

CHAPTER 31

AIR TRAFFIC CONTROL POLICY FRAMEWORK ADVANCEMENTS VIS-A-VIS REGIONAL AIRPORTS

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1. Introduction

Economic, social and territorial cohesion is one of the EU's main objectives. Many smaller communities and remote regions (e.g. Azores) rely on air services for a variety of purposes like access to core regions. Policymakers have understood the contribution of air connectivity to economic growth and therefore 'subsidise' 'non-commercial' routes to remote regions. Air transport may be the only means of transportation in remote and outmost regions, thus providing social inclusion and access to social services (Efthymiou and Papatheodorou, 2015). Around 45% of Norway and 35% of Greece are considered as Predominantly Rural Remote (PRR) and 45% of Ireland and Poland and 43% of Finland are Predominantly Rural Close (PRC) to a city regions (Brezzi et al., 2011). In Europe, a number of countries have poor road and rail infrastructure to certain regions due to geomorphology or weather conditions. The high number of inhabited islands in Greece make impossible the development of rail and road infrastructure to those islands, where communities are suffering from geographical discontinuity (Efthymiou and Papatheodorou, 2015) and thus are more dependent on marine and air transport. Moreover, the awkward geography of a country and sparse population (e.g. in Norway) can increase the reliance of the population on air transport (Lian, 2010). Thus, connectivity of remote and core regions in many cases cannot be achieved with road or rail transportation and emphasis has been given to air transport in the form of Public Service Obligations (PSOs) in many cases.

Moreover, the air transportation network is expanding from the established hub and spoke. Spatial and temporal concentration fuelled the hub-and-spoke networks utilised by Full-Service Network Carriers (FSNCs) (Reynolds-Feighan, 2001; O'Connell, 2011; Efthymiou et al., 2019). The appearance of Low-Cost Carriers (LCCs) that offer low fares and point-to-point connections has transformed air travel (Efthymiou and Papatheodorou, 2018). Increased connectivity has contributed to the discovery of new destinations (e.g. Kos island), but also the rejuvenation of old ones (e.g. Majorca). This traffic, which is vital and benefits local communities, relies hugely on preserving those flights and keeping the costs for the aircraft operators low and thus, the passenger fares. In conclusion, aviation contributes to tourism development (Corbet et al., 2019; Warnock-Smith and O'Connell, 2011; Papatheodorou, 2002), generating economic growth and providing jobs in peripheral regions, and therefore the air transport system is vital for those regions.

The main components of the air transport system are airlines, airports and Air Navigation Service Providers (ANSPs) (Efthymiou et al, 2016). Remote regions are served primarily by regional airlines, which are not recognised by all analysts as a separate business model and are affiliated to FSNCs. Regional airlines feed traffic to hubs and/or offer stand-alone, point-to-point services on routes that could not be profitably served by FSNCs or LCCs whose fleet structure was unsuitable

for certain smaller-scale operations (Efthymiou and Papatherodorou, 2018). The routes that they operate are usually very thin and from airports that are located in regions that do not have easy road/rail access to primary/hub airports. Airport types' definitions vary, especially for secondary airports. Wong et al. (2019) classified the airports according to topological features (such as degree and centralities), importance to regional traffic, and spillover effect from neighbouring airport(s). Dobruszkes et al. (2017) defined regional airports as airports not serving (or at least not primarily serving) large cities (e.g., Shannon Airport in Ireland). For this case, we look at secondary/regional airports with thin traffic and high costs.

Airlines and airports rely on the Air Navigation Service Providers (ANSPs) for the management of air traffic. Hence and as discussed above, Air Navigation Services (ANS) provision is significant for remote regions. The five biggest ANSPs, (DFS for Germany, DSNA for France, ENAIRE for Spain, ENAV for Italy and NATS for the UK) operate 54% of European traffic. More than 47% of the European airports are lossmaking (ACI Europe, 2019). Out of the 500 airports in Europe, more than 270 airports (depending on the definition of regional airports) have less than 1 million passengers (Verouden, 2013) and do not generate any profit. Therefore the traffic is not equally distributed among the ANSPs and the airports. This proves that the ATC cost in small regional airports is higher and based on full cost recovery principle, and the charges could be higher for aircraft operators in the smaller airports. This puts extra pricing pressure on airlines, airports and passengers.

Despite Europe being one of the most mature markets and having one of the busiest skies in the world with as many as 33,000 flights a day (EC, 2015), the airspace fragmentation is blamed for longer flight routes, delays, environmental and safety inefficiencies as well as higher cost for aircraft operators and passengers (Efthymiou and Papatheodorou, 2018). This fragmentation led to technical and operational inefficiencies costing 4 billion EUR a year (EC, 2015). When this cost is broken down to sectors or to terminal and en-route services, the cost in remote regions is higher due to thinner traffic.

This chapter discusses the Air Traffic Control policy framework in Europe and its relation to regional airports. Section two discusses the structure of the Air Traffic Control market in Europe. Section three elaborates on the policy framework and more specifically on the Single European Sky policy that aimed to reshape the airspace and make the ANSPs more efficient. The innovations that affect regional airports and remote areas are discussed in section 4. Section 5 concludes the chapter and provides recommendations to policymakers.

