlines / operators) and eventually by their customers (passengers and freight). In Europe, according to the Association of European Airlines (AEA) [11]these navigation charges account for 9% of the airline direct operating costs. For every airline ticket sold, 6% is devoted to navigation services.

Additionally, the ICAO principles imply that a reasonable margin of return should be allowed for ANSPs to invest in their network. This indirectly leads to a requirement to 'prefund' the network and certain investment projects. The ANSPs however – with a structure of large, fixed costs and inflexible labour pool – are particularly vulnerable to downturns in traffic. This vulnerability is exacerbated by the type of user-based financing that is generally used.

The ANSPs' labour costs are not as flexible as in other industries. In particular, the amount of labour required is established and largely fixed for the whole year according to projected summer peaks. Moreover, an average three-year lead time for air traffic controller (ATCO) training adds to the relative inflexibility in responding to short-term demand fluctuations. In addition, control personnel usually are required to exercise their license for a minimum amount of time each year at prescribed maximum intervals, and labour union and legal restrictions often apply to the use of overtime. To illustrate the inflexibility of labour supply in ATM, most ANSPs needed around half of their normal staff levels to ensure that the skies remained open during the pandemic even when air traffic was reduced to levels of 30% or below of pre-pandemic traffic (Turnbull, 2022).

Already in 2002 – after the events of the terrorist strikes of 9/11 – the Civil Air Navigation Services Organisation (CANSO, 2009) warned that the current system of cost recovery charging used by most European countries is inadequate. This financing system works well as long as traffic is gradually increasing. Fixed (projected labour) costs do not change, or only gradually as a result of an increase in traffic. This means that in periods of economic growth and traffic expansion (for example from 2002-2008 and from 2010-2019) the average cost of navigation services will gradually decrease. However, in mayor economic downturns the same mechanism of cost inflexibility will lead to major budget deficits. Typically, ANSPs raise prices to allocate fixed costs over smaller volumes during a traffic downturn, which causes airlines' costs to rise. Although airport and ANSP costs are a relatively

[11] The Association of European Airlines is the predecessor of Airlines for Europe (A4E). It was disbanded in 2016.

small proportion of airline costs, a sudden cost increase could have a detrimental effect on airline operations in times of falling revenues. In turn, this may further depress traffic in the next years, slowing overall recovery of the market and increasing the duration of the crisis.

4.3.2 Cost efficiency incentives

The next major problem of the current financing model is that it offers little incentive for cost efficiency gains. Directly connected with this, the current financing model allows limited margins nor incentive for investment in new (more cost-efficient) technologies. The origin of this problem is complex and roots in market fragmentation, natural monopoly and general conservatism in the sector. It cannot be solved only by a financial model, but any alternative should allow to incentivise cost-efficiency improvements on the longer term.

What is the alternative? Below, we first give a limited introduction on the nature of public goods. We discuss if air navigation services should be defined as such.

4.3.3 Fairness: is ATM a public good and who needs to pay?

Full user-paid infrastructure is an outlier in financing. The only other sectors that come close in that respect are the telecom sector and electricity transmission. Historically, almost all air navigation services were closely linked to government (generally transport) departments. Since the 1980s different ownership models have been introduced with varying degree of liberalisation and government control. This varies from state corporations to full privatisation. Clearly, the degree of independence of the provider from government does offer a clue on society's view on its public good nature. It is therefore interesting to observe the variety in ANSP ownership and indirectly the level of associated public service provision.

Economists such as Musgrave (1959) defined public goods simply as a 'goods produced by the government' such as defence or education. This good or service should be defined as 'of *national interest'*. The more broadly accepted definition by Samuelson (1954) defines public goods along two main characteristics: non-excludability and non-rivalry. Non-excludability signifies that it is impossible to exclude consumers from using the service. Non-rivalry means that consumers can use the service without impeding other users from using the same service. For example, local roads or public broadcasts are generally seen as a public good. Using your own car or bicycle for transport is clearly excludable and rivalrous. However, there is always case for discussion. New (GPS tracking) technology for example may offer a way to link consumers to congestible local roads.

The main guiding principle for public good provision is that a free market would either not or underprovide the required service. The reason is that public goods may carry external benefits that surpass private benefits. Transport services additionally have large, fixed cost of provision and retain elements of non-excludability and non-rivalry. Therefore, fully user financed infrastructure would generally lead to either under-provision or inefficient pricing.

Table 15: Comparison of public good principles of drinking water, public transport and ANS

	Drinking water provision	Public transport	ANS
Excludable?	Beyond basic provision	YES	YES
Rivalry?	Limited in normal circumstances	Limited, depends on demand	Depends on demand
National interest?	YES	YES	YES

What does this mean for ANS? Air navigation is clearly excludable with present technologies. It is also, to a large extent rivalrous as the ANSP labour time is limited and cannot be easily transferred to another customer. This is why many countries are treating ANS mostly as a private good. There are however two important arguments against this. The first is the large, fixed cost of navigation service provision – especially on maintaining and operating infrastructure – which is largely non-rivalrous. The second is the external social and economic benefit as well as national interest of air transport services. If ANS were treated as a private good, the ANSPs would have had to strongly reduce cost and staffing during the pandemic, combined with closing airspace at certain locations and times. This clearly did not happen. In contrast, the COVID-19 crisis clearly showed that governments have an interest in keeping airspace available and retaining minimum staff levels. This goes well beyond the provision of a pure private good. Therefore, the reaction of governments to the pandemic in 2020 and 2021 is the best argument to claim that ANS are at least 'mixed public-private' services.

What is the implication of this? Our intuition is that when air transport is functioning at a normal rate or 'on capacity' it is quite close to a private good. However, when demand drops the public good characteristics of ANS will dominate. This provides an argument for extending government funding in ANS to guarantee a minimum level of staffing. It is worthwhile to note that the current regulations allow this in certain circumstances (Regulations (EU) No 390/2013 and (EU) No 391/2013, (EC, 2013a and 2013b)), acknowledging the (at least partial) public good nature of ATM.

4.4 Possible adaptations to the current European ATM financing model – short term

Major problems to be tackled by a new financing model are the risk sharing mechanism (short run), the reduction of cross-subsidies and an increase in cost-efficiency (long run). It should be noted that the financing system needs to be complemented with regulations to compensate for the monopolistic nature of ANSPs. In this study we focus solely on the financing system itself.

For the short run there are several options that can be envisaged for the reform of the ATM financing system, going from small to more important reforms:

- Reduce/remove current exemptions (Australia)
- Variation on current risk sharing model to guarantee Core Services of General Interest
- Establishment of multinational trust fund for traffic risk (Baumgartner, 2022)
- Threshold funding model (Turnbull et al., 2022)

Each of these will be discussed in the next paragraphs.

4.4.1 Removing exemptions

Currently in most of the European airspace military aviation and aviation related to the national interest is exempt from paying navigation charges. To reduce cross-subsidies from commercial operators to public infrastructure and operations, an apparently simple proposal would be to remove current exemptions. What would be the impact of such a change?

To estimate the value of current exemptions in the EUROCONTROL area, we use data on exemptions as a share of total units served for three years (2019, 2020 and 2021). Our first observation is that the majority of the exempted units is military traffic. Our second observation is that exempted units only marginally changed during the pandemic, while overall unit served reduced with more than

50%. Therefore, during the pandemic, the exempted units jumped from less than 1% of overall traffic to almost 2%.

Table 16: Removing exemptions – estimated impact

ACTUAL COST AND PROJECTION	Units	2019	2020	2021
Units served	Million	167	70.8	89.9
Exempt units	Million	1.39	1.34	1.43
Military	Million	1.2	1.18	1.25
Exempt service units	%total	0.83%	1.89%	1.59%
Of which military	%total	0.72%	1.67%	1.39%
Total navigation cost (EUROCONTROL area)	MEUR	8661	8214	8318
Estimated % in total cost based on service units	MEUR	72	155	132

Source: EUROCONTROL (2019,2020,2021,2022) & own calculations

If we relate the share of exempted units in total units to the total navigation cost, we come to a total of EUR 72 million in 2019 and respectively EUR 155 and 132 million in 2020 and 2021. Removing exemptions would therefore have a small, but non-negligible impact.

Civil and military air use is a poor proxy of the total 'public good value' of airspace navigation services. During the pandemic, governments have imposed much more stringent service requirements for ANSPs. For example, the requirement to guarantee minimum service levels and continuity in airspace operations.

In conclusion we see the following (dis)advantages of removing the current exemptions:

Advantages:

- **Increase in equity, transparency and reduction of cross-subsidy:** all parties requiring navigation services would pay for those services.
- **Relatively minor change to current system:** At least theoretically this requires only minor changes to the current funding of ANS.

Disadvantages:

- **Political sensitivity:** Most of the exempted units are military flights, which for reasons of national interest are often shielded from paying charges.
- **Minor change to current system:** While it may appear that in this case governments are paying into the public good, they are only paying into it partially as a customer. Simply removing exemptions would be a poor substitute for deeper reforms.

