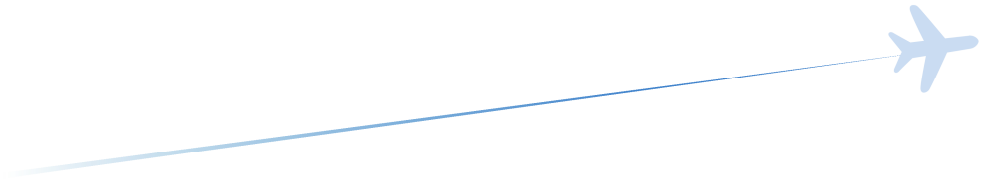

Report on institutional design options

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COMPAIR

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Compair

COMPETITION FOR AIR TRAFFIC MANAGMENT

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Abstract

Within this deliverable we develop a list of concepts on new institutional approaches for air traffic management. This includes a detailed description of their features and a qualitative characterization of the potential effects. This is based on an initial proposal of concepts, which are further fine-tuned based on literature and stakeholder input.

Table of Contents

Executive summary

The provision of air traffic management (ATM) services has for a long time been a national monopoly. In Europe, this has led to a very fragmented market in which each country has, at least, its own civil and military air traffic control provision. In order to prevent excessive pricing, the service charges are regulated – using determined costs as a base. Fragmentation, price regulation and the network character of most ATM technologies has led to problems of coordination, slow changes, inefficiencies and underinvestment.

There are different ways to increase the overall efficiency of ATM. The current approach is more focused on centrally steered regulation. COMPAIR focusses on the introduction of competition as a trigger for change. However, competition does not exist abstractly, but is influenced by the legal and regulatory framework, and can be introduced at various levels and in different ways. At the start of the project we identified some concepts to be further analysed:

- Regulatory approach using yardstick competition.
- Auctioning approach using tenders to licence air navigation services within a certain charging zone.
- Unbundling of central infrastructure management tasks from service provision tasks.
- Sector-less based operations where trajectories are managed as origin-destination.

Performance regulation and yardstick competition

The ownership form of ANSPs varies over countries, from government agencies to government-own corporations to semi-public, semi-private firms (for-profit or not-for-profit). It can be expected that increased involvement of ATM customers in the board of ATM providers should lead to a higher customer focus and more incentives to invest. In this model, there is no real competition in the market. It also does not address the issue of fragmentation. If for profit or governmental entity, some form of economic regulation is probably still needed. This could take the form of a yardstick competition regulatory model. Yardstick competition is a mechanism in which the price of the regulated firm depends on the costs of similar firms.

Unbundling

The unbundling of ATM services should probably start with the separation of terminal air traffic services. This is the activity where most direct benefits can be realised and which is also the easiest to separate. As a second step, a number of en-route air traffic services could also be unbundles. These are mainly ATM support services such as meteorological services, information services and communication, navigation and surveillance services. These services are not necessarily monopolistic in nature and could therefore be supplied by independent service providers. Further outsourcing of ATM activities could involve more specialised ATM activities with closer links to core air traffic control service such as the provision of contingency services.

Tendering of ATC licenses

This concept concerns the tendering of a license to operate core en-route air traffic services, namely the provision of ATC, in a specific geographical area and for a certain time period. The tender process is repeated after each fixed time period. The geographical scope of the tender can correspond to the area of an air traffic control centre or even a national charging zone. However, to mitigate political and national sovereignty tensions, it is probably most realistic to organise the tender at the level of an air traffic control centre (ACC). This time-based tendering process can over time also lead to consolidation among European ANSPs.

Sector-less ATM operations

Sector-less operations is a concept that is currently still in the R&D stage. It envisions en-route ATC without conventional sectors. One controller will be assigned several aircraft regardless of their location and will guide these aircraft during their entire flight in upper airspace. This concept could increase the scope of competition in the ATM sectors, with ATM providers competing on a per-flight basis, rather than per geographical zone. There could be one integrated ATM service provider for the sector-less airspace (assume the whole of Europe), or there could be multiple ATM providers. An airline could then choose one specific air navigation service provider to manage his/her entire network in the sector-less airspace. And there could be various providers for different airlines. At least, ATM provision is no longer tied to specific geographical boundaries, but an airline could choose between various ATM providers or dispatchers for a specific flight.

Time scale

Overall, the time frame for this study will be 2035 to 2050, SESAR's target year to attain the vision of air traffic control indicated by the 2015 Air Traffic Management Masterplan [20]. The institutional options for competition may be more or less appropriate to drive performance at different points in time, and their feasibility also depends on the status of ATM capability development. The institutional options also impose certain requirements in terms of capability development, for their effective implementation. Therefore, we also matched the institutional options for competition with the ATM capability development scenarios (a low development scenario, a baseline scenario (=ATM Master Plan) and a high development scenario). Options 1 and 2 can be assessed even in the low development scenario, while this might be difficult for option 3 and not feasible for option 4. Option 4 can only happen within the high capability scenario.

Qualitative assessment of options

The qualitative assessment of various institutional options is based on literature review, experiences in other sectors (mainly rail, electricity and other utilities), a workshop with the Advisory Board, face-to-face interviews with selected respondents and a survey which was sent out to a broader set of ATM actors.

Overall, we must conclude that we do not expect any dramatic performance impacts of option 1. On the other hand, the implementation of any proposed changes may be immediately feasible at short term and relatively low costs. Hence, it is still an interesting option to further include in our analysis. Option 4, on the other hand, could have strong and positive impacts but still faces significant challenges from a technical and implementation side. For instance, safety concerns are not out of the picture for the moment. Option 2 seems rather promising as it does not face any challenges that are difficult to overcome. Many ATM experts and sector stakeholders also consider this option as the most attractive option for introducing elements of competition in the provision of ATM activities. Moreover, it has been relatively successful in other sectors. For option 3, in contrast, political acceptability and social tensions are probably the main barriers. It is also not clear if within this option ANSPs will have an incentive to behave cooperatively if they need to collaborate in certain areas (increased information sharing) and compete in others (for ATS licenses).

The qualitative assessment focused on the options separately in order to keep the picture clean. This does not mean that combinations are not possible, or even desirable. For example, option 4 will most probably be combined with some form of tendering (option 3). At the same time will the design of tendering be important in determining the benefits of unbundling (option 2).

For the further – quantitative – assessment the four options are retained, given the expected trade-off of potential effectiveness and acceptability. This quantitative assessment is also the place to focus on the possibility of combining some of the options and/or using some of the lessons learned from one option to develop another option.

1 Introduction

1.1 Goal of COMPAIR

Air transport is facing many challenges such as increasing demand, larger airports, increased network congestion, etc. which also need to be reconciled with environmental issues. Hence, there is a need for smarter solutions at service, operational and technical level. One of the important players within aviation is Air Traffic Management (ATM). Since 2004, the European Union gained competences in ATM. The main objective of the EU is to reform the European ATM system in order to cope with sustained air traffic growth under safe, cost-efficient and environmentally friendly conditions. The Single European Sky (SES) initiative aims to re-structure the European airspace as a function of air traffic flows, create additional capacity and increase the overall efficiency of the ATM system. The European Commission has set ambitious goals for the SES in 2012 to be reached by 2020, including a 3-fold increase in airspace capacity and a cost reduction of at least 50% for the provision of ATM services.

Today's progress towards these objectives is perceived as slow: the steps taken towards enhanced collaboration between air navigation service providers (ANSPs) are sometimes considered ineffective; the implementation of functional airspace blocks (FABs) to defragment the European landscape of national ANSPs and enable economies of scale has had limited success [25]; and the Research & Innovation cycle is still too long ([5], [37],[24]).

In this context, the question of how to provide the appropriate organisational structures, institutions and incentives for new operational concepts and technologies to yield the expected results stands high on the policy agenda.

The **introduction of competition** has been proposed as a means to provide incentives for the realisation of the high-level objectives of the SES, through the speed up of the innovation cycle and the fostering of more efficient operations. On the other hand, competition does not prevent all market failures (e.g., negative externalities, congestion) and, depending on market conditions, liberalisation can also have undesired outcomes, such as the emergence of oligopolies or monopolies. The goal of COMPAIR is to study how to introduce competitive incentives in ATM so as to best contribute to achieving the European high-level policy objectives for aviation. The project objectives are:

1. Propose a set of **new institutional market designs** for the introduction of competition in the European ATM sector.
2. Define a framework allowing a **comprehensive assessment** of the impact of different institutional market designs.
3. Develop a variety of **economic and network models** allowing the assessment of the proposed approaches.
4. Assess the **feasibility and acceptability** of the proposed institutional changes for various market actors.
5. Propose a **vision for the implementation** of the most desirable institutional structures.

This deliverable focuses on the first objective: proposing a set of institutional market designs for the introduction of competition in the European ATM sector.

1.2 Scope and objectives of the deliverable

There are different ways to increase the overall efficiency of ATM. The current approach is more focused on centrally steered regulation. COMPAIR focusses on the introduction of competition as a trigger for change. However, competition does not exist abstractly, but is influenced by the legal and regulatory framework, and can be introduced at various levels and in different ways. At the start of the project we identified some concepts to be further analysed:

- Regulatory approach using yardstick competition.
- Auctioning approach using tenders to licence air navigation services within a certain charging zone.
- Unbundling of central infrastructure management tasks from service provision tasks.
- Sector-less based operations where trajectories are managed as origin-destination and time-based Air Traffic Flow Management (ATFM) slots.

The purpose of this document is to fine-tune and critically assess these concepts. The retained concepts will then be thoroughly investigated by means of quantitative analysis, impact assessment and a feasibility study.

1.3 Acronyms

Table 1: Acronyms

Acronym	Definition
AIS/AIM	Aeronautical Information Services/Aeronautical Information Management
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATFCM	Air Traffic Flow and Capacity Management
ATFM	Air Traffic Flow Management

Acronym	Definition
ATS	Air Traffic Services
CNS	Communication, Navigation and Surveillance
EU	European Union
FAB	Functional Airspace Block
ICAO	International Civil Aviation Organization
MET	Meteorological Services
SES	Single European Sky
SESAR	Single European Sky ATM Research Programme
SWIM	System-Wide Information Management
TANS	Terminal Air Navigation Services
TBO	Trajectory Based Operations
TMA	Terminal manoeuvring area (or terminal control area) covering approach control and tower control
TWR	Tower control

1.4 Structure of the document

The document is organised as follows:

- This first Chapter introduces the project, the scope and objectives of the deliverable.
- Chapter 2 discusses the problem definition and how competition could solve (some of) the identified problems.
- Chapter 3 introduces the main concepts for introducing competition and the future institutional scenarios for ATM in Europe.
- Chapter 4 consists of a qualitative assessment of the concepts presented in chapter 3.
- In Chapter 5 we give an overall conclusion on the qualitative evaluation of future institutional scenarios for the ATM sector.

2 Problem definition

Air Traffic Control (ATC) is responsible for coordinating flights, such that air transport is safe, efficient and delays are minimised. An important aspect of ATC draws from the network dimension. Although en-route flights may utilise multiple ATC suppliers, the airspace users require a seamless service. Today, the European ATC system consists of 37 National Supervisory Authorities overseeing the Air Navigation Service Providers (ANSPs) with the associate variance in systems, rules and procedures.