2. Structure of the ATC market in Europe

Article 1 of the Chicago Convention mentions that every state has complete and exclusive sovereignty over the airspace above its territory. Hence, Flight Information Regions (FIRs) were established based on national borders. Moreover, according to Article 28 of the Chicago Convention, the State is ultimately responsible for the provision and operation of air navigation facilities and services. Therefore, Europe has 37 Air Navigation Service Providers (ANSPs)(most of them) operating as monopolies controlling the 10.8 million km² airspace (EC, 2015). There are 62 Area Control Centres (ACCs), 262 Approach Control units (APPs), 56,300 staff (44% more than in the U.S.) (EUROCONTROL, 2016). There are 415 airports with ATC services, but only 34 of them have the 64% share of all the traffic in Europe (EUROCONTRO, 2016).

There are two categories of air traffic services, en-route services that control traffic during the cruise phase of the flight, and the Terminal Air Navigation Service (TANS) that relate to “radar approach and departure” (approach) service and the aerodrome service (figure 1). The approach service typically controls the aircraft within 40-50 nautical miles from the airport. The aerodrome service relates to the visual control provided by the ATC tower.

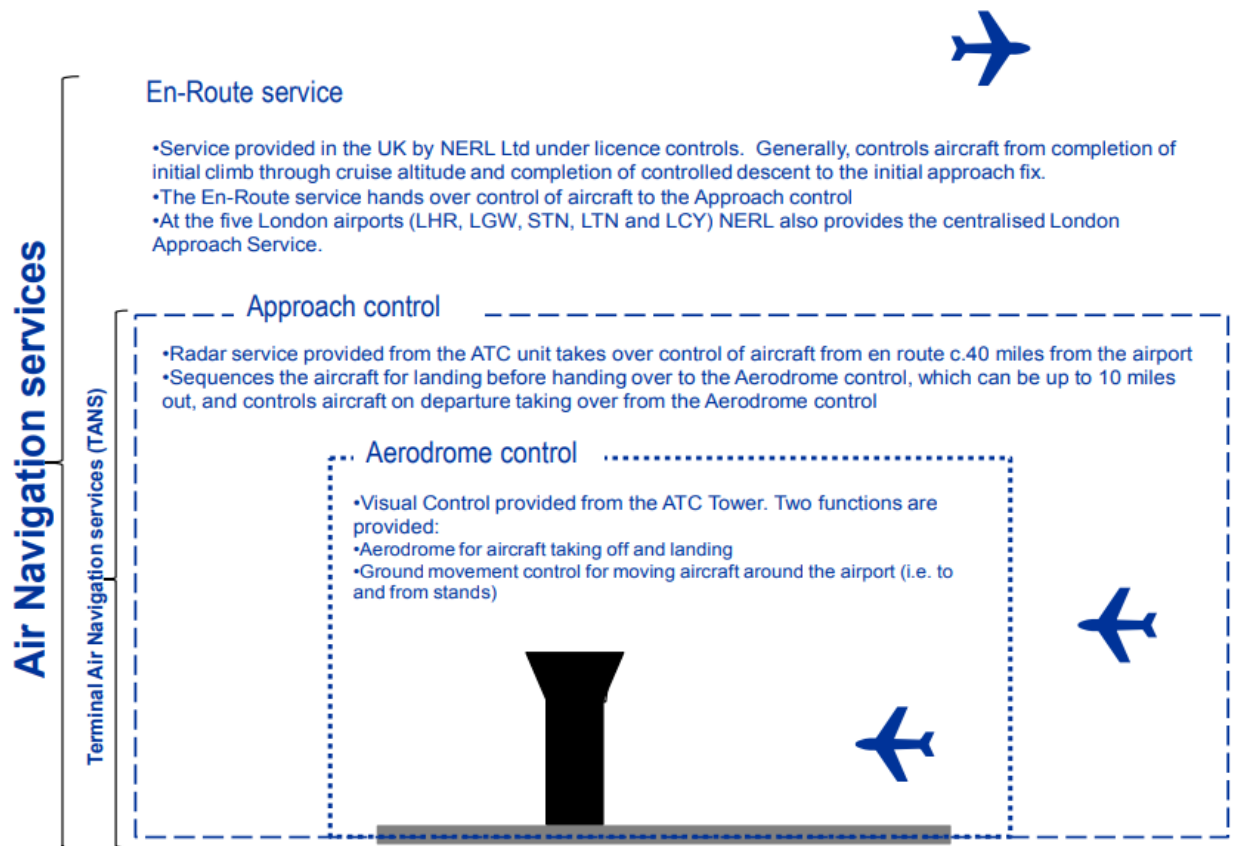


Figure 1: Illustrative definition of TANS (CAP 1293, 2015)

Despite the general integration of air traffic service provision (i.e. en route, terminal navigation and CNS) into one organisation, the European airspace is considered quite fragmented. There are too many ANSPs operating as natural monopolies. A number of scholars are researching the ANSP performance and commercialisation¹. A study in 2006 (Table 1) found that the additional costs caused by the fact that Europe has a large number of service providers totalled to €880m - €1400m.