4.4.2 *Adapting the risk sharing mechanism*

We discussed before that ANSPs have a structurally inflexible cost structure. Almost 85% of the cost of ANSPs can be considered to be fixed, including many of their staff and support costs. In 2020 even with a reduction in composite flight hours by almost 57% compared to 2019, costs only reduced by 5%. In our interviews with ANSPs the following motivation was given for the low reactivity to air traffic levels:

- National interest to keep airspace open
- Requirements in employment and training

- Restrictions on reducing labour hours for personnel

Table 17: COVID-19 reaction of ANSPs 2019 versus 2020

	Units	2019	2020	Change
Flights	Million	11	5	-54.5%
Composite flight hours	Million	22	9.5	-56.8%
ATCO employment cost	EUR	118	130	10.2%
ATCO hours	Million	23.5	20.2	-13.9%
ATCO hour productivity	Composite flight hours/ATCO	0.94	0.47	-49.8%
Support cost	MEUR	5892	5588	-5.2%
Employment cost	MEUR	2769	2626	-5.2%
Cost of ATM/CNS provision	MEUR	8661	8214	-5.2%
Financial effectiveness	EUR/Flight.h	394	865	119.6%

Source: EUROCONTROL (2021c)

The impact of this inflexibility is that the financial effectiveness of navigation charges is highly dependent on demand. As navigation charges are annually fixed on the basis of demand predictions, charges collected are generally not equal to actual cost of the system. To handle this variation, a risk sharing mechanism is in place. In the current risk mechanism, variations of demand up to 2% are entirely borne by the ANSP, while the consequences of shocks between 2% and 10% are shared 30/70 between ANSPs and airlines and those of shocks above 10% are fully borne by commercial aviation. This system works relatively well when shocks in demand are low and when traffic is growing.

Given the observed inflexibility in cost and the observed possibility of large shocks in demand, we propose an adaptation to the risk sharing mechanism that involves government support when demand falls below a certain threshold. At this point the public good element of air navigation services will dominate. As such minimal service obligations (Core Services of General Interest or CSGI) can then be co-funded by public authorities.

A possible variation of this system could be to introduce a state compensation when demand falls below 10%. Below 10% the additional gap in funding due to demand reduction is borne 50% by the public authority and 50% by commercial airlines. This share of the government could be limited up to a certain maximum contribution, used to finance the CSGI.

We show the impact of such a mechanism in absolute value in Table 18 and visually in Figure 10 and Figure 11

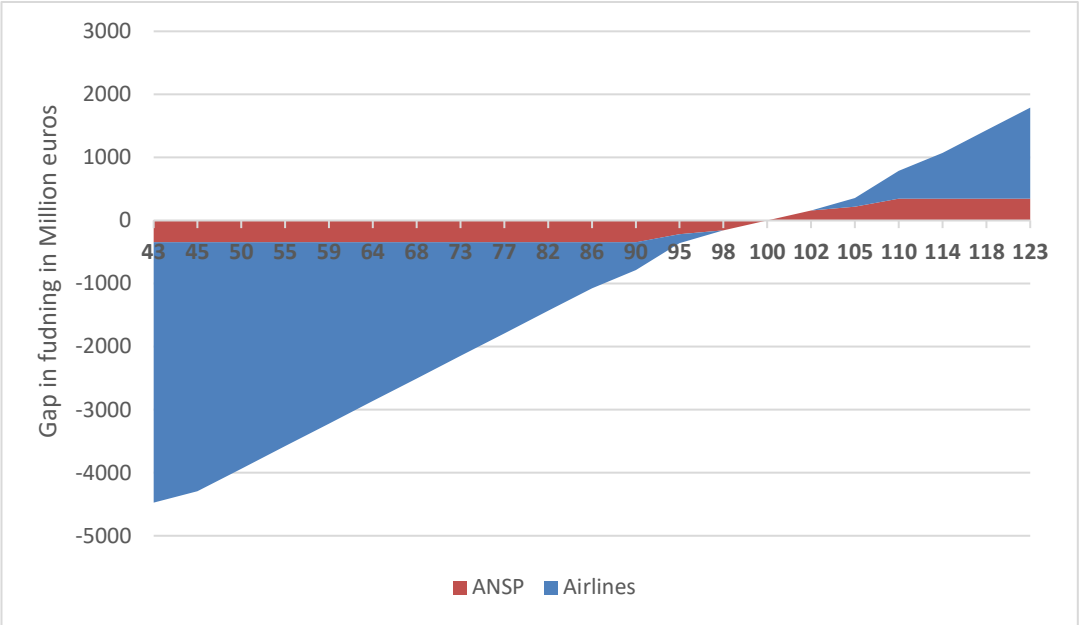
Table 18: Simulation of introducing adapted risk sharing with public funding based on 2019-2020 case

	Current risk sharing			Adapted risk sharing			
Index air traffic demand	**Share ANSP**	**ANSP (MEUR) ***	**Airlines (MEUR) ***	**ANSP (MEUR) ***	**Share government**	**Airlines (MEUR)***	**Government (MEUR)***
43	0%	-346	-4 128	-346	50%	-2 064	-2 064
45	0%	-346	-3 949	-346	50%	-1 974	-1 974
50	0%	-346	-3 591	-346	50%	-1 795	-1 795
55	0%	-346	-3 233	-346	50%	-1 616	-1 616
59	0%	-346	-2 875	-346	50%	-1 437	-1 437
64	0%	-346	-2 517	-346	50%	-1 258	-1 258
68	0%	-346	-2 159	-346	50%	-1 079	-1 079
73	0%	-346	-1 801	-346	50%	-901	-901
77	0%	-346	-1 443	-346	50%	-722	-722
82	0%	-346	-1 085	-346	50%	-543	-543
86	0%	-346	-727	-346	50%	-364	-364
90	30%	-346	-441	-346	0%	-441	0
95	30%	-218	-140	-218	0%	-140	0
98	100%	-157	0	-157	0%	0	0
100	100%	0	0	0	0%	0	0
102	100%	157	0	157	0%	0	0
105	30%	218	140	218	0%	140	0
110	30%	346	441	346	0%	441	0
114	0%	346	727	346	0%	727	0
118	0%	346	1 085	346	0%	1 085	0

*: A negative monetary value corresponds with extra costs.

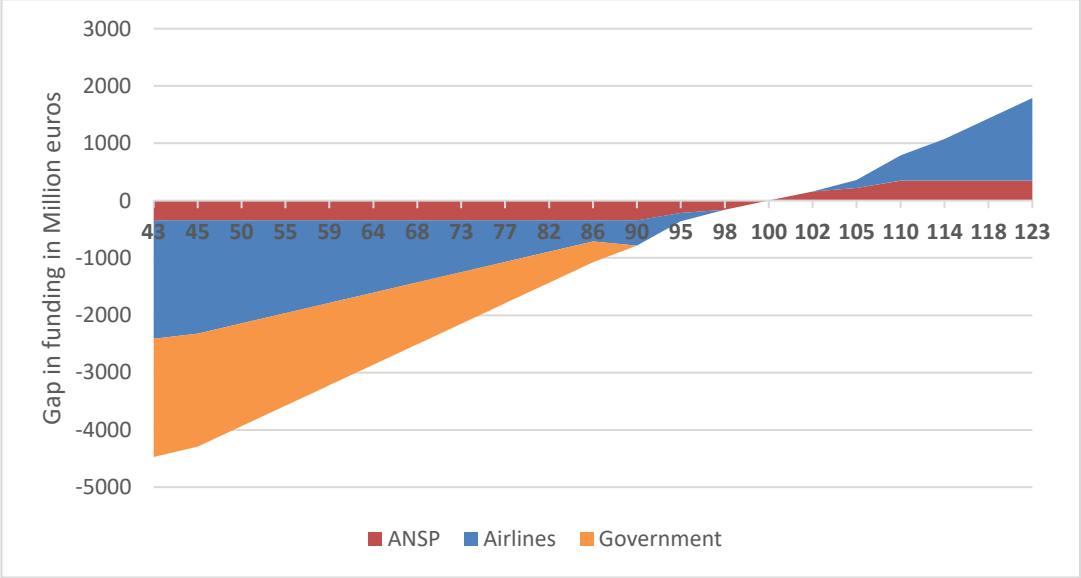
Source: own calculations using EUROCONTROL (2021c)

Figure 10: Impact of COVID-19 crisis (57% drop in flight hours) with current risk sharing



Source: Own calculations using EUROCONTROL (2021c)

Figure 11: Example of impact of COVID-19 crisis (57% drop in flight hours) with adapted system for risk sharing



Source: Own calculations using EUROCONTROL (2021c)

Figure 10 and Figure 11 simulate how a traffic variation similar to the traffic downturn during the COVID-19 crisis in 2020 would be covered. We use actual cost estimates provided by EUROCONTROL (see Table 17). Here again, we see how the current risk sharing mechanism leads to a large amount of uncovered costs of air navigation services. Under the current system, airlines are 100% liable for any revenue deviations above or below 10%. The **impact is highly asymmetrical in case of traffic downturns due to the very low elasticity of cost** with regard to air traffic. For the year 2020, commercial airlines are liable for; more than EUR 4.1 billion in uncovered cost for air navigation. For 2021 the gap in funding was only slightly below the one in 2020 (EUR 3.9 billion). For airlines, compensating such a loss would require at least 4 years with a traffic growth that is

almost 20% higher than expected. While growth in air traffic does catch up over longer time periods, the setback during COVID-19 was extremely large. During the economic recession in 2009 for example, traffic fell by 6.8%.