The COMPAIR project starts from the following observations[1]:

- The provision of air traffic management (ATM) services has for a long time been a **national monopoly**. In addition, it has traditionally been seen as a natural monopoly due to the need for large infrastructure investments. The majority of Europe's ANSPs are currently public-sector bodies that are separated from the Government yet remain State property.
- In Europe, this has led to a **very fragmented market** in which each country has, at least[2], its own civil and military air traffic control provision.
- There is a **home-bias** each country shows for its own ANSP. Even though cooperation and mergers between ANSPs can be more cost-efficient, none of the countries would like to see their ANSP disappear. The impacts on revenues, employment and security issues have an important role in this home-bias. Military interests are also important. States lose part of their control over civil/military cooperation and airspace design if the civil ANSP is not in national hands.
- In order to prevent **excessive pricing** (cf. monopoly situation), the service charges need to be regulated. Today the charges are based on determined costs, which is already an improvement of the full cost recovery basis it used to be. However, Adler et al (2015) show that the incentives to invest remain low.
- Most ATM technologies have a **network character**. This means that the technology becomes more effective when a large proportion of users adopt it. This leads to problems of coordination and underinvestment.

This structure has led to several problems such as:

- While recognising that SES can make a real difference by raising capacity, improving safety and cutting costs and minimising the environmental footprint, the expected implementation of the SES framework has been slower than expected [22],[23]. Slow changes are often linked to fragmentation of the industry along national borders. However, accelerated change

[1] Based on assessment made in Delhaye et al (2014) [15]

[2] In, for example, Belgium, the Netherlands, Luxembourg and north-west Germany there is also a separate air navigation services provided for the upper airspace (MUAC).

is not guaranteed even with less fragmentation, as is shown by the slow process in the USA. Slow changes are also linked to the incumbent inertia (i.e., little incentives to innovate) created by the lack of competition.

- Large differences in the costs of the provision of air navigation[3] both in the costs of labour and in the use of capital. These differences cannot only be explained by the type of air traffic control (upper air control, lower air control, oceanic, etc.), or by the size or complexity of the airspace.
- Relatively low degree of equipment standardisation.

The introduction of **competition** has been proposed as a means to provide the right incentives for the realization of the high-level objectives of the SES, through the speed up of the innovation cycle and the fostering of more efficient operations. On the other hand, competition does not prevent every market failure (e.g. negative externalities) and, depending on market conditions, liberalization can also have undesired outcomes, such as the emergence of oligopolies or monopolies. Besides, competition does not exist abstractly, but is influenced by the legal and regulatory framework.

Hence, the successful introduction of competition requires careful consideration and a comprehensive impact analysis to evaluate different regulatory approaches along a variety of dimensions. Not all the regulatory options which we consider will solve all the challenges mentioned above. Some may explicitly be targeted at reducing fragmentation, whereas others rather focus on client-orientation or incentives for cost reduction.

[3] As can be seen in the annual Cost-Effectiveness Benchmarking Reports [41][42][43][44].

3 Competition as a trigger for change

The introduction of competitive incentives may be helpful to increase the customer focus of air navigation service providers. The resulting performance incentives could lead to faster technology adoption and higher innovativeness. In addition, it could lead to consolidation in the sector, moving away from the fragmented nature of the airspace which we know today.

In general, there are two options to determine which person/entity will undertake specific ATM activities in a competitive environment:

- One option is to organise a time-based tender process. The outcome of this process is that the tender contract is awarded to one company for a specific geographical area and a specific time period. This approach is more suitable for activities with stronger network effects and stronger natural monopoly characteristics, as it avoids costly duplication of the service. We will call this competitive approach ***competition for-the-market***. An example of this approach is appointing the network management function which is in the hands of EUROCONTROL but which is in principle open to competition through a public tender process every five years.
- Another option would be to certify a few actors which have the necessary capabilities to provide ATM-related services. These certified actors can then compete for the provision of ATM services towards ANSPs or directly to airlines. ANSPs and airlines are free to choose their providers and could choose one provider for one route and another provider for another. In addition, they could decide to switch providers over time whenever they want. There is thus a higher degree of uncertainty and also a higher degree of flexibility in this system. Also multiple providers exist along each other and maintain competing service system at the same time. In this case, there is ***competition in-the-market***. A simple example is the consumer choice between various bicycle or car brands in their purchase decision.

Overall, the idea is that some competition may give the right incentives to assist the ATM sector in its transformation from national monopoly providers to a modern and integrated European system.

In the current chapter, we address the various institutional (regulatory/policy) options to introduce competitive elements in the ATM sector. These options are based on our initial ideas at the outset of the project proposal, which have been further fine-tuned in a variety of ways: literature review & desk research, a workshop with the Advisory Board Members, face-to-face interviews with selected respondents and a survey which was sent out to a broader set of ATM actors.

In chapter 4, we describe the inputs that we collected from the various input channels. We also explain how these inputs resulted in a qualitative assessment for each of the institutional options. In chapter 5, we describe how each of the institutional options fits into the overall ATM development vision towards 2035 – 2050 described in the SESAR ATM Master plan.

3.1 Option 1 – Performance regulation with variations in ownership and governance models & yardstick competition

Under this approach, performance regulation of national ANSPs remains the cornerstone of the economic and performance incentive tools oriented towards ATM providers. So there is no real competition for ATM services, but performance regulation aims to provide performance incentives **as if there were real competition.**

Regulatory agencies could provide recommendations on the appropriateness of various ownership and governance models. There is a significant variation in ANSP governance approaches and also in consultation processes by ANSPs of ATM stakeholders before making strategic decisions. In some countries, extensive consultation procedures are in place, whereas in others formal processes are currently under development or do not exist. The composition of an ANSP governance board may be designed to reflect the presence of specific skills or different opinions of ATM stakeholders. This variety may give rise to performance differences and the establishment of causal links between governance structures and performance. Still, there may be no one-size-fits-all approach that will work best in all circumstances, but it is more likely that governance approaches should be tailored to specific local characteristics.

In addition, the target setting model in the SES performance regulation is often a national negotiation/regulation approach. An option could be to take a more harmonised European performance benchmarking approach as in the yardstick competition model.

3.1.1 Ownership and governance models

The **ownership form** of ANSPs varies over countries, from government agencies to government-owned corporations to semi-public, semi-private firms (for-profit or not-for-profit) as can be seen in the figure below.

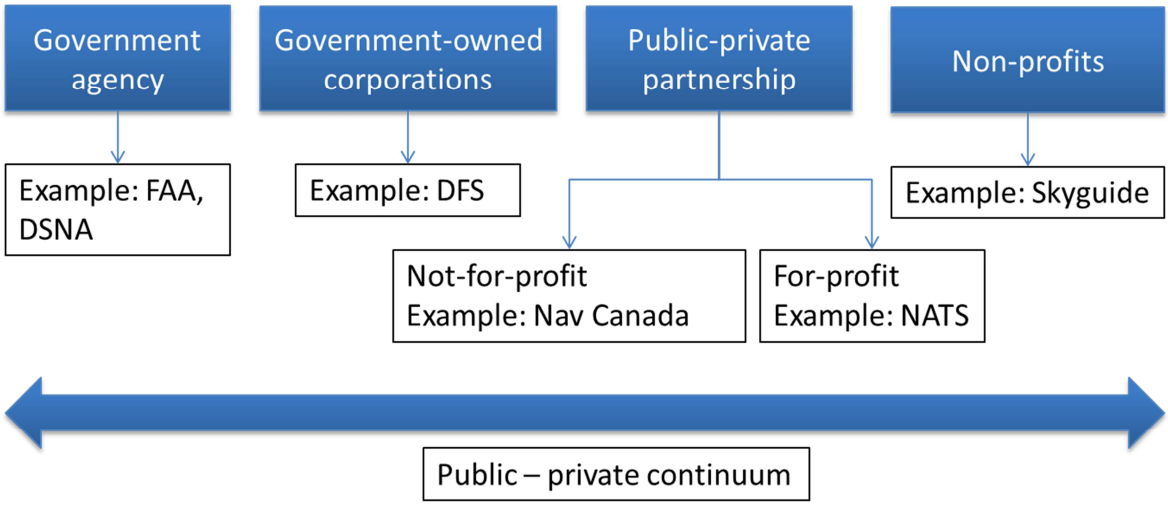

Figure 1: Ownership models

Economic research, as done in ACCHANGE[4], has shown that increased involvement of ATM customers (such as airports and airlines) in the board of ATM providers will probably lead to a higher customer focus. We consider two options to have customers in the board: a "board model" and a "market model". Already in 2002, Eurocontrol [19] stated that airlines are the main stakeholders of the service and the control on investments and costs could be better managed if airlines were associated with the decision making. One option put forward was vertical integration through a user arrangement in which airlines became shareholders of ATS providers (market model). However, this option requires the downstream market to have enough financial strength. At the same time profit margins for airline companies were and are relatively low. Hence the other option would be a quasi-vertical integration (board model) in which airlines do not own the stock of ATS providers, but substantially influence the decision making process (fees, investments).

Both of them are public-private partnerships where the level of integration is larger in the board model than in the market model. In the board model direct stakeholders are represented, while in the market model entities not directly related to ATM such as pension funds can be shareholder.

Board model

In a board model we assume the participation of ATM stakeholders in the governance board:

- This gives a higher customer-focus even in the absence of real competition
- This leads to a reduction in transaction costs through reliance on stakeholders in the board
- NavCanada is an example of an ATM provider that is governed by a user-dominated stakeholder board [35]. The board consists of 15 Directors, 4 elected by commercial carriers, 1 by business and general aviation, 3 by the government, 2 by employee unions, 4 independent Directors elected by the Board and the Chief Executive Officer.

Market model

In a market model we assume - at least partial – privatisation:

- If the stakeholders are also the "owners", customer-focus should increase further.
- This model does call for stronger imposition of economic regulation and performance monitoring as there might be issues of equal treatment if not all customers are represented in the board.
- NATS is an example. Note that NATS also has a pension fund as a shareholder.

3.1.2 Yardstick competition

Given that the ATM sector in Europe is dominantly a national monopoly situation, prices need to be regulated. The Convention on International Civil Aviation (the Chicago Convention) of 1944 already expressed the key principles underlying the imposition of charges for both airport and air navigation services ("airport and similar charges") and introduced the cost-recovery base ("Charges must correspond to costs actually incurred"). This was made explicit in 1958 when ICAO agreed on the principles for charges for air navigation facilities, although no specific method of charging was recommended. This was done in 1973 with the general principle that "providers may require the

[4] http://tmleuven.be/project/acchange/home.htm

users to pay their share of the related costs, including interest, depreciation and administrative costs". Hence, the ICAO principles were, and to a large extent still are, about recovering only the costs, although it was recommended that the recovery of the costs would be progressive. By 1981, 100% of the costs were recovered. In 1983 a change was made from historical costs to the recovery of forecasted costs [26].[5] The first Single European Sky package (SES 1) kept the cost-based charging system and included the possibility of incentive schemes. However, the incentive schemes were optional and there were no binding performance targets, with the exception of the UK. [7] showed that such a cost-plus regulation leads to excessive costs and capital investments and low incentives to collaborate in the European ATC sector. In 1997 a Performance Review System was set up to monitor the evolution of performance in key performance areas, including cost-effectiveness benchmarking and the issuing of – non binding – recommendations. The SES II regulation put an end to the full cost recovery principle and introduced a performance scheme. In this regime, "determined costs" (as opposed to previous full costs) are fixed in advance for each year. Hence it actually introduces a price-cap, including a risk sharing mechanism to cover the cost and traffic risk. [7] showed that a price-cap regulation incentivises cost efficiency but is more appropriate for a profit-maximising ANSP that is more similar to a private form. Moreover, setting the price-cap right would require extensive information and ANSPs could have an incentive to cut back on quality.