Table 1: Cost of fragmentation in European ATM systems (EC, 2019)

¹ Commercialisation refers to the introduction of commercial objectives to a publicly owned enterprise (Humphreys, 1999)

	Cause of fragmentation	Annualised costs	% of cost of fragmentation
Common issues	Piecemeal procurement (mainly ATM systems)	€30m - €70m	14%
	Sub-optimal scale in maintenance and in-service development (mainly CNS)	€10m - €15m	
	Fragmented planning	€60m - €120m	
ACCs	Economies of scale in ACCs (operating costs)	€370m - €400m	53%
	Economies of scale in ACCs (capital cost)	€105m - €140m	
	Constrained sector design (flight efficiency benefits)	€50m - €100m	
ATM systems	Lack of common systems (operating costs)	€150m - €215m	23%
	Lack of common systems (capital costs)	€30m - €90m	
	Increased coordination at interfaces	€10m - €20m	
CNS infrastructure	Optimum location of en-route nav aids	€3m - €7m	4%
	Overprovision of secondary radar	€15m - €60m	
Associated support	Economies of scale in training, administrative costs and R&D	€40m - €100m	6%
Total cost of fragmentation		€880m - €1400m	100%

The evolving ATM environment led to greater government independence and new models of collaboration (Efthymiou et al., 2016). There are different organisational forms. There are a) governmental agencies (e.g. FAA-Federal Aviation Administration in USA), b) state-owned or government business enterprise (e.g. DFS Deutsche Flugsicherung GmbH in Germany), c) private-public-partnership (PPP) (e.g. NATS in UK) and d) private entity (e.g. Nav Canada and ACR in Europe). All the European Common Aviation Area (ECAA) states and the organisational and corporate arrangements for the ANS provider are listed in Table 2. All the different ownership and organisational forms that exist have the potential according to ICAO (Doc 9161, 2013) to deliver excellent service under the condition of an appropriate government structure.

Table 2: Organisation and Corporate arrangements of the ECAA states (Efthymiou et al, 2016)

ANSP	Country	Organisational & Corporate Arrangements
ENAIRE	Spain	State enterprise
ANS CR	Czech Republic	State enterprise
ARMATS	Armenia	Joint-stock company (State-owned)
Austro Control	Austria	Joint-stock company (State-owned)
Avinor	Norway	Joint-stock company (State-owned)
Belgocontrol	Belgium	State enterprise
BULATSA	Bulgaria	State enterprise
Croatia Control	Croatia	Joint-stock company (State-owned)
DCAC Cyprus	Cyprus	State body

ANSP	Country	Organisational & Corporate Arrangements
DFS	Germany	Limited liability company (State-owned)
DSNA	France	State body (autonomous budget)
EANS	Estonia	Joint-stock company (State-owned)
ENAV	Italy	Joint-stock company (State-owned)
Finavia	Finland	State enterprise
HCAA	Greece	State body
HungaroControl	Hungary	State enterprise
IAA	Ireland	Joint-stock company (State-owned)
LFV	Sweden	State enterprise
LGS	Latvia	Joint-stock company (State-owned)
LPS	Slovak Republic	State enterprise
LVNL	Netherlands	Independent administrative body
MATS	Malta	Joint-stock company (State-owned)
M-NAV	F.Y.R.O.M.	Joint-stock company (State-owned)
MUAC	-	International organisation
NATA Albania	Albania	Joint-stock company (State-owned)
NATS	United Kingdom	Joint-stock company (part-private)
NAV Portugal	Portugal	State enterprise
NAVIAIR	Denmark	State enterprise
Oro Navigacija	Lithuania	State enterprise
PANSA	Poland	State body (acting as a legal entity with an autonomous budget)
ROMATSA	Romania	State enterprise
Skyguide	Switzerland	Joint-stock company (part-private)
Slovenia Control	Slovenia	State Enterprise
SMATSA	Serbia	Limited liability company
	Montenegro	

Cyprus ANSP before was a Government department and in 2015 started to be reformed again. DFS in Germany in 2002 was a Limited Liability Company. LVNL (The Netherlands) in 2002 was a State enterprise and Slovenia Control was a government department. Commercialization in ANSPs is deemed as a possible answer to financing and budgets constraints, as ANSPs are generally dependent on government budget for their capital and operational expenses. Cost reduction, increase in the speed of modernization and stabilising of funding are the main reasons given by advocates of ATC privatisation² (Sclar, 2003). Sclar (2003) implies that the ownership status of NATS is to blame for technical failures like multiple system shutdowns and operational irregularities as well as the financial bailouts valued in 2003 at two-thirds of the original sale price.

² Privatisation refers to transfer of ownership and control of government or state assets, firms and operations to private investors (OECD, 1993)

On the other hand, according to Poole (2013), government owned ANSPs like the FAA can be risk-averse, slow to make and implement decisions and mismanage procurement.

Adams (2005) studied four privatised ANSPs and found that two of them had a decrease in operating cost and one an increase, but all of them upgraded or were in the process of upgrading their equipment and systems and increased their efficiency. ANSPs that are self-supporting corporate entities (e.g. DFS, NATS, IAA) are found to be more customer-focused, more eager to adopt new technologies and procedures, and unaffected of government's budget constraints (Poole, 2013).