An additional option to consider would be to include a '*crisis financing option*'. This would imply that in case of extremely low traffic levels (for example below 10% of normal traffic), government takes up a part of the remaining liability for ANS funding (for example an additional 25%). This would allow the financing of the CSGI even in cases of extremely low traffic levels. While such a situation is very unlikely, it is not unthinkable, as was shown during the worst months of the pandemic.

An adapted risk sharing mechanism that is presented above has a number of interesting advantages:

- **Lower cost burden for commercial airlines**: The airlines' share of the cost for the traffic downturns similar to the Covid-19 crisis would be roughly halved. This is more fair / equitable as the cross-subsidy for maintaining airspace for national interest is reduced.
- **Limited role for government**: Government involvement is only required in case when traffic falls back by 10% and more of the expected value. In this case the governments pay at least partially (50%) for maintaining minimum service. An additional crisis financing option with higher government contributions could be considered, to maintain financing of CSGI in case of extremely low traffic levels.
- **Impact on cost efficiency**: Involvement of state governments may induce additional pressure to reduce costs during crises as governments are now also paying the cost of navigation services.
- **Simplicity**: this variation on the risk management system does not require extensive reform and could be implemented as an extension of the current risk management system.

However, there are also disadvantages:

- **Cost efficiency incentives still limited**: One of the main problems in European ANS is not solved: low efficiency and low elasticity of cost in case of downturn of traffic.
- **Financing of the government contribution**: it needs to be settled how the government contribution is financed (*see threshold fund and general tax funding below*)
- **Minimum service budget (Core Services of General Interest) has to be determined more concretely:** The modified risk sharing agreement sets a maximum (CSGI) budget for service provision of national interest. This budget is defined in absolute terms. It might be better to define the CSGI as a level of minimum service provision, independent of cost.
- **Equity/fairness issues:** (in combination with the previous point) Commercial airlines would still be liable for costs even when demand would (theoretically) drop to zero.
- **Involvement of all Member States involved:** Member States need to agree on the level of minimum service provision and agree to compensate national ANSPs in case of crisis.

4.4.3 Baseline Threshold Fund with government financing

The inflexible cost of ATM provision, the observed variations in air traffic and average cost pricing is arguably not a good match. The current model leads to gaps in financing which are to be covered by airlines in later years. Turnbull et al. (2022) therefore point to the possibility of a threshold funding model. In such a model, national governments would be responsible for the funding of the minimum services and staffing levels. This would de facto remove any cross-subsidisation that is present in the current system. Costs above this minimal (public good) service level would be covered by user charges as is currently the case. The current cost-recovery system then becomes a cost-plus minus subsidy system, closer to what is the case in other transport modes such as rail.

A main point of debate is the size of the government's involvement in funding air navigation services. A conservative estimate of the government contribution in overall navigation cost is between 20% and 40% of overall cost. We will use 30% as a reference value. Our main assumption is that independently of the situation, government pays 30% of the total cost of the system. Based on costs of 2019, 2020 and 2021 as well as calculations by Eurostat (2022a), this would imply a yearly public contribution between EUR 2.46 and 2.65 billion. Naturally this would substantially reduce the direct liability of commercial airlines in navigation charges both during normal years and during crisis years.

However, there are a number of caveats with this system. The first and most obvious issue is the financing the government contribution. Generally speaking, there are two possibilities to finance the contribution:

1. **From general taxes without any relation to air transport** (labour tax, sales taxes, …)
2. From **taxes related to air transport**, for example:
    a. Tax on passengers (tax on tickets or similar)
    b. Fuel taxes (on kerosene or other fuels)
    c. Tax on freight (by tonne or volume)

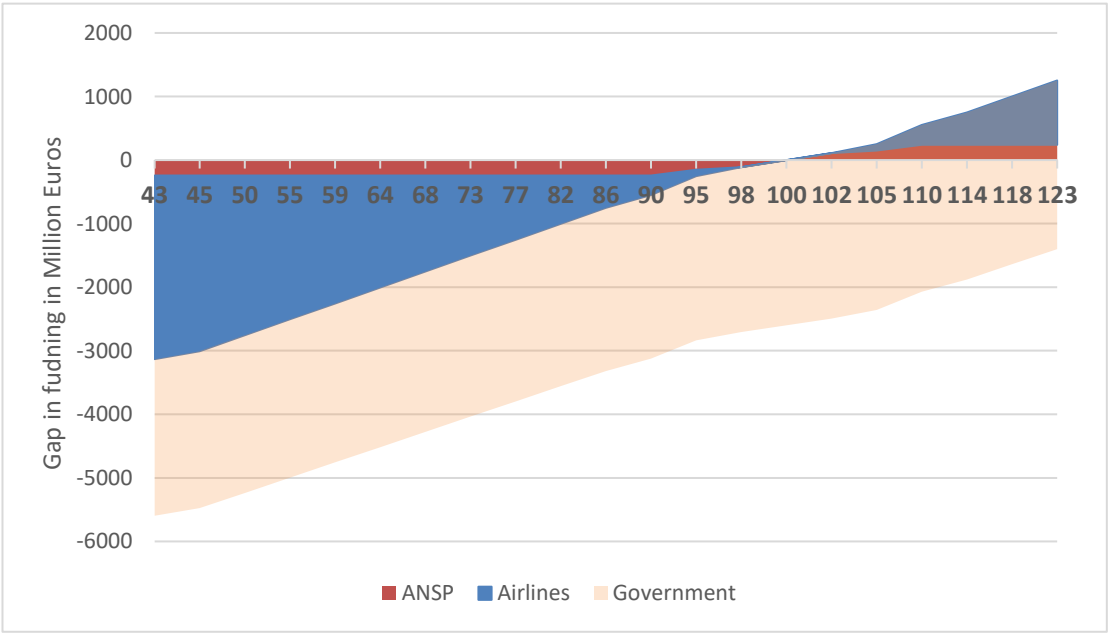
In case of general taxation financing, there is a societal impact but no direct impact on air transport or airlines. If other sources of financing are chosen, the impact may be diverse and possibly counterproductive. We will discuss alternative funding by passenger and/or fuel taxes in the next section when discussing the US system of funding ANS. For now, we will not discuss this added complexity and assume a funding from general taxation. If general taxes are effectively used to fund 30% of the ANS cost, the liability of commercial airlines for navigation costs will decrease with the implied government contribution (between EUR 2.45 and 2.65 billion – see above).

What happens in case of a traffic downturn similar to the one experienced in 2020? For this we assume that the current risk sharing agreement between ANSPs & commercial airlines is kept in place. In this case we find (see Table 19 and Figure 12) that the liability of airlines for the gap in funding to the system is around EUR 2.9 billion versus the basic risk sharing agreement of EUR 4 billion (see above). However, it is larger than the EUR 2 billion in the adapted risk sharing agreement discussed in the previous paragraph. The basic difference between **a threshold funding** model and **the adapted risk sharing system** in the previous paragraph, is that the threshold funding model implies a constant contribution of the government to ANS. In case of traffic downturns however, applying the current risk sharing mechanism implies that commercial airlines will still be accountable for more than 70% of the gap in funding.