As an alternative to the current regulation, one could consider yardstick competition. Yardstick competition also starts from the idea that franchised monopolies have little incentives to reduce costs [47]. Yardstick competition is a mechanism in which the price of the regulated firm depends on the costs of similar firms. It can then be proven that in equilibrium, each firm chooses a socially efficient level of cost reduction. The mechanism generalises to cover heterogeneous firms with observable differences. This could be an approach for increased harmonisation of target setting, whereas today this still remains often a national approach/negotiation process where the targets are based on previous – own – performance.

3.1.3 Relevance for COMPAIR

This option fits within the research question of proposing market designs which introduce competition in European ATM. While it does not directly introduce competition, it does so indirectly via two ways. Firstly, by introducing some form of vertical integration (market based or board based) competition is introduced in the DNA of the ANSPs as shareholders/board members do act in a competitive environment. We will also test whether this is indeed the case. Secondly, performance regulation – which would still be needed- in the form of yardstick competition. The goal of yardstick competition is exactly to provide incentives as if there is real competition.

[5] Note that since the seventies Eurocontrol started to collect the charges for individual Member States. By 2011, the Eurocontrol system served 38 Member States at an administrative costs of 0.3% of the total amount collected.

3.2 Option 2 - Unbundling

The provision of Air Traffic Management can be subdivided in the following components:

1) Network management: currently EUROCONTROL is in charge and is supported by national ANSPs
2) En-route air traffic service (ATS) provision
3) Terminal air traffic service (ATS) provision (incl. approach and tower control)

Most ANSPs in Europe are active in all three domains. They provide services towards EUROCONTROL for effective air traffic flow and capacity management (ATFCM) to enable proper network planning and operations. They further have activities for en-route ATS; and for terminal ATS.

The unbundling of ATM services should probably start with the separation of terminal air traffic services. This is the activity where most direct benefits can be realised and which also is the **easiest to separate**. Unbundling of terminal ATS happens already today at a number of airports in UK, Spain and Germany who have appointed their local tower ATC provider through a public tender process. The evidence on the effect of these market tenders is limited up to now, but it seems that the experience has overall been positive[6]. The approach for unbundling terminal ATS provision would thus be competition for-the-market.

As a second step, a number of en-route air traffic services could also be unbundled. These are mainly ATM **support** services, not the core ATC activities. These services are **not necessarily monopolistic**[7] in nature and could therefore be supplied by independent service providers. These providers can sell their services to ANSPs. Unbundling of these support activities could lead to a competition in-the-market for service provision. There are **no major network effects**[8] or natural monopoly characteristics involved in the supply of these support services, so various service providers could directly compete on a continuous basis. Support services that are typically cited [21] as candidates for unbundling are:

- Meteorological services (MET)
- Aeronautical information services/management (AIS/AIM)
- Communication, navigation and surveillance services (CNS) – this is mainly an infrastructure maintenance and management function

Further outsourcing of ATM activities could involve more specialised ATM activities with closer links to core air traffic control service:

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[6] For more details we refer to section 4.1.2

[7] One justification for a monopoly provision is that there are large fixed costs, or increasing returns in general which makes additional entry socially undesirable [6]. Hence it is not socially efficient to unbundle services which have natural monopolistic characteristics.

[8] A product is said to exhibit network effects if each user's utility is increasing in the number of other users of that product. When there are network effects, in the long run, we can expect that one product will dominate. This dominant good cannot be predicted beforehand and might not be the best available option [6]. This makes that goods with network effects are difficult to unbundle.

- Airspace organization and airspace management
- Demand and capacity balancing
- Provision of contingency services

Instead of each ANSP investing in its own redundancy systems, significant cost savings can be realised if the ANSP could rely on back-up systems of other ANSPs (within a FAB or unrelated to it). The collaboration can be effectively implemented through appropriate use of information sharing and virtualisation technologies, allowing the other ANSPs to manage airspace from a remote location (virtual centre). This type of unbundling could not only lead to cost savings, but in addition also boost information sharing between ANSPs and the use of interoperable systems.

The network management function should remain centralised and managed by EUROCONTROL, or possibly another entity which is qualified to perform network management functions. The strong network effects linked to this activity would make duplication very costly. The network management function is in principle already open to competition. The function is appointed following a public tender process every 5 years (competition for-the-market). But in practice there has not been an alternative competitor, next to EUROCONTROL, due to the highly specialised nature of the activity. This makes that the performance of network management is relatively well shielded from competitive forces today.

3.3 Option 3 – Tender of licenses for en-route air traffic services

Option 3 concerns the tendering of a license to operate core en-route air traffic services, namely the provision of air traffic control, in a specific geographical area and for a certain time period. The tender process is repeated after each fixed time period, which could lead to contract renewal for the incumbent provider or to a new provider supplying the market. The form of competition under this institutional option is thus that ANSPs compete **for-the-market**, i.e. they compete for the right to provide ATM services in a certain geographical area for a certain time period.

The geographical scope of the tender can correspond to the area of an air traffic control centre or even a national charging zone. However, to mitigate political and national sovereignty tensions, it is probably most realistic to organise the tender at the level of an air traffic control centre (ACC). This time-based tendering process can over time also lead to consolidation among European ANSPs. Certain ATS providers will be successful and be able to further improve their service provision thanks to learning effects. They may take over other providers which are less successful, thereby reducing fragmentation and enabling economies of scale through a market driven process.

To be more concrete, the bidding procedure could take the form of ANSPs being invited to submit a certain unit rate per service unit that will be applicable in that area. The submissions could also include a unit rate profile with a specified evolution over time, for instance linked to a certain cost indicator. Bids submission could be one-off, as in a highest-price, sealed-bid auction, or iterative, as in an ascending price auction. The winning bidder would be the one that has submitted the lowest

unit rate (profile[9]) over the contract period. His income could consist in a share that is independent of air traffic (= submitted unit rate x forecasted amount of service units) and a share that varies with air traffic (= submitted unit rate x actual amount of service units). This would be in line with the principle of 'traffic risk' as included in the SES performance regulation.

Contract conditions should also include performance incentives with respect to capacity, environment/flight-efficiency and safety to ensure that selected ATM operators are responsive to various performance dimensions. This could be implemented by making part of the contract payment conditional on meeting required performance in terms of capacity, flight-efficiency and safety. Contractual performance indicators could be very similar to the SES performance regulation framework. Only the enforcement of the performance targets would be more automatic as contractual payments would be immediately tied to achieved performance. In addition, at the phase of contract renewal, one has an additional option for performance evaluation and for selecting another provider if performance is deemed insufficient.

The service activity that is tendered is a day-to-day activity with rather short-term orientation. Organising a competition for-the-market tender process may even increase the short-term tendency, since ANSPs will be under pressure to cut back on costs which are not essential for core service provision. On the other hand, activities linked to ATM capability development[10] require a much more long-term focus and an integrated view on developments at European network level. So the effective implementation of the ATC tendering probably requires the separation of (en-route) air traffic service provision from long-term ATM capability development[11].

To overcome the possible investment issues, we could think of a situation in which the individual countries (through their NSA) purchase the technology and then tender out ATC daily provision. This would separate the long term investment issue from the short term tactical questions. This is the equivalent to privatising railway provision but keeping the infrastructure provider public.

3.4 Option 4 – Flight centric, sector-less operations

Sector-less operations is a concept that is currently still in the R&D stage[12]. It envisions en-route ATC without conventional sectors. One controller will be assigned several aircraft regardless of their location and will guide these aircraft during their entire flight in upper airspace. This operational concept should lead to a number of performance benefits such as: more efficient use of air traffic controllers (ATCO) resources, more even workload, no handover points between sectors so less coordination needed, single contact point for pilots during entire flight, etc.

Sector-less operations in itself is not an "institutional design option", but it will have institutional consequences. It can also increase the scope of competition in the ATM sectors, with ATM providers competing on a per-flight basis, rather than per geographical zone. There could be one integrated

[9] The rate offered should not necessarily be flat, but can include some form of congestion charging.

10 These are activities such as implementation of improved data management capabilities, to enable increased information sharing (such as SWIM), to enable virtual collaboration and implementation of virtualization technologies, etc.

[11] Similar to the provision of centralised services.

[12] See, for instance [16]

ATM service provider for the sector-less airspace (assume the whole of Europe), or there could be multiple ATM providers. An airline could then choose one specific air navigation service provider to manage his/her entire network in the sector-less airspace. And there could be various providers for different airlines. At least, ATM provision is no longer tied to specific geographical boundaries, but an airline could choose between various ATM providers or dispatchers[13] for a specific flight. For COMPAIR, these potential changes in institutional design are of interest.

A first step towards a possibly sector-less future ATM environment is the concept of trajectory-based operations and flight centric operations, as put forward in the SESAR ATM Master Plan (2015)[20]. This means that business trajectories are managed end-to-end and that the ATM system relies on extensive information sharing between ANSPs, increased automation and reliance on increasingly interoperable systems. The necessary technical requirements to shift to this operational paradigm of trajectory-based operations are already available. This could then further transition into a world of sector-less operations at European scale. Implementation of such a system can be gradual; it can start at regional level, for some parts of the airspace only, or at some moments in time only. Decoupling of system infrastructure and operations allows ANSPs irrespective of national borders to plug in services where needed.

However, a need for coordination may still arise in the target concept of flight centric and sector less ATM. Controllers of different flights may need to interact for separation management and for dealing with potential conflicts. The necessary coordination can be facilitated then by the automated application of flight prioritisation rules in the ATCO human-machine interface. But there is obviously a need for common information management, and consistency in the application of prioritization rules. The extensive need for information sharing raises the question of the extent to which competition between ATM providers can be an effective incentive for increased performance, if those providers at the same time still need to coordinate extensively among each other. After all, in a competitive market environment market actors are typically more reluctant to share their knowledge and data with others as it may put them in a competitive disadvantage.

In addition, the network manager will become increasingly involved in real-time ATC operations thereby blurring the boundaries between various activities (and further reducing the scope for competition). On the other hand, flight centric operations concept also reduces the national barriers (national monopolies) towards integration. So it is for the moment an open question to which extent this SESAR target operational concept may change the scope for the introduction of competitive incentives between ANSPs.

3.5 Summary of concepts

In

[13] Given the increased reliance on automatization procedures necessary, the role of ATCOs would become more like flight dispatchers.