Within Europe, the UK is by far one of the most liberalised markets³. NATS was proposed as a Public-Private Partnership (PPP) in 1998 and was finally formed as a PPP in 2001. NATS has two wholly-owned operating subsidiaries, the NERL that is responsible for en-route services and NSL that is responsible for terminal ANS. In 2001, Airline Group acquired 46% of NATS, the NATS staff took 5% and the remaining 49% was held by the government. Prices of NATS are regulated in accordance with the price-capping formula (RPI-X) to create incentives for efficiency and are revised every 5 years taking into account, inter alia, major investment projects. In 2009, NATS joined the A6 alliance and in 2011, NATS created a partnership with Ferrovial Servicios, called FerroNATS. FerroNATS provides air traffic control services to nine airports in Spain (NATS, 2019).

In a nutshell, the European airspace is one of the busiest skies in the world with as many as 33,000 flights a day and ANSPs are performing at different levels as the services are offered by different entities. When compared to the U.S., the European sky is deemed inefficient. The increased traffic, problems in capacity, climate change and the necessity of developing a more cost-efficient system led to an ambitious initiative to reform the architecture of the Air Traffic Management (ATM). This initiative was first launched by the European Commission in 1999 and is called Single European Sky (SES).

3. European Air Navigation Service Providers policy framework

According to ICAO Doc 9587 (2008) the objective of ongoing regulatory evolution is to create an environment in which international air transport may develop and flourish in a stable, efficient and economical manner without compromising safety and security and while respecting social and labour standards. Airline liberalisation/deregulation led to substantial economic and traffic growth. Fu et al. (2010) argued that this happened due to increased competition and efficiency gains. They also suggest that liberalisation allowed airlines to optimise their networks. Liberalisation in the area of airports had a similar effect (Efthymiou et al., 2016). What led to ANSPs becoming more efficient and cost-conscious was the ATM reforms.

The European ATM reforms, known as Single European Sky (SES), were first mentioned in 1999, but the major breakthrough was in 2004 with the adoption of the first package (SES I) and in 2009 with SES II (Crespo and Fenoulhet, 2011). The second SES legislative package was based on

³ Removal of government controls in the provision of the ANS services from a business perspective. Civil Aviation Authority is still regulating some aspects of ANPs operating in the UK.

certain key pillars: performance, safety, new technologies and capacity (Crespo and Fenoulhet, 2011).

SES is based on the four following main regulations:

- the Framework Regulation establishes the European Commission as the regulator for the civil sector and the Single Sky Committee to assist it in its regulatory activities;
- the Airspace Regulation which will establish a single European Upper Information Region and within it organize airspace into Functional Airspace Blocks (FABs);
- the Service Provision Regulation establishes a common licensing system for civil ATM providers; and
- the Interoperability Regulation which aims to ensure that systems, equipment and procedures operate seamlessly.

The main target of the scheme is to restructure the European ATC in accordance with the traffic flows, to triple the capacity, improve safety by ten times, reduce the cost of air traffic management by 50% and reduce the environmental impact by 10% (EC, 2013). Thus, the performance in Single European Sky is focusing on four Key Performance Areas (KPA) a) Safety, b) Capacity, c) Cost-Efficiency and d) Environment. The 4 KPAs are part of the wider set of 11 International Civil Aviation Organisation (ICAO) KPAs, which also include efficiency, flexibility, predictability, security, access & equity, interoperability and participation. National Supervisory Authorities (NSAs) are required to establish national targets and plans to meet the EC goals for the delivery of air traffic services (ATS) (Thompson et al, 2016).

If not the most important, definitely the most discussed area is the KPA cost-efficiency. The Cost Effectiveness of ANSPs is measured by the annual ATM Cost-Effectiveness (ACE) Benchmarking Report conducted by the Performance Review Unit (PRU) of EUROCONTROL. The main indicators that are taken into consideration are the ATCO-hour productivity and employment costs (PRU, 2018). Grebensek and Magister (2013) suggest that benchmarking methodology favours only the busy ANSPs serving larger airports with additional composite flight hours, thus making them more productive and financially more cost-efficient. Moreover, the report does not include private ANSPs (e.g. ACR) and does not effectively separate the costs of en-route to terminal services, an area important when comparing the cost of tower and approach control.

The market structure and market power in ATM are affecting the performance of SES and the implementation of the regulations. The Performance Regulation 550/2004 brought a relative liberalisation⁴ by stating that the issue of certificates shall confer on ANSPs the possibility of offering their services to other ANSPs, airspace users and airports within the Community. By this way, there is no obligation on choice and the management of performance of the service provider is done through an arm's length commercial contract.

⁴ Liberalisation is the removal or loosening of restrictions of ANS provision.

4. Provision of Air Navigation Services at airports

4.1 Terminal Air Navigation Services (TANS)

One very important aspect in the aviation industry is cost. In most cases, European ANSPs that provide both en-route and terminal services, follow a network approach to pricing and do not separate the cost of provision of services by service, sector and airport served. They follow a cross-subsidisation model to cover losses from the offering of services to airports with low demand. The Irish Aviation Authority (IAA) for example, generates a substantial income from the transatlantic en-route traffic and subsidises the cost for the services to regional airports like Donegal and Connemara airports. Another example is the Polish Air Navigation Services Agency (PANSNA), that cross-subsidises the loss of terminal navigation services to airports with low traffic from the profits of airports with high traffic. Arblaster (2018) suggests that economic theory and regulatory agencies support the avoidance of cross-subsidization. The lack of cost breakdown and the cross-subsidy policy can be a barrier to introducing competition in tower control services and a reduction in incentive for cost efficiency.