Table 19: Example of threshold funding model - overview

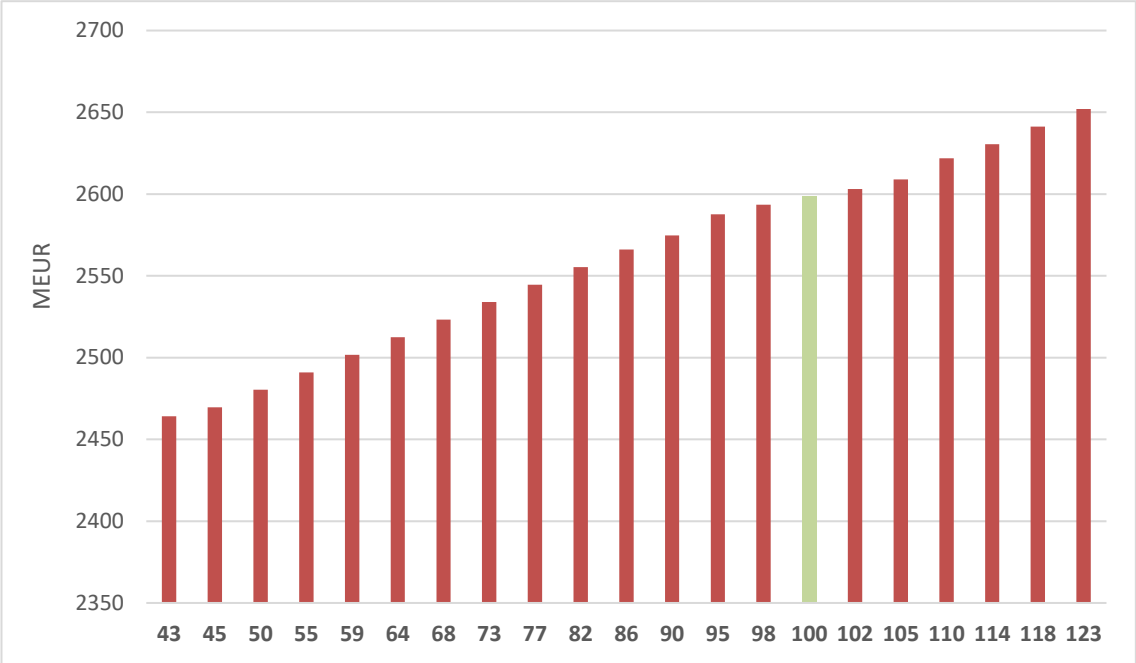
Index air traffic demand	Share ANSP	Share Government	ANSP (MEUR)*	Airlines (MEUR)*	Government (MEUR)*
43	0%	30%	-243	-2 889	-2 464
45	0%	30%	-243	-2 764	-2 470
50	0%	30%	-243	-2 513	-2 480
55	0%	30%	-243	-2 263	-2 491
59	0%	30%	-243	-2 012	-2 502
64	0%	30%	-243	-1 762	-2 512
68	0%	30%	-243	-1 511	-2 523
73	0%	30%	-243	-1 261	-2 534
77	0%	30%	-243	-1 010	-2 545
82	0%	30%	-243	-760	-2 555
86	0%	30%	-243	-509	-2 566
90	30%	30%	-243	-309	-2 575
95	30%	30%	-152	-98	-2 588
98	100%	30%	-110	0	-2 594
100	100%	30%	0	0	-2 598
102	100%	30%	110	0	-2 603
105	30%	30%	152	98	-2 609
110	30%	30%	243	309	-2 622
114	0%	30%	243	509	-2 630
118	0%	30%	243	760	-2 641
123	0%	30%	243	1 010	-2 652

Figure 12: Example of threshold funding in combination with risk sharing agreement



*: A negative monetary value corresponds with extra costs.
Source: own calculations using EUROCONTROL (2021c)

Figure 13: Government funding in ANS in Million EUR with threshold fund



Source: own calculations using EUROCONTROL (2021c)

Advantages:

- **More resilient:** The government covers the cost of minimal service levels. In the case of a drastic reduction in traffic, and thus revenues, costs will be covered. This reduces the risk for ANSPs as the government will guarantee a steady amount of funding for ANS.
- **Lower cost burden for commercial airlines:** User charges would only cover the costs above the minimal provision.
- **Impact on cost-efficiency**: Involvement of state governments may induce additional pressure to reduce costs during crisis as governments are now also paying the cost of navigation services.
- **Equity/fairness issues:** Cross-subsidisation is effectively removed.

Disadvantages:

- **Cost efficiency incentives still limited:** ANSPs might have less incentives to cut costs if it is guaranteed that some level of costs will be covered.
- **Remaining issues with resilience:** Liability of navigation cost for commercial airlines in case of downturn in demand is still an issue if the current risk sharing mechanism is applied.
- **Robust financing of the threshold fund:** The way the fund will be financed needs to be transparent. Revenues for the fund need to be robust against traffic downturn. This implies a contribution from the general budget of government rather than taxes on passengers or aviation fuel.
- **Possible increase of national government involvement:** An increase in government involvement on the level of the member states could strengthen the national character of ANSPs and go against structural reforms and gains in scale efficiency required under the SES.

4.4.4 Multinational Buffer Fund

The role of the national governments in the threshold fund model discussed in the previous section can be seen as a step back from the single European sky ambitions. Baumgartner et al. (2022) therefore propose to create a multinational fund to support ANSPs in the case of crisis, rather than the existing risk sharing agreement. This would prevent the current situation where states need to step in to support the ANSPs and commercial airlines are liable for costs during periods of exceptionally low demand. The buffer fund can be realised in several ways:

- From general tax revenue from the member states corresponding to ANSP regions.
- From a uniform tax on tickets.
- From taxes on fuel.
- From air navigation charges: as a certain percentage of navigation charge, this would imply allowing the ANSPs to charge above cost-recovery.
- From cost efficiency gains at ANSPs: most ANSPs realise cost efficiency gains under a price cap. A part of the gains could be mandated to the fund.
- From profit margins in good years: currently air users receive paybacks when traffic growth is 2% larger than expected. These extra revenues could be mandated (or part of them) to be put in the fund (similar to NAV CANADA – see below).

The size of the multinational fund should be managed to a 'sustainable' size. NAV CANADA uses a similar 'rate stabilisation account" that was established on the basis of profits made during 'good' years. In its financial statements, NAV CANADA describes the rate stabilisation account as follows:

The rate stabilisation account balance is comprised of operating deferrals. Should actual revenue exceed the Company's actual expenses, such excess is reflected as a credit to the rate stabilisation account. Conversely, should actual revenue be less than actual expenses, such shortfall is reflected as a debit to the rate stabilisation account. A debit balance in the rate stabilisation account represents amounts recoverable through future customer service charges, while a credit balance represents amounts returnable through reductions in future customer service charges. When establishing customer service charges, the Board considers the balance in the rate stabilisation account, the extent to which operating costs are variable and available liquidity and sets the level as appropriate.

It is important to note here that the rate stabilisation account of NAV CANADA was depleted after the 2001 dip in air travel after 9/11 and was also far from sufficient to neutralise the impact of subsequent crises in 2003, in 2009 as well as the pandemic in 2020. This implies that profit margins alone may not suffice to have a sufficiently large buffer.

While it is hard to put an exact number on this, an option could be to have a stabilisation fund that is able to cover about 6 months of air navigation charges. This financial buffer can then be funded through a combination of efficiency gains, profit margins and government contributions. This may replace the existing risk sharing system in Europe and avoid putting an additional financial burden on ANSPs and commercial airlines in times of crisis. In this sense it could also be interpreted as an insurance and stabilisation fund for ANS.

Advantages:

- **More resilient:** the fund can be used to cover losses in times of crisis and will stabilise navigation charges.
- **Less involvement of national governments:** governments will no longer need to step in to support ANSPs in time of crisis (or only to a smaller extent).

- **Alignment with Single European Sky and defragmentation:** this kind of fund is easier to implement in the context of an increased defragmentation and a common European ATM infrastructure.
- **Increase of cost-efficiency:** collaboration between ANSPs is encouraged which can lead to an increase in scale efficiency.
- **Existing risk sharing mechanism can be simplified.**

Disadvantages:

- **Cost efficiency incentives still limited:** the current flaws of the charging system remain.
- **Possible increase in burden for commercial airspace users:** unless the fund is funded with general tax revenues, it will ultimately be paid by the airspace users.
- **Possibility of fraud:** if cost efficiency or profit margins are used as a basis for the fund, ANSPs have an incentive to misrepresent cost.
- **Level of fund needs to be determined:** the accumulated funds need to be able to cover the minimal service provision. The stabilisation fund of NAV CANADA, for example was depleted by the traffic slowdown after 9/11 and the subsequent effects of SARS in 2003 (Turnbull et al., 2022) and the COVID-19 pandemic.
- **Need for a strong European network manager:** the enforcement of payments needs to be credibly enforced. For this a strong network manager with enforcement powers is needed.

4.5 Alternative financing model: funding through an Airport & Airway trust fund

Turnbull et al. (2022) reinterpret ANS as a public good that should therefore also be funded through public means. Besides partial public funding, they **refer to the funding system of the FAA in the US.** In this system there is **no direct payment of navigation charges, except for overflight** (so without origin/destination in the US). As is discussed previously in Section 2.1.3, ANS are therefore paid for from a tax on passenger tickets, freight and kerosene charges. These taxes provide revenues for the AATF fund that ultimately finance around 80% of the cost of the FAA, but this varies from year to year. The rest comes from the budget of the General Treasury (general taxation). This share is commonly rationalised by the 'public good' nature of air navigation services. This share varies in practice from 7% (2015) to more than 50% (2020).

If European ANS services were to be funded in a similar way, this would imply a transition to a very different system.