Table 2, we show the institutional design concepts for introducing competitive elements in the ATM sector. For each of these concepts we indicate who is responsible for air traffic safety, the provision of ATM services towards airlines, the ownership of the property rights for ATM services and the forms of competition possible. The list consists of four concepts, of which three can be classified as 'modest approaches' which could be implemented at a relatively short time frame. In these cases, the airspace management remains a national competence and so the institutional approach does not require a very large departure from the current situation. The fourth approach could involve the transfer of airspace management responsibility and of the property rights to deliver ATM services from a national to a European level. This can be considered as a radical departure from current practice. Feasibility for actual implementation of this concept at European scale is probably not to be expected before 2035, but rather 2050.

Table 2: Overview of possible institutional market designs proposed for increasing competitive dynamics

	Responsibility for air traffic safety	Provision of ATM services towards airlines	Property rights for ATM services	Form of competition (focus COMPAIR)	Timeframe
1 Yardstick competition	National	Several providers, one for each charging zone	National – ANSPs	Regulatory, based on benchmarking of performance	Short term
2 Unbundling	National	Several providers, one for each charging zone	National	Competition in the market possible	Mid term
3 Tendering	National	Several providers, one for each charging zone	National – government bodies	Competition for the market	Mid term
4 Sector less operations	National/ EU	Single ATM provider for a single trajectory	Transferred to EU level	Competition in the market	Long term

In chapter 5, we further address how the competition options fit into an overall development scenario for ATM in Europe. In the next chapter 4, we discuss qualitative elements to evaluate the advantages and disadvantages of various options.

4 Qualitative assessment

In this chapter we provide a qualitative discussion assessing the potential benefits and drawbacks of the institutional approaches. The information of this chapter is based on

- Literature review
- Experiences in other sectors with the concepts defined
- Feedback of stakeholders on the initial concepts (via the Advisory Board, interviews and surveys)

In sections 4.1, 0 and 4.3, we address each of these input sources. In section 0, we provide an overview of qualitative assessment per institutional option described in chapter 3.

4.1 Literature review

In this literature review we discuss the relevant literature for the four concepts – both theoretical as well as literature linked to air navigation services.

4.1.1 Ownership models and yardstick competition

Ownership

The **ownership form** of ANSPs varies over countries, from government agencies to government-owned corporations to semi-public, semi-private firms (for-profit or not-for-profit). [17] provides a general overview of selected global corporate ANSPs.

Table 3: Organisational form selected Air Navigation Service Providers.

Country	ANSP	Towers	Centers	Employees	Organization
Australia	Airservices Australia	29	2	4,204	Gov't-owned corporation
Belgium	Belgocontrol	5	1	919	Public company
Canada	NAV CANADA	42	7	4,832	Private company
Finland	Finavia Corporation	25	1	1,612	Gov't-owned public limited corporation
France	DSNA France	86	5	7,846	State agency
Germany	DFS Deutsche Flugsicherung GmbH	16	4	5,938	Gov't-owned company
Greece	Hellenic Civil Aviation Authority	18	2	680	Civil service agency
Ireland	Irish Aviation Authority	3	2	642	Commercial state-sponsored body
Italy	ENAV, S.p.A.	40	4	3,276	Joint-stock company
Mexico	SENEAM	58	4	2,254	Gov't agency
New Zealand	Airways New Zealand	29	1	761	Gov't-owned corporation
Poland	Polish Air Navigation Services Agency (PANSA)	13	1	1,771	"Certified legal entity"
Portugal	NAV Portugal	10	2	993	Gov't-owned company
Romania	Romanian Air Traffic Services Administration (ROMATSA)	16	1	1,516	Self-financed government administration
Russia	State ATM Corporation	250	57	9,500	Gov't-owned corporation
Slovenia	Slovenia Control, Slovenian Air Navigation Services, Ltd.	4	1	215	Independent gov't-owned company
South Africa	Air Traffic & Navigation Services (ATNS)	23	2	1,050	Gov't-owned corporation
Spain	AENA	22	5	4,249	Publicly owned company
Switzerland	skyguide	14	2	1,330	Nonprofit joint-stock company
Turkey	State Airports Authority & ANSP (DHMI)	36	2	4,822	Gov't-owned enterprise
United Kingdom	NATS UK	16	2	4,440	Public-private partnership
United States	Federal Aviation Administration (Air Traffic Organization)	512	21	34,911	Federal agency (separate organization)

Source: Civil Air Navigation Services Organization, *CANSO Members*, available at http://www.canso.org/canso-members.

Source: Elias (2015)[17]

He concludes that there is no conclusive evidence that any of these models is either superior or inferior to others with respect to productivity, cost-effectiveness, service quality, safety and security. He did see improvements in cost-effectiveness and performance and a faster implementation of technologies as a result of access to financial markets.

On the other hand, it can be expected that increased involvement of ATM customers (such as airports and airlines) in the board of ATM providers should lead to a higher customer focus. NavCanada is an example of an ATM provider that is governed by a user-dominated stakeholder board[14]. [46] stresses the point that management by a stakeholder board gives NavCanada efficiency incentives even in the absence of market competition. She makes a distinction between three ownership and governance forms for air navigation service providers: a government corporation such as Germany's DFS, a for-profit corporation subject to rate-of-return regulation and a non-profit corporation that is governed by a user-dominated stakeholder board, such as NavCanada. She argues that the user cooperative approach, such as the NavCanada case, has shown to be superior, in theory and in practice. A stakeholder board that is dominated by users creates an incentive for efficient performance in the absence of competition. It also eliminates the incentive for monopoly abuse. NavCanada's 19-year track record is a practical proof that the approach works as intended. User charges are a third less in real terms than the ticket tax they replaced in 1998. The system is handling 50% more traffic with 30% fewer people. And it has fully modernised its equipment with half the prior level of capital expenditure, by bringing software development in-house and relying on commercial off the shelf hardware. So, of the 60 air traffic control systems around the world that have been spun off as autonomous, business-like entities, this one is measurably outperforming the others. One would be tempted to state that the reason is that NavCanada's basic organizational design enables efficiency incentives. This was also echoed in the [2] which further corroborates the point that the NavCanada governance and ownership model has had a significant and positive track record. However, within the same article, DELTA stated that "corporatisation would disrupt the implementation of NextGen". At the same time DELTA is not convinced that it would reduce costs for the travellers[15].

[27] make a comparative analysis between four ownership models: the procedural model (USA FAA), the corporate model (Airservices Australia), the market model (NATS UK) and the board model (NavCanada). All models have different processes and requirements with respect to organisational and managerial autonomy, board composition, stakeholder inclusion, financial controls and regulatory oversight. There is no 'one size fits all' approach. The UK market model entails the need for stronger imposition of economic regulation ex-ante to monitor the organisation's performance and contractual conditions. The Canadian model mitigates transaction cost in comparison to other models through reliance on the stakeholders in the board to take care of themselves.

The comparative overview of ownership models provided by [10] shows that there is no evidence of safety standards being affected by commercialization, as long as appropriate structures for ensuring safety are kept in place. Commercialization allows for increased flexibility as new sources of funding (next to government budgets) become available. But efficient allocation requires that commercial risks are built into the system. So there is no evidence that commercialization in itself has led to any deterioration and in some respects we have seen clear improvements in the overall portfolio of services that are provided. So commercialization provides flexibility. The challenge is then to find a

[14] http://www.navcanada.ca/EN/about-us/Pages/governance.aspx
[15] Quoted in [40]

regulatory regime to limit excess monopoly power that may be associated with ANSP activities without stymieing incentive and innovation.

[33] identify the role of the stakeholder board as a proxy for market relationships with consumers. They extend categories of public and private organizations into an integral measure of an organization's privateness. So privateness is seen as directly related to ANSPs ability to respond to user needs.

One of the UK government objectives for NATS public private partnership was to 'ensure the strategic partners take responsibility for managing strategy, investment programme and new business developments"[12]. Eurocontrol (2002) [19]stated that the airlines do not have enough financial resources to make the market model work. With respect to the board model [19] stated that this would also not lead to major changes as airlines would mainly monitor investments in order for it to be at the pace of the growth of demand, reduce delays and keep costs as low as possible. ATM is not their core competence and given the low profitability the interest would be low. An upstream vertical integration, on the other hand, with intensified relationships between ATS providers and equipment manufacturers could lead to higher investment rates. Note that Lockheed-Martin also made a bid for NATS, but it was an airline alliance which won.

One danger of this type of vertical integration is the risk of collusions. [12] stated that, for example in the case of NATS, this risk would not materialise as the members of the airline group are also competitors and hence the scope for joint ventures (e.g. for increasing the costs for the airlines outside the group) is limited.

In this model, there is no real competition in the market. It also does not address the issue of fragmentation. But its desired effect, the customer-orientation, is built in through the composition of the board. If for profit or governmental entity, some form of economic regulation is probably still needed[16]. This could take the form of a **yardstick competition regulatory model**.

Yardstick competition

Yardstick competition starts from the idea that franchised monopolies have little incentives to reduce costs [47]. Yardstick competition is a mechanism in which the price of the regulated firm depends on the costs of comparable firms. This form of regulation implies that the regulator is "placing similar firms in competition with each other with respect to their cost levels"[4]. It can then be shown that in equilibrium, each firm chooses a socially efficient level of cost reduction. The mechanism generalises to cover heterogeneous firms with observable differences. However, problems exist due to the potential for manipulative collusion by the ATC providers to raise average prices, as described by [47]. In addition, transparency is important in order to calculate the average price accordingly [50]. Due to the current charging regime undertaken by EUROCONTROL, the current cost and pricing mechanism is relatively transparent to all actors.

An important question is how this would generalise to ANSPs with possible non-observable differences. Several attempts have been taken at understanding causes of ANSP efficiency differences using econometric techniques, but results have been inconclusive up to now. Also important is the question of how far the current and future SES performance regulation can be seen

[16] Not in the case of not-for-profit

as yardstick competition. Finally, an open issue in this form is the question of how to effectively enforce the economic regulation.

4.1.2 Bidding processes

[31] explains the features of bidding markets, to be found in auctions and bidding processes. He addresses why these features are often perceived as leading automatically to efficient outcomes and needing no antitrust or regulatory intervention. Then, he explains how most of the bidding market characteristics are usually not fulfilled and often even mutually inconsistent. Therefore there is a clear need for regulatory/antitrust monitoring of bidding processes to ensure that their outcomes are efficiency enhancing.

Klemperer argues that the (ideal) bidding markets contain the following elements:

1. "Winner takes all" kind of awarding contracts to bidders
2. Competition is "lumpy", meaning that each contest is important for a supplier's workload
3. Competition begins afresh for each contract
4. Entry of new suppliers into the market is easy
5. Some kind of bidding process is used to award the contract

Features 1 - 4 describe structural characteristics of the market and feature 5 describes the price-formation process. Any bidding process involving feature 5 is often implicitly assumed to fulfil features 1 - 4 as well. However, in practice features 1 – 4 are often mutually inconsistent. For instance, when the winner of a bid wins the entire contract value (feature 1) and this is indeed an important share of bidders' activities (feature 2), economies of scale often give this bidder an advantage to also win other bids (violating feature 3) and entering this market becomes more difficult due to economies of scale and learning (violating feature 4). Klemperer concludes that whereas bidding processes are often perceived in practice to automatically lead to efficient outcomes, this is not the case. Therefore he recommends regulators and antitrust authorities to monitor bidding processes just as other market activities for market concentration, potential for colluding behaviour, predatory behaviour, etc.