Airlines complain about the high costs of en-route and terminal charges. According to IATA (2013) airlines and passengers are estimated to have paid at least US\$92.3 billion for the use of airport and air navigation infrastructure globally in 2011, equivalent to 14.4% of the cost of transport. Cost efficiency is quite critical for an airline – as well as for an airport - to compete and survive in such a competitive market. Most of the ANSPs do not separate the cost of terminal and en-route service provision, and even if they do, the information is not available. In a location specific pricing principle, remote and regional airports are allocated lower common costs for terminal services as they are price sensitive for carriers in comparison to primary airports (Arblaster, 2018).

Another controversial issue is the connection of ownership and institutional structure on ANSP cost efficiency. Dempsey-Brench and Volta (2018) found that ownership is not directly impacting neither the ANSPs' cost structures nor their cost efficiencies. They also highlighted the need to increase the average size of the ANSPs in order to decrease the cost and lead to agglomeration as outlined in the SES initiative.

Dempsey-Brench and Volta (2018) study are one of the few looking into the cost structure of ANSPs and the ownership type. Nevertheless, the lack of separation of en-route and terminal cost does not allow for the effective study of TANS and en-route ANS ownership cost-efficiency. PWC (2001) in their commissioned study of terminal charges for air traffic control services in 2001, reported that airspace users were concerned about the charging scheme and that there was a lack of transparency in cost information. Nevertheless, it is a well-known fact that smaller regional airports have higher costs due to low aircraft movement volume.

The major concerns behind the transition of TANS provision are the negotiations about the equipment and staffing. Arblaster (2018) highlighted that the initial sunk investment and the access to qualified staff and assets (e.g. CNS infrastructure) can act as barriers of entry into provision of terminal navigation services. Usually, the ANS equipment belongs to the airport authority and is leased to the TANS provider. As far as staffing is concerned, there is high insecurity in terms of the number of locally qualified ATCOs that will transfer to the new provider and the additional cost of training replacement staff (Steer Davies Gleave, 2017).

ENAIRES is the fourth biggest ANSP in Europe, but in 2009 it noted a 9% reduction in traffic. The Spanish government, after the privatisation of the national airports company (AENA), separated the ATC and deregulated its aerodrome control services in order to lower the 1,700 ATCOs' costs that were 97% higher than the European average according to ACE report (PRU, 2011, 2014). The staffing cost in Spain makes up 71% of ATM-CNS costs, whereas in the rest of Europe they average 63% (Comendador et al., 2012). This also makes the productivity per ATCO (that is measured as cost/hour) appear low.

According to CAPA (2011), Spain planned to privatise TANS in 47 airports, but at the end decided to tender only 13 airports, most of which are in major holiday destinations and handle 25% of aircraft movements in Spain. Law 9/2010, Royal Decree 1516/2009, Royal Decree 931/2010, Ministerial order FOM/1841/2010, Royal Decree 1001/2010 constitute the basis of the ANSP TANS deregulation in Spain. FerroNATS was awarded the management of nine out of the twelve control towers. Thompson et al. (2016) noted that NSL had a proportionate drop in profit relative to revenue due to lowering the price charged to effectively compete in winning the TANS contracts. The Spanish government hoped that the reduced cost of TANS provision will attract more aircraft operators to the regional tourism dependant airports.

The Spanish ATCOs union, USCA, opposed to this change. ATCOs are highly skilled labour that enjoy great market power that many times is exercised via strikes. From 2010 to 2015, there were 95 strikes totalling to 176 strike days (French air traffic controllers went on strike on 95 days) and there were in total 223 days of disruptions (PWC, 2016). ATCOs went on strike and closed the Spanish airspace. ENAIRES filed sanctions against 61 Barcelona ACC ATCOs for the closure of the airspace, but dropped them in 2016.

USCA (2016), representing over 90% of the 2,400 controllers working in Spain, criticised the second collective agreement for the privatised towers. The 83% of ATCOs working in those 13 towers had initially rejected the agreement and requested improvements in the working conditions in respect to resting periods (USCA, 2016).

As far as the UK TANS is concerned, Civil Aviation Authority (CAA, 2013) concluded that the market conditions for a competitive environment in TANS did not exist; a situation that changes after 2011 when TANS has been 'liberalised' in the airports that are subject to SES performance regulation (Thompson et al., 2016). In 2013, there were 62 organisations certified to provide TANS in the UK (CAP 1004, 2013). Luton Airport conducted the first public tender process for TANS in 2011 and awarded the contract to NSL (i.e. NATS terminal services). Table 3 gives an overview of the TANS renegotiations and tenders in the UK.