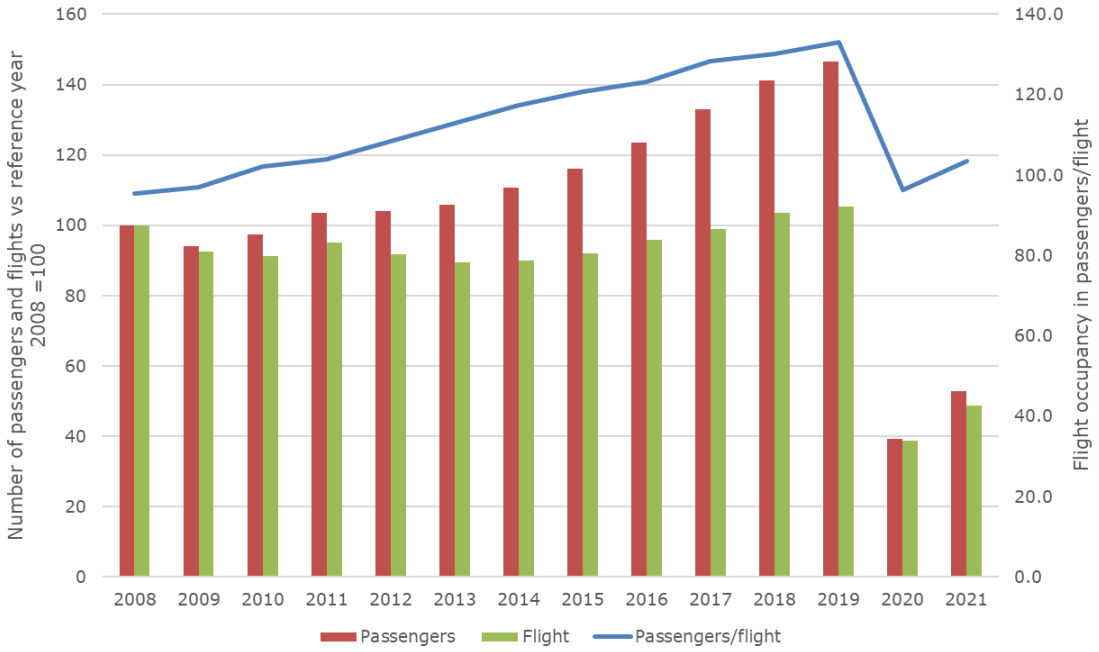
The first element would be abolishing existing navigation charges and much of the administration that is connected to it, at least on the side of the commercial airlines. On the side of the ANSP it would still be necessary to record ATCO hours, performance, costs, and flights, as this would provide input to get compensation from a European Airport and Airway Trust fund (EATF).

Similar to *the 'threshold fund'* model discussed above there would be a contribution from general taxation. However, this contribution would not remain at a fixed percentage (for example 30%) but vary each year according to circumstance and political support (Yang and Elias, 2017). In the US, the US Congress has had to bail out the AATF on several occasions, often at times of crisis.

As an example, suppose that European ANS are almost entirely funded through passenger taxes instead of navigation charges. We take the period 2008-2021 as a reference period (see Figure 14). During this period, flight occupancy increased substantially from around 95 passengers/flight to 133

passengers / flight. The actual number of flights however, dropped initially until 2015, only to increase above the 2008 value in 2018 and 2019. In 2020 the number of flights and passenger dropped to 40% of the level of 2008, to recover slightly in 2021.

Figure 14: Number of passengers and flights and flight occupancy in Europe – 2008-2021



Source: Eurostat (2022a) and own calculations

If is self-evident that the actual costs of air navigation are more closely related to the number of flights than to the number of passengers. A fixed passenger tax for this period based on the level of costs in 2008 would have raised much more revenue than necessary to fund air navigation services in the period 2010-2019. In 2020 the drop in revenue would have been much steeper as passenger numbers declined by more than 75% compared to 2019. The number of flights only decreased by 54.5%. We conclude that funding air navigation services through passenger taxes would imply much more variability in revenues. This while the costs of air navigation services tend to be rather stable.

Another important issue with the US system of funding ANS is equity. There are several problems. The first is that flights pay according to the number of passengers. In the US it has been noted on several occasions that this leads to underfunding of services by corporate owned and private planes. These planes tend to pay only a fraction of their actual navigation cost. Passenger taxes also indirectly imply exemptions for military flights. The second problem is that any type of passenger tax will lead to new inequities between carriers. If one chooses to tax a percentage of the value of the ticket (like in the US – 7.5%) this means that funding depends on the ticket price. That can create a discrepancy between legacy and low-cost carriers. On the contrary, a fixed ticket tax may lead to the opposite problem.

Yang & Elias (2017) note that the rise of low-cost carriers may have led to a drop in funding in the US AATF fund. The authors also remark that increasing the share of kerosene taxes within the AATF could be more equitable in this sense. Additionally - compared to the passenger tax system – it may provide an environmental benefit. It is probable that such discussions would also be of importance for our fictional EATF.

A benefit of the AATF is that it clearly earmarks taxes to the sector. EU countries have a history of introducing new taxes without clarifying the use of the revenues. Riccardo (2021) estimates that the existing ticket taxes in the EU (among others in Austria, France, Belgium, Netherlands, Germany, Sweden and Italy) will have a revenue of €2.6 billion in 2025. Kerosene is currently exempt from excise taxes, but under the revision of the ETD a minimum charge may be required that may increase up to €0.33/l in 2033. In an *'EATF'* at least a part of these tax revenues could be dedicated to providing ANS services.

A last problem is cost efficiency. Several reviews indicate that the FAA is more efficient than the fragmented system of European ANSPs (see above & EUROCONTROL, 2019). However, this may be mostly due to scale efficiency and not due to the way the system is funded. On the contrary, almost every US president in the last decades - Republican or Democrat - has attempted to reform the FAA. In general, these reforms included plans to liberalise the FAA and move towards more user paid principles like those used in Canada or Europe. The argument being – mainly- to reduce government spending and make the system more efficient and equitable (user paid). Additionally, economic intuition would be that financing predominantly through passenger taxes could go against increasing flight occupancy and therefore environmental sustainability targets.

To summarise we list the main advantages and disadvantages of a US style financing system:

Advantages:

- **More resilient:** while gaps in funding would also arise and may even be steeper than using navigation charges, there is a steady flow of public contributions from general taxation that fund the system in times of crisis. This makes the system more resilient.
- **Recognition of public good nature of ANS:** the public good characteristics of ANS are not questioned in this funding system. It is the commitment of the government that enables ANS to function at high levels of efficiency and invest in R&D and new technologies. This clearly puts responsibility into the hands of public authorities. When a minimum level of services is imposed on an ANSP, it will be the government and not the commercial provider that pays for the majority of the cost of keeping airspace open.
- **Earmarks taxes on passengers and fuel taxes to air navigation:** a fund similar to the AATF would be predominantly paid by passenger taxes, with a smaller contribution of fuel taxes and freight taxes. Indirectly this earmarks existing taxes on airlines to improving air navigation, instead of providing tax revenue for national governments.
- **Flexibility:** while passenger taxes are the main source of funding for the AATF, it is not necessarily so. Other revenue sources could also be considered, such as fuel taxes as well as other taxes, government contributions or even profits and efficiency gains of a more liberalised ANSP than the FAA. This could make a tax fund like the AATF more similar to the multinational fund we discussed above.

Disadvantages:

- **Cost efficiency incentives are limited and possibly worse than using navigation charges:** Financing through navigation charges links actual costs generated by airspace use more closely to ANS than any other means of paying for the charge. Abolishing navigation charges would therefore not help to improve the cost efficiency of ANSP.
- **Exemptions remain and new inequities could be created**: Exemptions for civil and military flights will probably be maintained in this system. Additionally corporate flights, private planes would only pay little into the system. New discrepancies may be introduced between low-cost carriers and legacy carriers.

- **Constant support by government necessary:** the system can only be maintained with constant support of the government, as the fund will generally not suffice to pay for all costs, especially in times of crisis.
- **Difficult to set-up in fragmented European environment:** the fragmented nature of the EU market with its many member states and national interests would make it hard to guarantee government commitment.

4.6 Overview of adaptations and new financing models for ATM

in Table 20 summarises the main advantages and disadvantages of each model discussed in Sections 4.4 and 4.5.

Table 20: Main advantages and disadvantages of ATM financing models

Financial model	Advantages	Disadvantages
Remove exemptions	Reduces cross-subsidy Does not require extensive reforms	No increase in cost efficiency Limited budgetary impact
Adapted risk sharing mechanism	Lower cost burden for commercial airlines Limited role for government Potential positive impact on cost efficiency Does not require extensive reform	Cost efficiency incentives still limited Minimum service budget (Core Services of General Interest) has to be determined Limited liability reduction for airlines
Threshold funding	More resilient Lower cost burden for commercial airlines Potential positive impact on cost efficiency Cross-subsidies are effectively removed	Cost efficiency incentives still limited. Robust financing of the threshold fund needed National Governmental involvement increased.
Multinational fund	More resilient Less involvement of national governments Alignment with Single European Sky and defragmentation Potential Increase of cost-efficiency	Cost efficiency incentives still limited Possibility of fraud/mismanagement Possible increase in burden for commercial airspace users Level of fund needs to be determined Need for a strong European network manager
European Airport and Airways Trust	More resilient Recognition of public good nature of aviation Decreases fragmentation	Decreases incentives for cost efficiency Loss of relation between cost of service and charges Increases member state involvement

4.7 Increasing cost-efficiency: long-term structural changes

4.7.1 The need for reform

The funding models discussed above mainly discuss how the current ANS costs could be divided between different stakeholders (commercial airlines, ANSP, national authority, EUROCONTROL,

…). However, the current ANS costs would not change significantly in any of the systems discussed above.

