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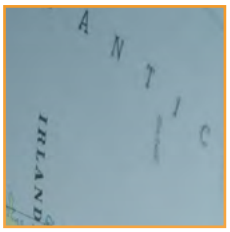

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# *Disruptive Technologies in Air Traffic Management*

*Editors: Matthias Finger, Nadia Bert, David Kupfer*

## Highlights

*Air Traffic Management (ATM) is a conservative sector in which technological modernisation follows an evolutionary path, at best. This evolution is predominantly shaped by regulation and the monopolistic infrastructure operators, the national Air Navigation Service Providers (ANSPs).*

*Technological disruptions, on the other hand, are associated with sectors in which market forces play a stronger role and where new entrants can shake up dominant players by applying a new disruptive approach.*

*In the absence of market forces the SESAR program was set up by the EU to promote technological modernisation in the sector by means of funding development and deployment of new ATM technologies in cooperation with the sector and according to the so called ATM Masterplan. Additionally the European Commission is favouring market opening and competitive tendering for some ATM related services. Can this setup achieve the modernisation and technological transformation of the sector? Or will it eventually be disrupted from players outside the traditional ATM community namely the emerging Unmanned Aerial Vehicle (UAV) industry that is actively developing new ways to provide air navigation services?*

# ATM: why a technological disruption is needed - and why it is coming

A comment by MATTHIAS FINGER | FSR-Transport Director

Air Traffic Management (ATM) is only one, yet a very crucial, element of the air transport value chain. Almost all elements of this very value chain have been optimized by now, ranging from aircraft producers (airplanes are now standardized products) to highly efficient air transport operations, to optimized aircraft maintenance, to yield management techniques, to increasingly better airport operations, and many others more. ATM is probably one of the last, if not the last element of the air transport value chain waiting to be optimized in turn.

The European Commission (EC) has recognized this since long, launching its Single European Sky (SES) initiative already back in 1999. But, despite of all the various efforts undertaken by the EC and many others, the SES has not delivered and actually, to quote a general feeling, has ended in gridlock. The introduction of Functional Airspace Blocs was never completed successfully, and the latest update of the legislative framework (SES2+) is far from reaching the necessary support of Member States.

But, because the current – nation- and sector-based – ATM system is rapidly reaching its limits, i.e., producing capacity crunches, and because drones (Unmanned Air Vehicles or UAVs) are rapidly filling the airspace, it is simply not possible to improve the current ATM system any further without a qualitative, i.e., disruptive change in the technologies applied. Yet, to implement this urgently needed technological upgrade in ATM, the SES gridlock needs to be overcome.

But, just before talking about the concrete ATM technologies, especially disruptive ones, let me make a brief detour via theory or rather conceptualization. We, at FSR, are indeed working since a long time with a conceptual framework called "co-evolution between technology and institutions" (institutions being formal and informal rules). Both technology and institutions need to evolve somewhat in parallel so as to produce the best results. If there is no coherence between the two, their combination will lead to suboptimal outcomes; and if the discrepancy between the two is too big, i.e., producing unsatisfactory outcomes, disruption on either the technological or the institutional side is likely. The following graph illustrates this basic idea:

And this is precisely what is happening today in ATM: on the one hand, the fragmented situation of the institutions in charge of ATM has

fundamentally remained unchanged. On the other hand, substantive technological progress in satellites, communication and digitalization – some of which actively promoted by the EC itself thanks to Galileo and the Single European Sky ATM Research (SESAR)– is leading to new, potentially disruptive innovations for ATM, such as virtual centers and corresponding centralization of some of the ATM services, remote towers for Air Traffic Control (ATC), flight-centric operations, sector-less ATM, and probably other disruptions more in the not so distant future. As a matter of fact, drones and UAV more generally are themselves the result of disruptive technological progress, and are now pushing for a disruptive change in ATM.

Everybody agreed at the 8th Florence Air Forum, that, while disruptive technologies can push for a (potentially radical) transformation of the way ATM is currently done, technology alone cannot just substitute rules. In other words, rules or institutions will have to (radically) evolve to accommodate or simply to allow these technologies to be deployed. Indeed, the battle around the SES is a big European laboratory which has given rise to all kind of technological innovations, but if the rules of the game do not change now and do not allow at least some of these technologies to be rolled out, this will hamper the development of many innovative European firms and ultimately the European air transport industry altogether.

So, besides the urgent need to adapt European ATM regulations to the newly emerging technologies in ATM and elsewhere, the European Parliament (EP) and the EC also need to learn how to "effectively regulate" technological disruptions: maybe something like "regulatory heavens" (i.e., exemptions from certain regulations for a limited period of time) or "regulating experiments" (under full respect of existing procedural and safety rules) are needed so as to be able to test such newly emerging technologies in ATM and beyond. Maybe entire countries can offer themselves as a place of experimentation. This will be needed in order to allow disruptive innovators to deliver proof of concept and ultimately to develop the technologies and corresponding productions. Once such experiments turn out to be successful, it will be necessary to change the overall (ATM) regulatory framework so as to allow and eventually facilitate these technologies to be rolled out in Europe and commercialized beyond Europe. Such considerations are of course valid far beyond ATM. Yet, ATM is currently the laboratory where disruptive innovations are urgently needed and where new technological solutions such as virtual centers, remote towers, sector-less ATM or flight-centric operations need to be encouraged so they can ultimately be rolled out on a cross country scale.