Table 3: Renegotiations and tenders for TANS in the UK (CAP 1293, 2015)

Airport operator/Airport	Services tendered	Date of tender	Compliant bids	Outcome
London Luton Airport Operations Limited (LLAOL)	Aerodrome and Engineering	2011/12	2 bids	<ul style="list-style-type: none"> - NATS (Services) Ltd - 3 year contract with 2 and 1 year extension options

Airport operator/Airport	Services tendered	Date of tender	Compliant bids	Outcome
Birmingham airport Limited (BAL)	Approach, Aerodrome and engineering	2012/13	1 Bid and the development of a self-supply alternative	– Self-supply
Belfast International Airport Ltd (BFS)	Approach, Aerodrome and engineering	N/A	Renegotiated	– NATS (Services) Ltd – 5 year contract
Cardiff Airport Ltd (CAL)	Approach, Aerodrome and engineering	N/A	Renegotiated	– NATS (Services) Ltd – 5 year contract
Gatwick Airport Limited (GAL)	Aerodrome and Engineering	2013/14	3 Bids	– Deutsche Flugsicherung – 10 year contract
Manchester Airports Group (MAG)	Group contract for MAN and STN airports Approach (MAN only), Aerodrome and engineering	N/A	Renegotiated	– NATS (Services) Ltd – 10 year contract
Heathrow Airport Ltd (HAL)	Aerodrome and Engineering	2014/15	Renegotiated	– NATS (Services) Ltd – 10 year contract

In 2013, Birmingham airport decided to fully in-source the TANS under the newly formed Birmingham Airport Air Traffic Ltd. (BAATL). The fact that Birmingham airport owned all the relevant TANS equipment at the airport eliminated the need for negotiations and led to an easy transition with no significant impacts on the safety levels (Steer Davies Gleave, 2017). Secondment agreements with NATS Services Ltd (NSL) resolved the staffing concerns and offered increased flexibility to the transition process. The report conducted by Steer Davies Gleave for CAA in 2017, did not reveal any costs related to the change of provider.

In 2014, Gatwick airport ATC services have been opened to tender. According to CAP 1293 (2015), there were 14 providers interested, 5 submitted pre-qualifying questionnaires, from which Gatwick airport selected 4, 3 (including NATS) of which eventually submitted compliant bids. DFS subsidiary, Air Navigation Solutions Ltd, won the contract and started offering services on 1st March 2016.

When a TANS provider is selected, technical operational aspects and economic aspects need to be taken under consideration (Comendador et al., 2012). Monopolistic, revenue-driven entities tend to have little incentive to ensure fees are kept as low as possible whilst the labour-intensive nature of ANSPs contradicts the minimisation strategy of privatisation to keep costs low, as safety levels are the highest priority and reductions in the workforce may implicate safety levels.

In the UK, airport operators negotiate the TANS cost with the provider and then pass the charges to the aircraft operators as part of the overall airport charge (Thompson et al, 2016). Airport operators can also subsidise the cost of TANS if they wish. In the Republic of Cyprus, for example, the aircraft operators do not pay for TANS in order to make the airports more attractive to airlines and support the tourism development of the island.

In a nutshell, creating competition for TANS in airports (main or regional) can have economic and in some cases, operational benefits, that can benefit airlines, passengers and airport operators. Nevertheless, as recommended by International Federation of Air Traffic Controllers' Associations (IFATCA, 2017), organisations that provide ATM services beyond state borders, should clearly define the operational legal implications of providing these services, and controllers should be trained in the implications.

4.2 Remote towers

A number of technological innovations have been developed in ATM. Arblaster (2018) highlighted that a high degree of planning and coordination with the stakeholders is needed for the successful adoption of technology. Resistance to change can act as an obstacle. Advancements in Air Traffic Control (ATC) technologies can have a significant effect on small regional airports. ATC towers in small regional airports with very thin traffic are expensive to operate and maintain. ATC cost is significant for regional airports as it represents a substantial portion of their overall operating costs (Kearney and Li, 2018).

Various private companies with small cost of operation have contracts to operate towers at airports with low traffic in the U.S. According to Van Beek (2017), small airports qualify for a contract tower only if the benefits exceed the costs (i.e., a benefit/cost ratio of at least 1.0). Federal Aviation Administration (FAA) was considering shutting down 189 contract towers. Europe has a similar issue, where many small airports with extremely low frequency still require full-time Air Traffic Control Officers (ATCOs). ATCOs at the airports provide instructions on taxiing, departures and arrivals. In non-towered airports, pilots follow visual flight rules and monitor a common radio frequency.

Regional airports have a mix of Instrumental Flight Rules (IFR) and Visual Flight Rules (VFR) traffic with the latter being unpredictable for the ATCOs and requiring a more flexible reaction of the controllers. Moreover, VFR pilots are usually inexperienced and may not follow the commands from the tower correctly. Therefore, there is usually a more frequent controller–pilot radio communication (Papenfuss and Mohlenbrink, 2016). Moreover, remote airports typically do not have a wide range of sensor technology and the approach radar information covers only the aerodrome traffic but not traffic on the ground. Therefore, the presence of the ATCOs is still vital.

Some remote airports have difficulties recruiting ATCOs. Regional airports or airports with very thin routes can have significant savings by avoiding staffing the towers when the workload of ATCOs is low. Thus, the better utilisation of staff can have significant benefits in reducing the cost of low traffic density airports.