The COVID-19 crisis can be seen as an opportunity to reform the European ATM system more fundamentally. There is a consensus among stakeholders that the current system is not encouraging cost-efficiency from the side of the ANSP. To increase cost-efficiency more in-depth reforms are needed that often go beyond the reform of the financing system: it requires a reform of the market structure and the defragmentation of the European airspace. Since such reforms are out of the scope of this study, we do not go into too much details. The ATM policy institute (2016) proposed five measures to improve overall scale efficiency in the current system, namely:

1. Unbundled data, training and infrastructure services
2. Competition for Terminal Air Navigation Services (TANS)
3. Franchised en-route services
4. Competition for oceanic services
5. Optimisation of flow management

In this section of the report we will briefly introduce a number of potentially beneficial reforms that would increase competition in the market. This may lead to structural changes that deliver longer term increase in efficiency and cost reductions.

4.7.2 *Towards a single European ATM provider*

Following the reasoning of reforms already proposed in SES, Baumgartner et al. (2022) propose a **top-down merger of ANSPs**. This is not without cost. The SES unit issued a report in 2015 that the extra cost of not implementing the operational objectives of functional airspace blocks (FABs) leads to extra costs close EUR5 billion per year in infrastructure cost, delays and operational inefficiencies. It is estimated that users pay about EUR10.5 billion annually (including inefficiencies). This is a high cost that results from fragmented service provision.

To achieve the objective (according to Baumgartner et al. 2022), the role of EUROCONTROL should be strengthened, both as a regulator and as a network manager. **Current FABs and joint alliances between ANSPs could be used as a starting block but should not be stringently applied**. While the rationale behind their creation was valid, the implementation was assessed to be ineffective and counterproductive. The authors propose a more bottom-up approach to FAB's towards truly operationally optimal groupings. For this the FABs should be deregulated. One of the main problems cited by the authors is the lack of incentives that ANSPs had to work together in FABs. To overcome this, financial incentives could be given to ANSPs willing to cooperate or merge (e.g., government could take over the debt for ANSPs that merge their activities). Moreover, Baumgartner et al. claim that the performance scheme was counterproductive as it blocked several key elements that would have led to long term cost reductions. The SES2+ package under negotiation recognises this and allows more flexibility for regional cooperation beyond the strict application of the FABs. Adler et al. (2022) study the integration of several national ANSPs in FABs and work out several cases with integration. In almost all of these cases, costs were only marginally reduced and, in some cases, they led to higher cost for airlines. Actual progress on increasing scale efficiency in this way could (according to Adler et al., 2022) only be realised with a sufficient reduction in fixed costs after integration of ANSPs (40% reduction) and with a move towards Marginal cost / Ramsey pricing.

More extremely Baumgartner et al. (2022) propose to move towards a **single provider model.** The ultimate step would be to have a single ATM provider with a single ATM/CNS infrastructure managed as a European infrastructure.

While a single provider model would help to achieve operational objectives formulated within SES and provide the necessary scale for long term reductions in cost, it is not clear if this is the ideal end point of the liberalisation process. In fact, moving towards a single provider would eliminate the suboptimal - but interesting - state of the European market that could be called a 'laboratory' (Finger et al., 2017) for ATM reform. In effect it would transform European ATM in something close to the model used by Canada: one European ANSP ("*Nav Europe*") that provides ATM services either on a non-profit or possibly even for-profit basis. The problem with such a system is that it would effectively root out any competition on the market and have one entity claim a natural monopoly in airspace management. In the longer run that might be detrimental for cost savings.

Advantages:

- **Decrease fragmentation of the market** and increase scale efficiency, possibly triggering cost reduction through better use of available infrastructure and staff.
- **Increase transparency** since there would be only one provider to negotiate or exchange information with.
- Only **minor changes necessary** to the funding system.
- Moving **towards a single provider**: efficiency gains similar to the one of the FAA.

Disadvantages:

- Not clear if increase in scale will trigger enough cost reduction for ANSPs, especially in the short term.
- Simulation of ANSPs operating under a stringent price cap or operating on non-profit basis shows that **incentives may be too limited to cooperate**.
- In the case of for-profit ANSPs there may be **an increase in market power**, which triggers increase in navigation charges, without actually benefitting commercial airlines.
- If one moves towards a single provider: **creation of a monopoly situation**, similar to the one in Canada.

4.7.3 Vertical unbundling

Vertical unbundling of support services for ATM means that en-route traffic services are decoupled from other services, for example, air traffic data services, CNS, MET and Terminal air services. The original SES2+ proposal of 2013 made vertical unbundling of support services for ATM mandatory. The current SES2+ package under negotiation replaces this by a *voluntary* decoupling. This means that operators can provide all services in an integrated manner but will not be able to prevent other operators to provide competing services.

ATM providers will therefore be able to decide if they want to procure these services under market conditions. If so, these services will not be subject to economic regulation. For terminal air traffic services, the choice will be with airport operators, subject to prior decision by Member States. To enable competition, operational data of one provider should be shared to other providers at low cost, enabling cross-border data services and competition on the European market for data service provision. The goal is to break previously monopolistic air services provision.

Advantages:

- The reforms are expected to trigger **cost reductions.**
- **No fundamental changes to the funding system**.

Disadvantages:

- Strong **opposition from labour unions.**
- To trigger effective cost reductions, ANSPs need to be subject to the **right economic incentives**. It is not clear whether this will happen with the current regulatory regime and funding. Additionally, unbundling is only voluntary under the current SES2+ package.

4.7.4 *Dynamic airspace sharing*

A step beyond unbundling of services would be to enable 'capacity-on-demand' or **dynamic airspace sharing of ANSPs** (EUROCONTROL, 2022b). For this a market should be established between ANSPs to allow offering excess capacity of personnel in one (associated) zone to ANSPs that are capacity constrained. This would reduce the need for ACCs and ATCOs, reducing the cost of minimal service. It would also increase the use of free route airspace where aircrafts are not constrained by any route structure. The concept could deliver increased flight efficiency without affecting the sovereign responsibility of the national authorities. While dynamic airspace sharing looks simple, it is very complex in practice. To make it operational ANSPs need to have compatible technology, communication and procedures. Additional problems on distribution of cost and creating a joint platform may exist. Therefore, in practice dynamic airspace sharing could be very difficult to implement.

Advantages:

- **Improved use of excess capacity:** remaining capacity of (neighbouring) ANSP could be optimally used.

Disadvantages:

- **Implementation cost** may be too high compared to the expected benefit. Effective airspace sharing requires additional reform. This may limit the applicability of the model in practice.

4.7.5 *Tendering of ANS services*

Another radical reform is proposed in Adler et al. (2020) who develop a **model of tendering ANS services** in a way similar to how motorway concessions are organised in France. This model could help to solve two problems simultaneously. The first is to resolve the issue of fragmentation and the second to stimulate the adoption of new technologies. An additional windfall benefit would be to reduce the need for economic regulation and performance schemes.

The main idea is to allow member states to open tenders to a number of possible ANSPs to manage their airspace[12]. This would effectively move from an 'infrastructure based' to a 'service based' ATM market. This is also proposed in Baumgartner et al. (2022). Governments retain sovereignty over their airspace, as well as set a number of requirements that ANSPs should meet. This could be a price cap, minimum service level, congestion penalty, how much a single company is allowed to participate, etc.

Reopening the tender should be done every 5-10 years to ensure sufficient competitive pressure. COMPAIR simulations in Adler et al. (2017) showed that navigation charges could be halved when markets are opened for competition in this way. The market would move to oligopoly conditions. Additionally, charges would be more harmonised across countries. Interestingly the authors show that a competitive environment based on for-profit ANSPs would achieve larger cost reductions than

[12] ANS provision through tendering is already applied in the Middle East. Serco already operates in several countries.

non-profit ANSPs. The reason is that non-profit organisations enjoy a less clear mandate than for-profit organisations. Overall non-profit organisations tend to take less risk with adopting new technologies and achieve less defragmentation of the airspace. As such, non-profit organisations would only be optimal if procedures for tendering are working sub optimally or cannot be repeated.

Tendering ATM provision would not eliminate the need for regulation. In fact, simulations by Adler et al (2020) showed that there may be a tendency for firms to reduce capacity, hence any tendering should adequately require minimum service levels in the bid process. Companies should be tracked to see if targets are actually met. Regulatory instances for managing safety and measuring delay would equally be necessary. Overall, this would be comparable to managing motorway concessions, with the same possible benefits and possible pitfalls.

In case of large demand fluctuations like during the pandemic, it is not unimaginable that governments would need to step in. In this sense it would be optimal to use a funding model that is more resilient to shocks. A guaranteed minimum level of public funding (see the funding models above) could help to build in resilience.

Another possible caveat is to guarantee if the cost efficiency gains can be maintained after some time. The tendering of airspace can lead to slowly turning the ATM market in an oligopoly with competition between larger multinational providers. It might be necessary to review regulations to ensure competitiveness.

Advantages:

- **Decrease fragmentation of the market** and **increase scale efficiency**, possibly triggering cost reduction through better use of available infrastructure and staff.
- **Possibility of a large reduction in cost:** well-functioning tendering may enable large cost reductions and may trigger innovation and investment in new technologies.
- **Transparency:** in the tendering procedure, the contract with the ANSP can stipulate costs and required service level. The performance of ANSPs therefore becomes more transparent.
- **Breaks natural monopoly of ANSPs:** this is replaced with repeated tendering every 5-10 years.