[30] addresses the auction "Revenue Equivalence Theorem (RET)" which states that all the standard auction mechanisms are equally profitable for the seller and that buyers are therefore also indifferent among them. This theorem holds under a set of reasonable-sounding conditions, which are however often violated in practice. In particular, the assumption that bidders have independent private information about the value of the good being auctioned seems unrealistic. When this assumption is relaxed, the simple ascending auction[17] becomes the most efficient auctioning

[17] In an ascending auction, price and allocation are determined in open competition among bidders. The bidders willing to pay the most win and pay prices that no other bidders are willing to top. A simple ascending auction may stimulate competition by creating a reliable process of price discovery, by reducing the winner's curse and by allowing efficient aggregations of items. However, the information may also be used by the bidders to establish and enforce collusive outcomes. [13]

procedure. The quantitative importance of this effect, however, turns out to be relatively small, as demonstrated by numerical simulations.

In practice, other potential pitfalls are often more important. What really matters in auction design is robustness against collusion and attractiveness to entry, just as in ordinary industrial markets. Ascending auctions may be more efficient but are more vulnerable to strategic colluding behaviour by auction participants [29]. The reason for this is that bidders may use the repeated interaction to signal information to each other strategically. In addition, ascending price auctions often also lead to increased entry barriers for potential new entrants. The winner's curse makes relatively small, "weaker" entrants particularly hesitant to enter an ascending auction. If they would outbid stronger actors, they are almost certain that they have overvalued the uncertain common value of the good.

Standard first-price, sealed-bid auctions in principle give less rise to collusion and low entry. Due to the one-off nature of the award procedure, with no possibility to change bids subsequently, even weaker players have a possibility to win the contract and are therefore more inclined to take a chance. Incentives may change again in case of repeated first-price, sealed-bid auctions, as actors are allowed to learn from previous procedures. There are a number of ways to deal with these issues, and to reduce possibilities for gaming within auction contexts. Examples of these are the obligation to bid round numbers, the prescription of increments for subsequent higher bids and the anonymization of bids received. The Anglo-Dutch auction[18] is a hybrid auction type incorporating elements of ascending-price and sealed-bid auctions that should allow capturing benefits of both approaches.

On the other hand, it is also important to understand the political situation, the political perception and the wider sector context of the auction taking place. No single auction design that was successful in a certain context can simply be transposed to another context. Sequence of auctioning processes may for instance be important, as bidders can learn from previous procedures. In the case of radio spectrum auctioning, the number of bidders reduced over time, as bidders learned that large players were better positioned to win the contracts, and were therefore no longer willing to invest. Therefore, the recommendation of [30] is to start from economic theory on auction, but to invest significant time and effort in understanding the political, regulatory and economic sector context. This is necessary to design a successful auctioning approach.

Within ATC there are two examples of bidding processes: the bidding for centralised services and the bidding for tower control in the UK.

Centralised services

EUROCONTROL has developed the concept of centralised support services in 2012. These are services with strong network character/economies of scale and hence benefit from being exercised at a central European/network level. Nine centralised services were identified and broken down in 18 contracts. Some of these services may and are currently tendered to the market through a public tender process. The tenders included safeguards and contractual provisions to have a good

[18] An Anglo-Dutch auction is a two-stage auction, which begins with an "English" phase during which the price is increased until all but a predetermined number of bidders drop out. At this moment (and price), the auction switches to a second "Dutch" phase. In this stage, only the remaining bidders can submit (simultaneous, sealed) bids and only bids above the price at which the English phase stopped are allowed. The Anglo-Dutch auction fosters entry and increases the revenues of the seller. [3]

representation of ANSPs (EU and non-EU) in the consortium. This concept might pave the way towards opening up the European ATM market. Eurocontrol estimated that the centralised services could lead to savings of 200 million euro/year. This could build up to 1.5 to 2 billion by 2030. As the process has just started, no results are available.

Tower control

Tower control is a monopolistic activity considering the fact that one tower controls the traffic around one airport. However, over the past years, a number of airports in Spain, UK, Germany, have appointed the management of their tower control and terminal activities through a public tender process, or have in-sourced them to self-supply (cf. above). Evaluating this process, airports have cited the following benefits for them:

- Realization of cost savings
- Increase in the strategic focus of ATM operations

In the UK three public tendering of tower control took place19. All tenders were conducted on the basis of three lots. These were for the air traffic service, the engineering support services and one for a combination of both services.

- Luton: In 2011, London Luton Airport Operations Ltd conducted the first public tender process for terminal air navigation services (TANS). They received two compliant bids. The contract was awarded to the incumbent, NSL. There was little competition from other providers, but the airport operator still got a relatively good deal. By tendering the airport operator obtained transparency surrounding the cost base, a more productive relationship with the supplier and a clear set of responsibilities in the contract.
- Birmingham: In 2012 Birmingham Airport Limited launched an open tender, which resulted in a move to self-supply. The tender process did not offer many alternatives for Birmingham airport, so it was not perceived as successful in itself. They received one bid. Still, the insourcing of the tower control allowed the airport to realise costs savings. Birmingham did believe that if they had been in a position to delay its tender by a year, there may have been more interest from other European providers.
- Gatwick: full tender which received 2/3 credible bids. DFS won. Gatwick stated that they realised cost savings, but public figures are not available. DFS considers that transition and set up costs, such as safety regulation certification and designation, remain the biggest barrier. They argue that these costs disadvantage new entrants, making scale of entry important.

Other airports used this experience to (credibly) threaten to take service in-house as part of the negotiations with NATS and hence indirectly benefit from the possibility to tender. At the same time a number of contracts (four) did not go to the market and were directly renegotiated with the current supplier.

[19] Based on interview with the UK- CAA and [11]

Contract durations for existing contracts are much longer (10 years – including extensions in Heathrow, Manchester, Stansted, Glasgow to 15 years in London City) than the contracts which were tendered (Luton: 3+2 yr. extension, Gatwick: 5+2+0.5 yr. extension). The CAA did not see any concerns with contracts around 5 to 7 years as there is a need for contracts to recover bid costs and to be sufficiently long to provide a return to the ANSPs, especially where investment is needed. The length transition process (and associated costs) is also seen as a factor pointing to relatively long contracts. They do however have some concerns with the renegotiated contracts with the incumbent lasting 10 years. With respect to the assets and possible problems related to transfer of equipment, the CAA encourages airports to take over the assets for local ATC. This ensures long-term continuity with airport investments. The ANSPs can advise on the equipment, but in the end only bring in the management and the ATCOs.

4.1.3 Unbundling

The idea would be to unbundle support ATM activities from core ATM services with a strong network component. As said, there are different, not- exclusive, options to unbundle. There is the option to centralise support services to reduce fragmentation and enable economies of scale. Over time the right to provide these services could be awarded by public tender (similar to option 2). This means that at a certain point of time, there is only one provider (or provider group) of the specific service for a specific period. This is the example of the Centralised Services. It is also the option to certify support service providers and to let the market determine who should provide them. In this option different providers exist next to each other, offering their services for relatively shorter time periods.

In the field of simulation and training, some form of unbundling and competition is already present. Another example, within Aeronautical Information, is Jeppesen, SITA and ARINC who are providing consolidated information for airliner and airspace users.

[5] also see unbundling of ATM support services as a potential approach to move out of the SES gridlock. They see the centralization of these services at a higher level (for instance Eurocontrol) as a desirable step. However, there is a risk that an even larger operational monopoly is being created which is not in line with the EU liberalisation agenda. Another approach would therefore be to unbundle the services, open their provision for competition and let the market determine who provides them. [5] also mention the creation of intermediary and shared data exchange platforms as a way to reduce infrastructure costs and create a SES at the data-management level.

Unbundling has taken place in similar industries such as rail and energy. These experiences are discussed further on in this chapter.

4.1.4 Flight centric, sector-less operations

The paper by [18]describes the automated airspace concept for air traffic control, which is one of the building blocks for shifting towards trajectory-based operations. The concept enables significant increases in both terminal area and en-route capacity, while at the same time enhancing safety and flight-efficiency. The key to this concept is automated separation assurance, to relieve controller workload associated with tactical separation monitoring. This will allow them to shift attention to more strategic control of traffic flow, handling of exceptional traffic situations, reroutes due to weather as well as manual separation monitoring and control of unequipped aircraft. The automation of separation assurance removes several operational constraints that limit the capacity

and efficiency of today's system. With the reduction of controller workload achieved in this environment, controllers can accept more aircraft in their airspace, along more flexible flight trajectories. The relevant ATM capacity constraint then becomes the physical availability of airspace, rather than the availability of human controllers.

The automated airspace concept requires new components on the ground and in the cockpit as well as a reliable two-way data link for exchanging information between ground and airborne systems. Primary ground-based component is an automated airspace computer system (AACS) that generates efficient and conflict free traffic control advisories, and associated trajectories. The most important technical and operational challenge in designing this system is providing a safety net to ensure the safety of operations in the event of failures of primary system components such as computers, software and data link systems. This includes defining procedures for reverting to safe, though less efficient, back-up systems. The controller will play an indispensable role in this, by assuming separation assurance responsibility. A Tactical Separation Assisted Flight Environment (TSAFE) is a new ground-based system that may assist for protection against near term loss of separation in case of failure of the AACS.

The flight prioritization deep dive report[20] analyses various options on Flight Prioritization (FP) rules in a trajectory-based operations paradigm for the USA. Under this paradigm, more capable communications, and net-enabled system-wide information sharing will provide the capability for flights operating in congested environments to be prioritised in ways that increase overall capacity and efficiency in the system, while at the same time providing more predictability, flexibility, and collaboration for operators. Flight prioritization rules should be developed in a thoughtful way and converted into algorithms, to be used in the automation platforms. Parameters must be derived both for traffic flow and trajectory management. The FP rules are based on projections and are, therefore, operating in advance of physical loss of separation. It is only when a loss of separation is imminent that safety rules are invoked and take precedence.

The authors propose a set of options of flight prioritization, with some options being more of operational nature and other options being more market-based and oriented towards eliciting economic valuations:

- first-projected first-served (FPFS)
- priority-by-schedule (PBS)
- first-filed first-served (FFFS)
- transitional preference (TP)
- best-performing best-served[21] (BPBS)
- market-based prioritization mechanisms

[20] [14]
[21] Similar to the best-equipped, best-served principle.

- priority points
- minimization of airspace delays
- delay credit prioritization
- prioritisation based on societal values.

The study selects the following options as the most promising flight prioritization rules:

- Best-performing best-served
- Priority points
- Priority-by-schedule
- Market-based prioritization

These principles should not be seen as individual options but may be complementary in a variety of combinations, possibly involving even other FP rules. FPFS is one such concept that may be integrated in a solution that functions across the US airspace.