Remote Tower Centre (RTC), also known as Virtual Towers (VT) is the replacement of traditional control tower by an advanced sensor-based control centre. Instead of placing a tall ATC tower with controllers in the top floor, sensing devices like video cameras with a 360-degree field of view and communication antennas can transmit the data to a location that is staffed with ATC

personnel. Remote tower (RT) technology allows the object tracking (e.g. birds and foreign object debris) and alerting, infrared vision, digital image magnification and hotspots monitoring. Kearney and Li (2018) suggest that the advances in the Augmented Vision Video-panorama technologies improved the monitoring capabilities of RTCs. Moreover, RTC can be an alternative to raising or maintaining towers at remote airports and can enable the 7/24 airport operation.

The Single European Sky ATM Research (SESAR, 2013) has three operational concepts for two kinds of aerodromes; small aerodromes with low traffic, and medium to large aerodromes with high traffic. In the first group, it promotes the replacement of the traditional tower with the RT for single aerodrome (SDM-0201), or the RT for multiple aerodromes (SDM-0205). Figure 2 depicts the Remote Tower Centre at Dublin Air Traffic Services Unit that can offer services in Shannon and Cork simultaneously. In the latter group, SESAR recommends the remote provision of ATS for contingency situations (SDM-0204). The saving potential of RT for a single aerodrome is quite limited, whereas the RT for multiple airports can create cost savings via economies of scale.



Figure 2: Remote Tower Centre at Dublin Air Traffic Services Unit (Kearney and Li, 2018)

Sweden, Estonia, Norway, Ireland, United Kingdom, Malta, Hungary, Italy, The Netherlands and Germany have or are in the process of creating RTCs. The first remote tower was installed at Angelholm airport in Sweden in 2008. In 2014, LFV, a Swedish ANSP, operated the first RTC in Sundsvall, serving Ornskoldsvik airport which in 2015 was completely served by RTC, and in which €36 million will be invested between 2010 and 2020. (Copenhagen Economics, 2019). There are currently no operational multiple remote towers. By 2020, Estonian Air Navigation Services (EANS) aims to offer Multiple Remote Tower Operations (MRTOs), where one ATCO is providing services to more than one airports at the same time (EANS, 2019).

Norway has the largest number of PSO routes (around 60). Norway prioritises the accessibility of remote areas, but weather conditions and the limited number of passengers make the provisions of the terminal services very expensive. Avinor, the Norwegian ANSP, serves 46 airports and by 2020 aims to operate 15 RTs. The new RTC in Bodo, Norway that will be able to control multiple airports and will employ 60 staff, costs €11 million (ATC-Network, 2019). The total capital

expenditure budgeted for the remote tower project between 2015 and 2020 is €130 million, of which €60 million is for technology investment (Duestad, 2017). The estimated capital costs for a single-station RT in the USA is between 1.5 and 2.5 million USD (Van Beek, 2017). Irish Aviation Authority estimated that the RT operations reduce costs on the buildings, infrastructure and operational manpower by €1.3 million per year (Kearney and Li, 2018).

Table 4: Costs of Traditional Tower vs Remote Tower (Kearney and Li, 2018)

	Traditional Tower	Remote Tower
Build	Roughly cost £12M to Build. To assume 10% annual running cost for the building is reasonable £1.2M a year.	Build costs will reduce significantly as only a mast needed to house the cameras. Estimated cost of mast £2 M saving £10 M. To assume 10% annual running cost for the Mast is reasonable e.g. £200 K a year saving £800 K a year. In summary if the tower is depreciated over 30 years, saving is $(12-2)/30 = £333$ K in CAPEX, plus £800 K in OPEX so £1.33M a year.
Equipment	Usual Communications, Navigation, Surveillance and Flight Data Processing Systems.	Additional CAPEX is £2 M. If the remote tower system is depreciated over 8 years, additional costs is $2/8=£250$ K in CAPEX, plus £200 K in OPEX so £450 K a year. There should be potential to save on some of the Communications, Navigation, Surveillance and Flight Data Processing Systems Costs via centralisation which will offset some of the increase in network costs.
Manpower	Typical manning is 8–10 staff per H24 position.	Remote Towers will facilitate staffing efficiencies. The objective is to crew to workload such that operational staff are always busy within allowable safety limits. For the IAA example of Cork and Shannon controlled from Dublin we anticipated a saving of 4 ATCO's or £400 K a year.

Remote towers can offer a more cost-efficient alternative to traditional towers only when an RTC operates under sequential or simultaneous multiple modes. LFV suggests that RT can generate cost savings of up to 10% per year, whereas Copenhagen Economics (2019) suggests that this figure is not accurate. Regional airports with thin traffic can have significant savings with RTC, especially, if one RTC supports multiple airports. Van Beek (2017) suggests that the FAA should also invest in RTCs. He based this on the fact that the FAA terminal charges are not based on cost recovery. Passenger taxes cover the capital and operational expenditure of the FAA and general taxpayers contribute by 5%-30% depending on the budget year. Thus, the costs of less efficient tower centres are hidden and at the same time the FAA –in comparison to European ANSPs- does not have an incentive to be the most cost-efficient (Van Beek, 2017).