Disadvantages:

- **Large implementation cost**: complete overhaul of the market.
- **Follow-up necessary**: national governments will need to follow-up contracts and check if minimum service levels and required capacity are guaranteed. Simulations show that there may be a tendency to underprovide capacity.
- **Resilience** can still be a problem: experience with motorway concessions show that in times of crisis government support or even nationalisation might be necessary.
- **Only works if there is sufficient competition:** In absence of competition or in the case of high entrance costs, one provider may establish a new monopoly and increase charges.

4.8 Ranking of the financing models

Similar to what we did with the existing financing models, we rank the new financing models against the desired properties. Again, as before, this assessment is based on the potential of the models independent from the implementation.

Table 21: Ranking of financing models against the desired properties[13]

Weight	*5*	*4*	*3*	*2*	*1*	*3*
	Fair / equitable	**Resilient**	**Incentivises cost-efficiency**	**Simplicity**	**Earmarking**	**Ease of implementation**
Current European ATM financing system	+	−−	+/−	+/−	++	
Adapted risk sharing	++	+/−	+/−	+/−	+	++
Threshold fund	+++	++	+	-	+/−	−
Multinational fund	+	++	+	-	++	−−
European Airport and Airway Trust	−	+	−−	+	−	−−−

As is clear from Table 21, there is always a trade-off between properties.

Fair/equitable: The adapted risk mechanism and the threshold fund model are deemed fairer if one considers that there is a minimal level of ATM provision which corresponds with a Core Service of General Interest. At the same time, these models retain the user-pays principle and are thus an improvement on the current system.

Resilient: All models, except "European Airport and Airway Trust" (EAA trust) will offer more resilience in the case of a drastic reduction in demand. The threshold fund offers the best guarantee provided that the fund is not financed with ticket taxes, as these will also be highly dependent on the demand and will suffer the same problems as the US system and when making use of a EAA trust.

Cost-efficiency: It can be argued that if governments are providing funding for ATM, they will be more encouraged to increase the cost-efficiency of the ANSPs. A multinational fund encourages collaboration which also enhances efficiency but on the other hand the system remains largely unchanged and current issues could remain.

Simplicity: In general, the more parties involved, the more complex. The need to decide on the size of Member States contribution will increase the complexity of the system.

Ease of implementation: The less drastic the adaptation, the easier it will be to be implemented. Some of the adaptations could prove to be politically sensitive.

To get **an overall ranking of the models**, we associate a score to each funding system. We use the following methodology: (i) we associate a score for each property (+/- is equal to 0, + is equal to 1, etc.), (ii) as not all properties are ranked equally, we give a higher weight to fairness than to resilience and so forth[14]. The results are given in Table 22.

[13] We have omitted the "no exemption" model as the changes compared to the current model are too small to be captured by the rough assessment methodology used.

[14] For example, the weighted score for the current European model = 5*1+4*(-2)+3*0+2*0+1*2=1).

Table 22: Overall ranking of new ATM financing models including and excluding weighting of properties.

	Unweighted score	Weighted score
Current EU system	*3*	*5*
Adapted risk sharing	3	**17**
Threshold fund	**4**	**21**
Multinational Fund	2	10
EAA Trust	-5	-15

As has been mentioned previously, to increase the cost-efficiency of the provision of ATM long-term structural changes are necessary. It is therefore important to see to what degree the new financing models are compatible with the structural changes mentioned in Section 4.7. Our assessment of the compatibility of the financing models with the structural changes is given in Table 23.

Table 23: Compatibility of new financing models with structural reforms

Structural change	Current European system	Adapted risk sharing	Threshold Fund	Multinational Fund	European Airport and Airway Trust
Unbundling / Dynamic airspace sharing	+/–	+/–	+/–	+	+/–
ANS tendering model	+/-	+/-	+	+	---
Top-down redesign of airspace	+/-	+	++	++	+++
Single provider model	–	+	++	+++	+++

The current European system is not very compatible with necessary structural reforms. Any new funding system would optimally increase incentives towards scale efficiency and market competition.A general tax fund like the "European Airport and Airway Trust" would be most compatible with top-down redesign of the airspace/ANS or a single provider model. It would not be very compatible with tendering, as the market would be too concentrated to allow for competitive competition. A threshold fund could be combined with a tendering process that is initiated by Member States and repeated every 5 to 7 years. A multinational fund could be combined with almost any model, depending on its set-up and financing.

The assessment above and in Table 23 is indicatory only. The compatibility of funding systems with structural reforms is hard to predict and depends strongly on its implementation. Therefore we do not take it into account for the overall ranking of financing models.

4.9 Proposal for top two financing models

Finally, we are in position to narrow down the potential financing models to the two preferred options. The two models are:

Threshold fund: Governments are responsible for the funding of the minimum services and staffing levels, while costs above this minimal (public good) service level are covered by navigation charges as is the case currently. This ensures increased resilience in the short term and reduces costs for

airlines. It makes the funding model in aviation sector more in line with other transport sectors and is relatively easy to implement.

Adapted Risk Sharing: The current EU system of financing ATM is not changed. Only the risk mechanism is adapted to require governments to contribute to a part of the navigation charges in times of crisis. Crisis is defined here as a situation where traffic drops below a certain level. Our study proposes that governments step in when traffic drops below 10% of the expected traffic due unforeseen events. The size of the government contribution can be limited to a maximum level.

Both models have advantages and disadvantages. The threshold fund model would imply a steady contribution of the government from general taxation. This would have a stabilizing influence on ATM financing. In terms of implementation, it would require a larger effort than changing the risk sharing mechanism.

The adapted risk sharing model would only imply government involvement in times of crisis. This represents a smaller overall contribution, but still a strong engagement from public authorities to provide funds to air navigation counter-cyclical to economic conditions.

5 Roadmap to implementation

A reform of the ATM financing system is a complex exercise as there are several aspects that need to be addressed. First of all, there is the problem of resilience which became apparent during the COVID-19 crisis. Secondly, the interviews with the stakeholders have made it clear that not only the financing system needs to be improved but also that the regulatory framework as it stands now has some serious flaws. Finally, as argued in the previous sections, some structural reforms are needed to increase the cost-efficiency of the ATM sector. We therefore need to distinguish between short-, mid- and long-term reforms.

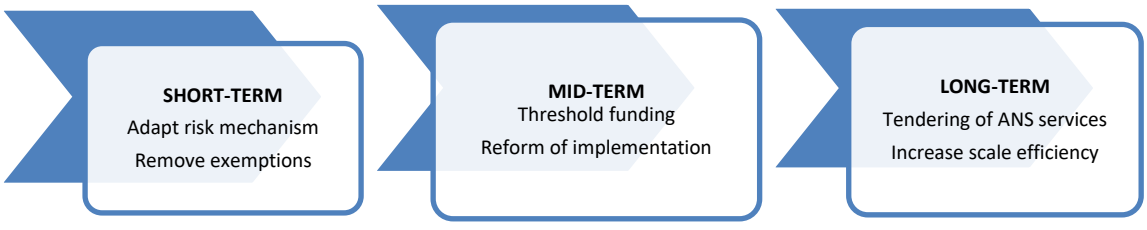
In the **short-term**, we propose to (i) remove (or at least reduce) charging exemptions and (ii) adapt the risk mechanism as described in Subsection 4.4.2 in order to share the burden more evenly across all beneficiaries of the aviation industry.

In the **mid-term** a fund could be established to ensure that in the advent of a new crisis, the ATM sector has a buffer large enough to be able to cope with the loss of revenues and to stabilise navigational charges. Our proposal is to introduce a threshold fund where Member States contribute a fixed share of the ATM costs yearly.

Regardless how ATM is financed, a number of disadvantages of the current system mentioned by the stakeholders in Subsection 3.2 will remain. These are often related to the implementation and the regulatory framework. It is thus important that regulatory reforms to increase cost-efficiency such as reviewed targets and KPIs, shorter review periods and stricter enforcement are envisaged at the same time. In all cases there should be a transparent consultation procedure across stakeholders to ensure the credibility and acceptability of the system.

Central to the problem of resilience is, however, the lack of flexibility to decrease costs on the side of the ANSPs even when air traffic is down. To remedy this, **long-term** structural reforms are needed to decrease the fragmentation of the European airspace and increase overall cost-efficiency. One first step would be to unbundle ATM services from the provision of other services and move from an 'infrastructure based' to a 'service based' ATM market. To increase scale-efficiencies, a further defragmentation of the European airspace and an increase in cross-border collaboration will be necessary. Introducing a tendering model as described in Subsection 4.7.5 would achieve this.

Figure 15: Roadmap to implementation



6 Conclusion

The COVID-19 pandemic presented an unprecedented challenge for commercial air transport. Right after the crisis, a relatively quick recovery of demand for air transport was expected. However, the ongoing geopolitical instability has forced EUROCONTROL and other stakeholders to review their forecasts. The pandemic has highlighted problems with the current European ATM system such as the lack of resilience in the face of large traffic down turns. The current risk mechanism where airlines have to pay for the full loss of revenues is neither equitable nor transparent.