4.2 Experiences in other sectors

4.2.1 Ownership –public private partnerships

The potential of public-private partnerships is seen as large if the accounting and decision making is shared and if plans are coordinated and integrated

4.2.2 Yardstick competition - utilities

Yardstick competition has been applied in the regulation of various utilities (hospitals, water utilities, Norwegian busses, etc.). [8] discuss these examples in more detail. They show that yardstick competition is very flexible, in the sense that it can be used in multiple cases, given various constraints and objectives. They conclude that yardstick competition is particularly interesting for some kind of transport service regulation. [34] analyse the effectiveness of yardstick regulation on the Japanese rail industry and find that it led to a decrease in variable costs of the rail transport provider, with an overall cost reduction of 11.5% over the period 1995-2000. [45] evaluated yardstick regulation for European airports. The paper focusses on the difficulties arising from airport benchmarking as well as on the possible benefits. While not implemented in practice, there are examples in the European airport industry where yardstick competition was used as an input. The authors give the example of the Dublin Airport Authority plc where a form of yardstick competition was used to determine the prices that the airport could charge. It was not implemented as the airport never agreed to a list of potential comparators[22]. In the UK, the Civil Aviation Authority also considered a form of benchmarking analysis, but this was not used in the end within the regulatory framework.

[22] Based on personal communication with Dr. Cathal Guiomard.

4.2.3 Unbundling

This is something that happened within the electricity sector and rail which moved from one vertically integrated monopoly to a system with one "infrastructure manager" and several service providers. These sectors have similar characteristics as the ATM industry in the sense that their activities often require large investments and therefore naturally give rise to the emergence of a natural monopoly. In addition, they are also going through a structural market reform process from national provision by national (monopoly) firms towards a more integrated European market. Studying reform process in these sectors may therefore provide interesting ideas/approach for approach in ATM.

The experience of electricity liberalisation in Britain has been well documented. [39] states that the British reform demonstrated the importance of ownership unbundling and a workable competition in generation in supply. The standard model of electricity supply in almost every country before liberalisation was an effectively vertically integrated franchise monopoly under either public ownership or cost-of-service regulation. Before the reform of the electricity supply industry (ESI), pricing may have been sophisticated, investment planning, and in particular investment delivery was poor, slow and costly, and there were few incentives to deliver cost efficiency. Liberalisation and restructuring was intended to replace the existing command and control structure with its regulated charges by a decentralised market-driven system that would nevertheless deliver secure, reliable electricity efficiently and at competitive prices. He concludes that, in the UK, privatisation of electricity in 1990, combined with unbundling and a transparent wholesale market provided incentives for considerable efficiency improvements. Labour productivity doubled, real fuel costs per unit generated fell dramatically[23], and substantial new investment occurred ate considerably lower unit costs than before the privatisation. However, the concentrated market structure also enabled incumbents to retain those cost reductions initially. Hence, initially the prices did not drop. This was due to the fact that only two generators were created, which could have been avoided by creating five generators [37]. Moreover, unbundling and liberalisation does increase the risk for generators and encourages them to seek vertical integration with suppliers. This offers the opportunity for the regulator to trade horizontal for vertical integration and to reduce concentration – but at the costs of increased entry barriers. [39] argues that it would have been a better alternative to start from a more fragmented structure. In Scotland, where a different system was set up, negligible efficiency improvements were found. One reason was for this difference was that the two Scottish companies were not restructured and remained vertically integrated, making it more difficult for competitors to gain access to their home market. [37] estimated the restructuring costs at £2.9 billion, while efficiency gains from cutting non-fuel costs were worth £7.2 billion. Note that [38] claim that the largest gains were for the producers and that consumers and government lost.

In rail, different approaches (from full separation to partial integration to staying fully integrated) to vertical separation have produced different results, with different impacts on competition [48]. In the UK competitive franchise bidding helped to stimulate market growth and this also encouraged

[23] After the first five years, costs were permanently 6% lower than under the counterfactual continued public ownership.

service innovation. However, costs increased substantially since 2000. In Sweden both performance and reduction in delays improved and costs (excluding investments) decreased. Other countries also saw an improvement in service levels and no evidence of an increase in costs.

4.2.4 Tendering

In the US most cities had contractual franchise for most utilities, starting with the introduction of gas in New York in the 1820. These contracts typically provided for access to public rights of way and a franchise monopoly in return for restraints on prices and concessional terms for supplying the municipality. The contracts were typically for 20-30 years, long enough to repay the large capital investments. Over time, more and more regulation and monitoring came in place which led to improvements in the system of regulation rather than to public ownership. Only 8% of the electrical utilities and less than 1% of trams were publicly owned by 1902 and 50% of water companies [37].

4.3 Stakeholder input

4.3.1 Advisory Board

A first Advisory Board meeting was held on 7th April 2016. The goal of this meeting was to discuss the first set up of the scenarios. The AB Experts indicated that we should first clearly highlight what problems we aim to address by introducing competition, by which timescale and under which baseline scenario. This would give a clearer picture of the added value of competition for supporting the transition of nowadays European ATM system ("SES gridlock") towards a new, modernised system. It would also allow us to appraise the potential value of competition. The beneficial impact of certain approaches would need to be large, and the problem they solve would need to be very important, in order to justify taking quite radical steps away from the current approach.

Going over the options for introducing competition, the experts prefer unbundling as they believe it is the most feasible option (technically, economically and politically) to introduce competition in the sector. The idea is that ANSPs focus on core activities (core ATC and ATFM) and delegate provision of ATM support services towards other actors. These support services include elements such as: CNS, ATM data management and ATM data provision, provision of meteorological information, management of infrastructure, management of common network resources, training services, etc. These services could be provided through public tenders (competition-for-the-market) or by letting service providers compete in-the-market. The best option probably depends on the type of service discussed. So experts recommend going into more detail here. In addition, it should be noticed that ANSPs may still provide some of these support services if they happen to be the most efficient actor to provide them on the market. However, there should be some type of wall within the organization to prevent activities and interests to interfere with each other.

The second option on bidding services may also be relevant in combination with the unbundling of services, but experts do not propose to go for this option as the main one given the fact that is probably very difficult to implement from a political perspective. To be promising, experts propose to disentangle ATM technology/infrastructure provision (ATM capabilities) from the ATM operations/service provision. The first option on changing ANSP governance structure and regulation can give some complementary ideas as well, but is to a certain extent already there today and we should not expect any radical sector impacts from it. The fourth option on flight centric operations is rather different in nature, as it is rather an operational concept that could be a potential competition

enabler, rather than a regulatory/policy instrument. In addition, the basic TBO option will probably not be the enabler of radical change and this is the only "uncontroversial" concept. The more advanced option where there are different controllers managing different flights is much more controversial and experts consider it too far-fetched to be considered seriously at the current moment.

4.3.2 Interviews

Six face-to-face interviews were made, where each interview focussed on a different subject. The goal of these interviews was to get a better insight into a specific subject. The subjects discussed are summarised in the following table.

Table 4: Interviews

Interview	Topics
Skyguide	Competition between ANSPs Candidates for unbundling Current ANSP performance Importance of distribution effects of scenarios Virtual centre model
Hungarocontrol	Competition between ANSPs Candidates for unbundling Current ANSP performance Importance of distribution effects of scenarios Virtual centre model
University of Maryland	USA situation - NavCanada Economic tools for capacity prioritisation under flight-centric operations
IATA	Current ANSP performance ATM development Tendering and unbundling Governance models
CAA	Tendering of tower control Tendering and unbundling of support services Introduction of competition into ATM sector
Eurocontrol	Centralised services Sector-less operations Questions for information

From the interviews we can learn the following lessons:

General

- It is important to consider the distributional effects of the solutions as an outcome might be beneficial in total, but will not be implemented if there are clear winners and losers.
- One of the obstacles to change is that ANPSs have invested a lot of money in their current systems and will want to use them until the end of their lifecycle.
- Air navigation service provision will face competition in the long term. Small and medium ANSPs should amend their core businesses with additional services like simulation, training capabilities, etc.

Governance

- The key issue for ANSPs is governance rather than ownership. Whether public or private, ANSPs operating as monopoly service providers must be subject to independent and neutral economic and performance regulation to facilitate cost-efficiency.

Tendering

- One should think careful about the advised length of the license.
- The issue of assets and ensured investments can be resolved via licence conditions that include performance incentives in the regulation. These should take into account that there has to be some return on investment. A “regulated asset base” can protect the investment, subject to a certain traffic risk. The question remains how long of a period you need for the return of investment and if you link this to the licence period.
- It would increase competition not only between ANSPs, but between the states too (which want to keep control over own airspace and jobs)
- One should not limit this to geographical control. It is perfectly possible to control the airspace from a different geographical location, although there is no evidence that a business case would be positive.

Unbundling

- There are indeed services within ATM which can be unbundled (CNS, MET, AIS), but the question is whether cost savings realised through synergies (by having one provider of each service for various ANSPs) are large enough to outweigh additional coordination costs from separating these services.
- There are three stages in ATM activities (network management, en-route service provision, terminal service provision) and these can be linked to steps within the unbundling process.

Flight centric

- This option would decrease the fragmentation of the airspace due to the need for increased information sharing. It may therefore also be more difficult to introduce.
- This option would be technically feasible
- This will affect revenues of the ANSPs.

4.3.3 Surveys

A short survey was conducted in the period May 2016-July 2016. The project team has sent out the survey to its direct contacts, including a message that forwarding would be appreciated. The goal of the survey was to collect opinions from a variety of ATM actors and sector stakeholders. We developed a survey that was relatively short and to the point, to maximise the response rate and the collection of information. We worked with scales on which respondents had to indicate their level of agreement with feasibility, (political) acceptability and economic potential of the proposed options. We did have quite a lot of open ended questions accompanying the scales, in which respondents could further refine and justify their responses. The complex nature of the topic makes an open survey format more appropriate. The survey can be found in annex 1.

We did not set a specific target in terms of number of responses or response rate. Our focus was rather on collecting in-depth insights from a variety of actors with different backgrounds. In total, we collected 21 replies. 15% respondents could be directly linked to European ANSPs, 30% from actors in the research and consultancy domain, 15% replies from airports, 10% replies from airlines, 10% for industry associations and 20% from a regulatory/government agency.

We will now give an overview of the main points that emerged when analysing the stakeholder survey:

On feasibility in general

- Most of the concepts which we propose are considered as technically feasible to implement. With the exception of the sector-less operations concept that still raises concerns in terms of safety and performance under various traffic regimes.

On political acceptability in general

- Acceptability probably depends from country to country and region to region. One policy may be acceptable in one country but not in another. This of course makes it more difficult to come up with solutions which would work at European level. On the other hand, it could give opportunities for more local collaborations and initiatives. But these then have to converge in certain aspects if one wants to end up with an interoperable and integrated European ATM framework.

On economic effects (positive and negative) in general

- Many of the options could have positive impacts, but on the other hand also may entail additional costs. Examples are contingency services, unbundling of en-route support services, etc. So for many options it is not clear what the cost-benefit balance would be. This needs to be thoroughly assessed.

On the unbundling of terminal air navigation services

- The political feasibility will be different in different EU Member States.
- The feasibility and potentially positive economic impact depends on the specific TMA area and how clear the separation is between tower control (TWR) and approach control (APP).