In terms of the construction costs of traditional towers, Copenhagen Economics (2019) supports that there are overestimations. LFV estimates their construction cost to 6-10 million EUR, Irish Aviation Authority to 14 million EUR and the actual cost of Skelleftea was 1.5 million EUR and 0.7 million EUR for Torsby airport in Sweden. Technological innovations, like RT, that are supported by airspace charges should be used to strengthen the dominance of the big 5 ANSPs

while creating the conditions for further competition in the ATC can have benefits for the social welfare.

IFATCA (2017) highlights the need to ensure that RTCs provide an equivalent level of safety to that of traditional tower operations and that there is ATCO licensing with a specific RT endorsement. EASA (2015) also recommends the introduction of a transitional and conversional training. In 2018, EUROCAE published the first industry-standard on the technical aspects of remote towers in the document ED-240A - Minimum Aviation System Performance Specification (MASPS) for Remote Tower Optical Systems.

The FAA conducted a study in 2007 and found that the workload of controllers in RTC was lighter, and their performance increased, especially in low visibility conditions (Poole, 2014). Human factors and specifically, human-computer interactions are central elements in RTC. The European Cockpit Association (ECA, 2014) expressed its concerns in their position paper. Adequate contingency procedures in case of hardware malfunctions and system downgrades should be in place, as well as cyber-security measures. ECA (2014: 5) stated that it ‘ECA does not support the implementation of Multiple RTS, until sufficient experience with Single RTS has been gained and until human factors and technical implications have been thoroughly researched and are adequately mitigated to ensure safe ATC operations’. It also does not support the implementation of cross-border RTS service, until a legal EU framework is implemented.

In adopting new technologies in ATM, Arblaster (2018) highlighted the need for interoperability and continuity of the services. Long-term planning, extensive testing and contingency management are important elements for the successful implementation of every technology, including remote towers. Nevertheless, Multiple Remote Tower Operations (MRTOs) offer further solutions for cost efficiency of air traffic services for small and medium size of airports (Kearney and Li, 2018).

5. Conclusion and policy recommendations

Remote regions rely on air transport in terms of economic development, but also social cohesion. After the liberalisation of airlines and airports, the policymakers and regulatory authorities are now focusing on Air Navigation Service Providers. More pressure is put on improving capacity and reducing delays as well as airspace charges. Regional airports, in particular, are quite price-sensitive and high charges in terminal air navigation make the competition for attracting routes even more difficult.

The Single European Sky reform is one of the most discussed topics among air traffic management practitioners and ANSPs have now to comply with the Performance Regulation in the four KPAs, i.e. Cost efficiency, Capacity, Environment and Safety. Cost constraints require new ideas and concepts, as well as structural reforms. ANSPs formed alliances and collaborations to reduce cost and enforce their market position. Some ANSPs become government enterprises gaining autonomy and flexibility. Under this regulation, the ANSPs restructured and some competition was implemented in the provision of the Terminal Air Navigation Services (TANS).

In the area of regional airports, the two relevant developments are the provision of Terminal Air Navigation Services (TANS), and the operation of Remote Towers (RTs). ANSPs started expanding their operations outside of their country borders. Some countries liberalised ATC and issued a call for tender for the provision of ATC services in towers aiming to improve the quality of service at those airports, but also to reduce the cost of service.

As a consequence of SES reform, technological innovations were also used a dominance strategy. Greater commercial freedom allows organisations to improve productivity and efficiency, diversify their products, expand in new markets and innovate. The second area of interest to regional and remote airports is the remote towers. Remote tower centres that serve more than one airport can have a significant benefit to remote airports as they reduce the cost of delivering ATC services and offer operational benefits like the 24/7 ATC coverage. Nevertheless, this initiative needs to be further tested to ensure the safety of operations, regulations, standards, interoperability and implementation.

There is still a lot to be done to ensure effective market competition in this area and the policymakers should properly evaluate the market conditions and enhance a solution that promotes social welfare. There is no clear conclusion on which way would be the most suitable to improve the quality of service and enhance performance. Moreover, ANSPs' performance needs to be properly evaluated and parameters that are in accordance with the airspace users, airports and passengers requirements need to be established. The ANSPs need to provide an accurate breakdown of their costs and profits per airport and per sector over the last decades. This would lead to a better understanding of the ANSPs performance.

Policies need to be diversified in accordance with the requirements and role of each entity. Airports, like Amsterdam Schiphol, that are price insensitive can bear the high cost of terminal air navigations, but airports with thin traffic and thus price sensitive struggle to attract and preserve air route that are vital for the economic development of the region and therefore competition in the TANS or replacement of the traditional tower with a Multiple Remote Tower Operations (MRTOs) can potentially lead to significant cost reduction and quality improvements. Given the high cost of Research and Development, mandates and funding can push the development and implementation of technological innovations like RTs. Nevertheless, this needs to be done carefully and after extensive Cost Benefit Analysis (CBA) to avoid subsidisation of entities that could lead to oligopolies or monopolies that abuse their monopolistic power in the long-term future. A clear pathway, that takes under consideration the specificities of each country and that is consistent with optimal service standards, does not exist and should be developed.

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