A rethink of the whole current financing system is necessary. This feeling is shared amongst most stakeholders as has been made apparent during the interviews performed during this study. Although the principles governing the current system are seen as sound, the implementation and the lack of incentives to increase cost-efficiency or to increase collaboration are problematic. The pandemic has also highlighted the public good nature of aviation and whether member states should be contributing towards the financing of ATM services n some form.

After reviewing the current literature on ATM and financing of the non-transport and transport sectors, we propose two alternative financing systems:

A **threshold funding model** where national governments would be responsible for the funding of the minimum services and staffing levels, while costs above this minimal (public good) service level would be covered by user charges. This ensures increased resilience in the short term and reduces costs for airlines. It would result in a funding model in the aviation sector more in line with other transport sectors. Some fundamental questions remain, however. First, what is the precise level of government contribution needed? Second, how would the government contributions be financed. The impact of such funding will be quite different depending on whether the contributions are financed with general taxes or specific air transport taxes.

A second possibility is to adapt the **current risk sharing model**. Commercial airlines are fully liable now for any gaps in funding caused by downward deviations in traffic over 10%. We propose an alternative that for downward traffic deviations larger than 10%, governments contribute directly to ANS in a 50/50 share. We simulate the size of such a contribution on the basis of the observed changes in traffic in 2019, 2020 and 2021. Additionally, such a model could introduce a 'crisis financing' option that guarantees financing of minimum services provided by the ANSPs in case of very low traffic

It is important to note that a reform of the financing system alone will not solve all the issues with ATM in Europe. A well-designed, credible, and transparent regulatory framework together with structural reforms are necessary to create a more flexible and cost efficient system. Cross-border collaboration and simplifying airspace are needed to increase scale-efficiencies and a new financing model should be compatible with this long-term vision.

References

Adler, N., Hanany, E., Proost, S., 2022. Competition in congested service networks with application to air traffic control provision in Europe, Management science

Adler N., Hanany, E., Proost, S., 2020. Introducing competition through auctions in air traffic control markets. Working Paper, The Hebrew University of Jerusalem.

Adler N., Proost S., Delhaye E., Torres J., 2017. Summary of quantitative model results report D4.3 of COMPAIR project

ATM policy institute, 2016. The case for liberalising air traffic control.

Baumgartner, M., Finger, M., 2014. The Single European Sky gridlock: A difficult 10-year reform process. *Utilities Policy*, 31, pp.289-301.

Baumgartner, Andribet, Garot, 2022. Reinventing European air traffic control based on covid-19 pandemic experience. Utilities Policy 78, https://doi.org/10.1016/j.jup.2022.101343

Buyle S., Dewulf W., Kupfter F., Onghena E., Meersman H., Van de Voorde E., 2021. From traditional to professional Air Navigation Service Provider: A typology of European ANSP business models

Cave M., Genakos C.,Valletti T., 2019. The European Framework for regulating telecommunications, Review of Industrial Organisation (2019) 55:47-62

CANSO, 2009. Alexander Ter Kuile, CANSO's Open Letter to Aircraft Operators, 27 March 2009

DECEA 2021. Relatório de Performance ATM do Sistema de Controle do Espaço Aéreo Brasileiro (SISCEAB) *[In Portuguese]*.

de Rus G. and Nash C., 2007. In What Circumstances is Investment in High-Speed Rail Worthwhile? Institute of Transport Studies, University of Leeds, Working Paper 590

Doll, C., Rothengatter W., Schade W., 2015. The Results and Efficiency of Railway Infrastructure Financing within the EU. Study performed for the European Parliament

EC, 1991. Council Directive 91/440/EEC of 29 July 1991 on the development of the Community's railways

EC, 2001. Directive 2001/14/EC of the European Parliament and of the Council of 26 February 2001 on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification

EC, 2004. Council Regulation (EC) No. 549/2004 laying down the framework for the creation of the single European sky (the framework Regulation)

EC, 2013a. Commission Implementing Regulation (EU) No 390/2013 of 3 May 2013 laying down a performance scheme for air navigation services and network functions Text with EEA relevance (https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32013R0390)

EC, 2013b. Commission Implementing Regulation (EU) No 391/2013 of 3 May 2013 laying down a common charging scheme for air navigation services Text with EEA relevance. (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R0391)

EC, 2017, Support study for an ex-post evaluation of the Single European Sky Performance and Charging Schemes, Final Report.

EC, 2018. ATM Information Digest, September 2018 edition.

EC 2019. Do current regulatory frameworks in the EU support innovation and security of supply in electricity and gas infrastructure – final report

EC, 2020. Commission Implementing Regulation (EU) 2020/1627 of 3 November 2020 on exceptional measures for the third reference period (2020-2024) of the single European sky performance and charging scheme due to the COVID-19 pandemic (https://eur-lex.europa.eu/eli/reg_impl/2020/1627/oj visited on 12/01/2023)

EC, 2022. Directive (EU) 2022/362 of the European Parliament and of the Council of 24 February 2022 amending Directives 1999/62/EC, 1999/37/EC and (EU) 2019/520, as regards the charging of vehicles for the use of certain infrastructures (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L0362)

EUROCONTROL 2017. US-Europe continental comparison of ANS cost-efficiency trends

EUROCONTROL 2019. Comparison of air traffic management – related operational performance: US-Europe

EUROCONTROL 2021a. High-level Summary Report on Preliminary ACE 2020 Data.

EUROCONTROL 2021b. Special report on the impact of the Covid-19 pandemic on the US and European ANS systems

EUROCONTROL 2021c, ATM Cost-Effectiveness (ACE) 2019. Benchmarking Report with Special Focus on COVID-19 Impacts in 2020.

EUROCONTROL 2022a. ACE 2020 Benchmarking Report with 2021-2024 outlook.

EUROCONTROL 2022b. Ravenhill P. Time to rethink infrastructure ownership https://www.eurocontrol.int/article/time-rethink-infrastructure-ownership (visited 19/01/2023)

EUROCONTROL 2022c Performance Review Report 2021, June 2022.

European Court of Auditors (ECA), 2019. The EU's regulation for the modernisation of air traffic management has added value -but the funding was largely unnecessary.

EUROSTAT, 2022a. Air transport statistics

Fayard A., Meunier D., Quinet E., 2012 . Motorway Provision and Management in France: Analyses and Policy Issues

Finger, M., Baumgartner, M., Zeki, E., 2017. The Need to Evolve Air Traffic Management: Europe as a Laboratory, Chapter 17 in Air Transport Liberalization a Critical Assessment

Flyvberg B., Holm S., Buhl S.L, 2013. How (In)accurate are Demand Forecasts in Public Works Projects? The Case of Transportation. Working paper.

Flyvberg B., Holm S., Buhl S.L, 2004. What causes Cost Overrun in Transport Infrastructure Projects, *Transport Reviews, Vol. 24, No. 1, 3–18, January 2004*

Genakos, C., Verboven, F., & Valletti, T., 2018. Evaluating market consolidation in mobile communications.

Gugler K. Rammerstorfer, M. Schmitt S., 2013. Ownership unbundling and investment in electricity markets – A cross country study, Energy Economics 40 (2013) 702-713

Henriot A., 2013. Financing Investment in the European electricity transmission network: Consequences on long-term sustainability of the TSO financing structure

Heyndrickx, Ch. & Vanheukelom, T. & Proost, S. (2021). Distributional impact of a regional road pricing scheme in Flanders. Transportation Research Part A: Policy and Practice. 148. 116-139. 10.1016/j.tra.2021.03.014.

ICAO, 2022. Effects of Novel Coronavirus (COVID-19) on Civil Aviation: economic impact analysis, presentation, Montréal, Canada.

IRG-rail, 2020. Review of charging practices for the minimum access package in Europe.

Musgrave, R.A. (1959). The Theory of Public Finance. McGraw Hill, New York.

OECD 2018. Financing water. Investing in sustainable growth. Policy perspectives

OECD 2021. State Support to the Air Transport Sector: Monitoring developments related to the Covid-19 crisis.

PRC (Performance Review Commission), 2021. ANS funding in a post-COVID world. News – February 2021.

PRC (Performance Review Commission), 2022. Performance insight #4, Impact of COVID-19 on en-route unit rates and charged billed to airspace users. May 2022.

Ricardo 2021. Study on the taxation of the air transport sector. Final Report, Report for European Commission (DG TAXUD).

Samuelson, P.A. 1954. The Pure Theory of Public Expenditure. The Review of Economics and Statistics, Vol. 36, No 4. Pp 387-389.

Turnbull P., Thomas H., Harvey G., 2022. Navigating the Covid-19 crisis. Air Traffic Charging Models and Financing of Air Navigation Service Providers

ter Kuile A. 2002,. CANSO - Civil Air Navigation Services Organisation, presentation made in Tegucigalpa, 2002 (https://www.icao.int/SAM/Documents/2002/institu%20aspects/ATK-CANSO.pdf)

UIC (International union of Railways) 2020. Management of COVID-19. First estimation of the global economic impact of Covid-19 on Rail Transport.

UNECE 2017. Innovative ways for Financing Transport Infrastructure

Yang R., Elias B. 2017 The Airport and Airway Trust Fund (AATF): An Overview, Congressional Research Service