    - If both activities are integrated, it is probably more costly and more complex to separate tower control and tender it to the market
- In addition, it also depends on how both activities are financed. Approach is usually part of the en-route charges, whereas tower control may be recovered through airport charges, may be subsidised by the government or may be recovered through an airport pool (covering several airports: major hub and small regional/local).
    - So separation probably requires a clear distinction in charges for TMA activities
- Moreover, unbundling tower and approach services is complex task from an operational and oversight perspective – although feasible. Therefore a well-planned process needs to be put in place for it. In the absence of such a process there is a risk of long drawn-out transitions due to operational, oversight, or other complications.
- Under an unbundled and tender-based system, technological acceleration in Terminal ANS could deliver major operational and economic benefits to aviation via higher airport performance and runway capacity, SESAR integration, resilience as well as overall contractual performance guarantees. The example of the UK is given for which it is argued that competition has delivered the most efficient runway utilisation in the world.
- It is stated that the current cost pass-through arrangements under the EU Charging and Performance Schemes do not always drive value for money for the aviation system and ultimately the passenger, and in certain cases perpetuate high operational expenditure and outdated working practices in ANS provision.
- In all, unbundling of terminal air navigation services is considered as feasible and will probably have positive economic and performance effects.

On contingency services: organisation of cooperative approaches between ANSPs for contingency services

- Feasibility and realisation of cost savings: most actors indicate that it would be feasible, only some ANSPs are more reluctant due to additional layer of complexity
    - Still costs should not be underestimated as it may require hiring and training additional ATCO staff, develop appropriate communication, navigation and surveillance systems, etc.
    - So question is on whether positive effects would outweigh the additional costs
- Size of benefits probably depends on the scale of operations of the ANSP
    - Benefits probably more important for small ANSPs, as they have less possibility to organise contingency internally
    - Costs probably more important for larger ANSPs: easier for them to organise contingency internally and more costly to align systems with those of an external provider
- The option also faces legal issues, linked to airspace legal liability and international security concerns. Currently most airspace delegations between states are in place over the ocean.
- Could also lead to social tensions as it may be perceived as a first step towards centre consolidation.

On the potential of unbundling ATM en-route support services

- According to survey respondents, support services represent about 20% - 40% of ATM costs en-route (rather 20% than 40%)

- Most respondents see the highest potential in unbundling of meteorological services. But there are respondents who disagree; some respondents think that there is more potential in the unbundling of CNS (infrastructure management) activities or in the unbundling of AIS.
    - There is agreement on the fact that MET, CNS and AIS should have higher priority for unbundling than more strategic activities such as airspace organization and airspace management.
- In the end, this should boil down to a strategic choice made by the air navigation service provider, unless it is mandated in some way by a regulatory/governance body. If the service has the appropriate incentives, he will probably make the correct choice himself.

On tendering and organization of bidding processes for awarding en-route ATC operating licenses

- One respondent mentions that states have already the freedom to tender ATS services today, but they do not use this possibility in practice
    - So there should be an obstacle explaining why states do not implement it
    - We should propose a way to overcome this barrier
- The number of air traffic control areas seems to be unaffected under this regulatory option; this is a problem because fragmentation is one of the underlying causes for inefficiency
    - We should explain better how we expect this regulatory option to lead to sector consolidation, if this is the case
- The approach may over time lead to an oligopoly of providers and leave us even worse off than we are now
- Long-term incentives may be jeopardised in this approach as ANSPs will be focused on winning short-term contracts and refuse to make long-term investments
- Another respondent comments that movability of trained controllers would be a major blocking factor, next to ownership issues and infrastructure.

On sector-less operations

- Respondents are reluctant to provide feedback as they are not fully familiar with this concept
- Overall, they stress that the safety case needs to be seriously considered under various traffic conditions (also heavy traffic)
- In addition, operational and economic benefits of this operational concepts need to be proven

On ATM stakeholder representation and consultation processes

- Overall, representation and consultation processes are considered as insufficient
    - Most respondents give a score of 1 or 2 indicating low representation of ATM stakeholders among ANSP decision bodies
    - Scores are slightly higher for consultation than for representation
- Some replies indicate that integrated stakeholder management processes are currently being developed
- Others argue that board of directors is rather composed to ensure the presence of specific skills, rather than specific stakeholders

4.4 Qualitative assessment per institutional option

We now summarise the key insights from the various input sources per institutional design option.

4.4.1 Qualitative assessment of option 1 - performance regulation

Whereas the precise form of performance regulation and the target setting process may shift slightly, the main issue with the current performance regulation seems to be its uncertain enforcement. Some states may be tempted to cross-subsidise certain ATM activities that would be loss-making under a strict performance regulation approach. Also, the position of the European Union with respect to enforcement of performance targets is currently not entirely clear.

In terms of governance and consultation processes, it is currently not entirely clear what approach works best. Probably, there is not a one-size-fits-all approach that works best under all circumstances; governance and consultation approaches should rather be tailored to the specific needs in various institutional environments.

So overall, we must conclude that we do not expect any dramatic performance impacts of this institutional design option. On the other hand, the implementation of any proposed changes may be immediately feasible at short term and relatively low cost. So given this, we consider that it is still an interesting element to further include in our analysis.

Having this said, we see two main obstacles for the implementation of this option. Firstly, it is not clear quantitatively what the potential of different ownership models can be. This is probably also the reason why the example of NATS has not been followed in other European countries. Secondly, the main obstacle for implementing yardstick competition will probably be to agree on the “potential comparators and the right comparison” as was the case for airports in Ireland. In order to overcome these hurdles more research into the differences in performance and the reasons behind these differences should be done.

4.4.2 Qualitative assessment of option 2 - unbundling

In general, the main effects to be expected from the unbundling of en-route support services are:

- Realization of cost savings if specialised service providers can produce the service more efficiently and at a wider scale than each ANSP on his own
- Increased strategic focus of ANSPs on core activities
- Possible improvement in interoperability between various ANSPs if increasing specialisation leads, over time, to consolidation in the provision of ATS support services

For these reasons, many ATM experts and sector stakeholders consider unbundling as the most attractive option for introducing elements of competition within ATM activities.

The separation between the functions of network management, en-route service provision and terminal area service provision is a clear and workable categorisation of ATM functions. However, we have to keep in mind that the split may not always be as clear-cut as we imagine. For instance, the role of network management used to be limited to ground holding of aircraft to prevent bottlenecks or capacity overflows in the air. Currently, the shift towards time-based operations and trajectory-based operations has led to increasing involvement of network management in more tactical phases

of the flight, interacting with real-time air traffic service provision. This is important for us, because network management is a function with clear network characteristics and which is therefore less suitable for the introduction of competition. On the other hand, the domain of en-route air traffic services (ATS) is an area where we see more possibilities for introducing competitive incentives.

Secondly, in terms of support services the 'typical candidates' MET, AIS and CNS are indeed the first candidates for unbundling. This could lead to a realization of specialization benefits and increased focus of ANSP activities. The separation of CNS activities should in addition contribute significantly to a reduction in CAPEX, given its high capital intensity. The same holds for AIS, but to a smaller extent. Most people estimate the relative share of the support services in total ANSP costs around 20%, although there are also higher cost estimates of 60%. On the downside, unbundling could lead to a loss in local employment and it will also likely lead to social tensions and national sovereignty issues. These obstacles are similar to barriers for other institutional changes.

ATM stakeholders consider the further unbundling of support services less suitable because they are more strategically important functions for ATS providers. Airspace organization and airspace management, as well as demand and capacity balancing, are both activities which are relatively close to the core function of en-route air traffic services.

Unbundling of contingency services is highlighted as an interesting element by many actors. A first goal of this is the provision of back-up ATC capacity and maintenance of minimum service levels under exceptional circumstances (strikes, technical failures, security incidents). A secondary, and maybe more important, target is that a strong mandate would motivate ANSPs to interact with each other for improving the interoperability of systems and platforms; and provide tangible results based on this. This process would contribute to the effective removal of national boundaries and enables mutually beneficial collaborations. This could then ultimately lead to enhanced cooperation possibilities, as operational procedures are more aligned, and enable a transition path towards the future, less fragmented ATM network. It is important that any mechanism underlying the transition path supports a first-mover advantage, instead of a first-mover disadvantage, to stimulate the ongoing process. This would effectively be the case in the 'contingency service' approach as the introduction of such a service would lead to cost savings and benefits could be shared among the participating ANSPs. The ANSPs that engage first in the process can benefit from a learning effect and seize new business opportunities out of their national borders.

However, it is not the preferred option of some ANSPs in particular not the large ones. They probably have less to win by cooperating with other ANSPs for contingency; because their scale allows them to organise redundancy within their own systems relatively efficiently. On the other hand, adjustment costs needed to ensure interoperability with other ANSPs are more likely to be large. For smaller ANSPs, the coin is probably on the other side. Their potential cost savings, in the provision of redundancy, are more likely to be larger in comparison to the necessary adjustment and coordination costs for effectively implementing the system.

Unbundling is already happening today, and hence the obstacles for this option are relatively small in general. This is especially true for real "supporting services". The main hurdle for implementing the unbundling option would be the power of the unions as this will lead to job losses within the ANSPs, especially among the supporting staff. Apart from very practical arrangements (e.g. by using lower

replacement rates) a good insight into the potential benefits and costs of this option will be a first step to overcome this hurdle.

4.4.3 Qualitative assessment of option 3 – tendering

ATM experts pointed out that the option to tender the en-route ATS provision is already available today to states. However, none of the states has really used this option in practice. So it seems that it is not in their interest to do so. Therefore, we should think about how to induce/oblige governments to engage in tendering the ATC service and remove obstacles for doing so.

On the other hand, ATM experts were also wondering about what incentives the ANSPs have to move out of their geographical zone. It may give them new market opportunities, but if they recognise that this also means that other providers may enter their domestic market they may become reluctant of doing so.

Next to this, a potential barrier for effective organization of competition in this way is the increasing requirements of cooperation between various ATS providers under the new SESAR operational concepts. There is an increased involvement of the network management in tactical ATC with time-based and trajectory-based operations. Trajectory-based operations concept will also impose increased demands in terms of information sharing between ATM providers. But if the same providers are at the same time competitors, they may become more reluctant to share information. Therefore, we should address the issue of whether ANSPs still have the incentive to behave cooperatively if they need to collaborate in certain areas (increased information sharing) and compete in others (for ATS licenses).

Overall, this option seems to be interesting, but is not directly the most preferred way forward by most ATM sector stakeholders. Hence the lack of acceptance is a clear barrier for implementation. A clear picture of the costs and benefits, and of the most likely losers and winners is needed.

4.4.4 Qualitative assessment of option 4 - sector-less operations

Sector-less operations in itself is not an institutional design option. However, in the future, it might have a major impact on the institutional design of ANSPs. The sector-less ATM concept may allow for direct competition between ANSPs and even encourages a non-national approach to ATM. The operational concept itself is currently in R&D phase and is not yet a well-established SESAR concept. There are still a number of issues to be dealt with, such as the requirements in terms of controller-controller coordination, the development of advanced rules-of-the-air for flight prioritization, the interfacing with adjacent sectors that may not be under a sector-less ATM paradigm and the performance of the operational concept in ATM area or in congested airspace sectors. Therefore, there is still significant uncertainty linked to the application of the operational concept. This leads to even higher uncertainty linked to the potential use of the concept for organizing competition between ATM providers.

Today, the major hurdle is technology. Once technology is more developed an important issue would be the sovereignty as it does imply that national government delegate the management of their national airspace to different ANSPs at the same time. This is different from tendering a licence to manage your national airspace. It does remains an interesting – although more theoretical – approach of looking at ATM provision as it is the only option which would allow for direct competition **on** the market.

4.4.5 Summary of qualitative assessment of options

In order to summarise the qualitative assessment of the four options, we developed an initial assessment framework based on a limited set of criteria. These criteria were also included in the survey.

We used the following selection principles for our framework:

- *Contributory* in advancing wider understanding about the policy
- *Focusing* on the information we need for further work
- *Comprehensiveness* over different dimensions

Table 5 gives the overview of the qualitative assessment of various institutional options. Overall, we can say that option 1 is easy to implement but will likely not have a dramatic impact, whereas option 4 could have strong and positive impacts but still faces significant challenges from a technical and implementation side. For instance, safety concerns are not out of the picture for the moment. In addition it would completely change the way ATM is working today (potentially leading to social tensions) and implies a delegation of the national airspace to several ATM suppliers at the same time (which is against current legislation).

Option 2 seems rather promising as it does not face any challenges that are difficult to overcome; there are no red boxes in the table. It is also the option which is already happening today. For option 3, in contrast, political acceptability and social tensions are probably the main barriers.

Table 5: Summary of qualitative assessment (Green = Positive, Yellow = somewhat positive, Orange = somewhat negative, Red = Negative)

	Option 1	Option 2	Option 3	Option 4
Technologically feasibility				
- Is the technology there to realise it				
- Time scale necessary for implementing the option				
Economic feasibility				
- possible cost reductions				
- cost of introduction				
- effect on performance improvement incentives				
- potential negative side effects				
Regulatory feasibility				
- easy implementation				
Acceptability				
- by nations				
- by ATCO's				
- By other ANSP personnel				
- by airlines				
Impacts				
- impact on capacity				
- impact on safety				
- impact on environment				
- social welfare				
- distributional impacts				
- contribution to defragmentation/realisation of economies of scale				

4.4.6 What about combining these options?

In the analysis above we focussed on the four options separately. However, there might be some potential in combining two or more of them. There are two main reasons why we did not discuss combinations up to now:

- Firstly, the division between the options is not as strict as it seems. For example, tendering of licences could be seen as an extreme form of unbundling in which also the en-route traffic control is being tendered. The design of a good auction is important for option 2, 3 and 4.
- Secondly, most of these options have not been quantitatively been studied. We first need to have a good idea of their potential (positive and negative) on their own, before looking into combinations. Once we know the positive and negative effects, and who wins/loses we can investigate whether some combinations would strengthen or weaken the effects.

5 Conclusion: scenarios for COMPAIR

The institutional options for competition may be more or less appropriate to drive performance at different points in time, and their feasibility also depends on the status of ATM capability development. An option such as yardstick competition could in theory already be implemented today, while competition on OD level (option 4) will probably only be feasible by 2050. The institutional options also impose certain requirements in terms of capability development, for their effective implementation. For instance, the introduction of a sector-less ATM airspace in the whole of Europe would not be feasible in the currently highly fragmented ECAC area.

Therefore, it is necessary to situate the institutional options in an overall scenario on future ATM capability development in Europe. In section 5.1, we develop three future ATM capability development scenarios: a reference scenario, a low and a high ATM capability development scenario. Then, in section 5.2, we match the institutional options for competition with the ATM capability development scenarios.

5.1 Background scenarios on future ATM capability development in Europe

Overall, the time frame for this study will be 2035 to 2050, SESAR's target year to attain the vision of air traffic control indicated by the 2015 Air Traffic Management Masterplan [20] [22][21]. In the vision of the SESAR Master Plan, the ATM system evolves towards trajectory-based operations; the target concept for the year 2035. This means that ATM capabilities should be in place to provide seamless air navigation services (ANS) in support of the execution of the business or mission trajectories. An aircraft can then fly their preferred trajectories without being constrained by airspace configurations. The vision is enabled by a progressive increase of the level of automation support, the implementation of virtualisation technologies as well as the use of standardised and interoperable systems. The system infrastructure evolves with digitalisation technology, allowing ANSPs irrespective of national borders to plug in operations where needed, supported by a range of information services. System-Wide Information Management (SWIM) enables information sharing throughout the whole networked ATM system in such a way that all stakeholders have access to information of the right quality at the right time and place. In addition, common centralised service providers have developed integrated support tools for individual ANSPs, thereby realizing economies of scale, avoiding costly duplication of similar services and increasing the interoperability between systems of various national providers.

We take these developments put forward in the SESAR master plan as the **reference baseline scenario**.

In the **low capability development scenario**, the implementation of the SESAR Master Plan remains sluggish and slow, in line with observations made by several actors on effective implementation of

SES initiatives thus far. This entails that existing 'silo structures' between various national ATM systems are still in place. Integration of systems and information sharing not put in place, thereby limiting the effectiveness of virtualisation technologies and limiting the scope for disentangling service provision from a specific geographical location.

In this scenario, the ATM system remains similar to the one in place today until the year 2035.

In the **high capability development scenario**, the ATM system evolves beyond the concept of trajectory-based operations towards performance-based operations. This implies that the TBO target vision has been realised and the ATM system is characterised by a high degree of automation. In this context, multiple options can be envisaged, such as seamless collaboration between ANSPs across Europe and/or end-to-end air navigation service provision. This could also involve the concept of sector-less ATM operations[24], characterised by a sectorless airspace organisation in which 1 controller is responsible for n aircrafts' trajectories from origin to destination. Sectorless ATM requires a high degree of coordination and information sharing between ATCOs managing different flights. The controllers could be based in different Area Control Centres or even different ANSPs. To facilitate the necessary coordination, there is probably a need to rely on extended flight prioritization rules and to integrate these rules for automated decision support in ATCO human-machine interfaces.

Performance-based operations could materialise in the period 2035 – 2050, according to the SESAR ATM Master Plan. In the high development scenario, we will assume that sectorless operations are a reality in European airspace in the year 2035.

Table 6 Background 'capability development scenarios' for ATM system in Europe

	Virtual centres	SWIM	Increased automation support	Sector-less ATM
Low capability development scenario: maintenance of existing silo structures				
Reference background scenario: SESAR master plan – trajectory-based operations	X	X	X	
High capability development scenario: performance-based operations	X	X	X	X

[24] See [49], [16] and [32].

5.2 Matching the ATM capability development scenarios with institutional framework scenarios

In Table 7, we match the institutional competition scenarios with the technological development and ATM capability scenarios to better understand when and under what circumstance the institutional scenario could assist in driving ATM performance.

Table 7 Matching ATM capability development scenarios (vertical side) with institutional options for introducing elements of competition (horizontal side)

	Option 1	Option 2	Option 3	Option 4
Low capability development scenario: maintenance of existing silo structures	X	X	(X)	
Baseline scenario: SESAR master plan – trajectory-based operations	X	X	X	
High capability development scenario: performance-based operations	X	X	X	X

Institutional option 1 "performance regulation and yardstick competition" does not impose any requirements in terms of ATM technology/capability development. It is feasible under all technology development scenarios. Various ANSP ownership models exist already today. Statistical analysis of an "ownership effect" in an ATM productivity function could be insightful. Results can be combined with any of the three other competition scenarios to formulate recommendations in terms of regulatory and institutional approaches for air navigation service provision.

Institutional option 2 "unbundling" also does not impose specific ATM capability development requirements, as is the case for next options. Unbundling of ATM support services and centralisation, as in the case of centralised services, occurs already today. Another approach could be to unbundle support services and decentralise them, letting the market decide who should provide them. The institutional scenario would rather rest on a mandate by regulators to further unbundle support services and does not entail any technological developments.

Unbundling can assist in increasing technology take-up and innovation potential in the ATM sector, as market providers are more exposed to competition than ANSPs and therefore more client-oriented and more eager to embrace efficiency-enhancing solutions. However, it is likely that we will only see a real uptake of unbundling in combination with commercialisation/privatisation – hence in combination with option 1.

Institutional option 3 "tendering of ATC licenses": For effective decoupling of the air traffic service provision from a geographical location, this option requires the development of virtualisation technologies together with a certain degree of system-wide information management and

information sharing. If this would not be the case, tendering of ATC licenses risks to become merely a shift of the management team without the ability to fundamentally change work processes, organization structure, collaboration agreements with other actors, etc. It is unlikely that simply a shift in management team could lead to a drastic shift in ATM performance. Thus, effective development of option 3 would require at least an ATM capability development in line with the baseline technology scenario ("ATM master plan").

So the appropriate time scale for the development of the ATC licensing option at European scale could be around the year 2035, after realization of the SESAR target concept. On the other hand, the capabilities do not need to be in place for the whole of Europe. It may be feasible to apply the concept earlier on a more local basis, enabling cooperation between ANSPs that are more advanced in terms of ATM capability development. It seems then important that the option enables mutually beneficial collaboration for both the licensee and the licenser. Possible approaches for mutually beneficial ATC operating licenses could take the form of licenses targeted at the provision of ATC contingency services; or there could be other forms to share performance benefits realised by ATC licensing. If the concept is successfully realised at a specific place and time, it may be an example for others to follow and spread out to other areas, thereby increasing the propensity to adopt necessary SESAR ATM capabilities.

The situation for **institutional option 4 "sector-less ATM operations"** is very different. The form of competition between various ATM providers in the sector-less airspace would be direct competition for flights, unrelated to any sectors or other geographical limitations. The concept, however, still requires the specification and implementation of advanced ATM capabilities, such as a high degree of automation and information sharing to assist in the coordination activities between different controllers serving different flights. The concept is therefore to date not a well-established SESAR concept; it is still in the R&D phase. There has been a feasibility study with stepwise validation of the concept in German airspace, however; a collaboration between DLR and DFS. This study has demonstrated the basic feasibility and promising nature of the concept in terms of efficiency improvement and capacity enhancements. This concept is probably more relevant towards the years 2050 in line with the vision in [20] which aims for the implementation of performance-based operations, which might include full end-to-end ANS provision.

The time frame for developing the necessary ATM capabilities for deploying the system at European scale is probably around 20 years in the most optimistic scenario. Therefore, we realise that our analysis of the concept, focused on economic and competition impacts of the approach, is rather an exploratory "what if?" research question. The goal is to quantify potential effects of organizing competition between ATM providers in a sector-less European airspace. This can be contrasted with a single entity managing European airspace, to quantify potential benefits of competition under a sector-less ATM operational concept.

Furthermore, the need for extensive coordination (in terms of information sharing, application of prioritization rules, etc.) between ATM providers of different airlines is high. This raises the question whether competition would still be an effective performance incentive tool: how can we make ATM providers compete if, in the same time, they also depend on each other for a safe coordination of airspace traffic? Competition could, in this case, give ATM providers an incentive to make the others look bad and reduce performance of the overall system. This is an effect which we will need to balance with the potential positive effects of the institutional framework.

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7 Annex 1: Survey