*Matthias Finger*

# 8th Florence Air Forum "Disruptive Technologies in Air Traffic Management"

Discussions at the 8th Florence Air Forum touched upon several aspects of the technological and regulatory development in European Air Traffic Management (ATM). Concrete examples of potentially disruptive technologies were presented as well as possible implications for the system and ideas for a new regulatory system. Discussions addressed four main questions:

- What are disruptive technologies and how does the concept apply to ATM?
- What can ATM learn from other sectors to address the challenges connected to the rising need for innovation speed?
- How can innovation be supported effectively and which are the most promising solutions that SESAR should be focussing on?
- The role of regulation: Do we need to rethink the regulatory approach to ATM in light of new technologies?

## *What are disruptive technologies and how does the concept apply to ATM?*

Background for the 8th Florence Air Forum is the long standing issue to improve the efficiency of the European airspace. The Single European Sky, many agree, is currently in gridlock while growing traffic volumes urgently require a more efficient cross European organisation of ATM. In spite of the Single European Sky legislative packages, airspace in Europe remains fragmented along national boundaries and is far less efficient than the US airspace, which is of a comparable size[1]. Technology plays a key role in this process; most importantly as an enabler for more efficient ATM and as a way to facilitate the transition to a more logical organisation of the airspace without compromising the politically undesired closure of control centres. As technology evolves an increasing amount of solutions is becoming available that would fundamentally challenge current principles of the organisation of ATM, which is today still based on the same technological approach that has not changed over the past 40 years.

Against this backdrop the Florence Air Forum looked into the state of play of new technologies in ATM with a disruptive potential.

1. Eurocontrol, 2016, 2015 Comparison of Air Traffic Management-Related Operational Performance: U.S.A. and Europe

The definition of disruptive technologies caused some discussions in the beginning and principally it was agreed that the **logic of disruptive innovation** cannot actually unfold unless there is a competitive market. Since this is clearly not (yet) given in ATM, part of the discussion also addressed the question of how ATM, or parts of it, can become more market based so as to allow for such disruptive processes. The discussion on markets in Air Traffic Control (ATC) had, in fact, taken place also at previous Florence Air Forums[2]. However, it was agreed that in spite of the absence of disruptive processes, potentially disruptive technologies are clearly becoming available in ATM.

Disruptive ATM technologies that are currently in different stages of their development were discussed, most prominently virtual centres, remote towers, sector-less ATM and flight-centric operations. Some of these technologies are clearly already "managed" by the established players in the field (manufacturers and Air Navigation Service Providers, ANSPs). It was therefore differentiated between technologies that potentially disrupt operations and those that may disrupt the entire industry. The latter may be the case for the emerging technologies surrounding ATM for unmanned vehicles (Unmanned Aircraft System Traffic Management, UTM) which is mostly championed by non ATM players, namely telecommunications companies (see section 2).

Generally speaking, the technological trend is that thanks to virtualisation ATM service provision will progressively be decoupled from the physical infrastructure in the future. This would create enormous efficiency gains as, for instance, data and infrastructure could be shared between different centres and thereby make better use of existing resources reducing investment costs.

Some of the cases presented by ANSPs made it very clear that new technological approaches are not compatible with the current fragmented system. For instance flight centric operations have been tested under real conditions and are at a mature stage of development, which is causing some optimism as to the productivity increases they could achieve. However, their application only makes sense in larger airspaces. On the one hand, it was argued that this calls for a more cross border approach. On the other hand, it was argued that this technology first has to be tested in one of the larger airspaces (such as France or Germany). Furthermore, in order for a market approach to function it would be necessary that more than one supplier is able to deliver the technology so as to create competition.

2. Florence School of Regulation Transport Area, 2014, Markets in Air Traffic Control and the Evolving Role of Eurocontrol, European Transport Regulation Observer, 2014/02

These and other examples showed that the development of new ATM technologies has been quite successful from the technical side. At the same time, as these technologies were developed there seems to have been a lack of thinking about the system of service provision under which they could actually enter the market. Many approaches cannot be deployed on a national basis, and there is currently a lack of a corresponding system-wide vision. Manufacturers need clear signals that the technologies they are investing in will have a market at some point on a European and ideally global level.

Clearly, ANSPs and their management are in a central position to drive the change. How come so few are actually pro-actively embracing new approaches? The answer was seen in the way incentives are currently structured. Currently ANSPs that want to move on face costs and risks that are not sufficiently outweighed by the corresponding ensuing benefits (see section on regulation).

## *What can ATM learn from other sectors to address the challenges connected to the rising need for innovation speed?*

Several important inputs at the forum came from outside the ATM world, namely from the telecommunication sector and from the ticketing system provider Amadeus.

The telecommunications sector provided interesting insights in two ways: on the one hand, the industry had undergone disruptive changes itself, and many players have used new technologies to develop new business models. On the other hand, communication and data technology are an essential element of ATM, and looking at ATM from the telco perspective may actually show where the biggest potentials of new technologies lie.

Most importantly, the telecommunication industry showed how far the development of UTM already is and how it could benefit the ATM sector. Yet new technologies are not immediately embraced by the ATM community.

In fact, it was pointed out that ATM is a highly protected sector. The technology used has to undergo several years of testing and certification before it can be deployed. Regulation is very detailed and leaves little room for entrepreneurial initiative. Furthermore ANSPs, manufacturers and regulators form a microcosm that hardly ever faces the event of new players entering their field. The combination of these factors, according to some comments, makes ATM the most conservative technology sector. Furthermore in the political arena “security” and “sovereignty” are often used as arguments to defend the status quo. The validity of

these arguments was questioned at the forum. For instance, the notion of national sovereignty that needs to be defended by strictly government owned infrastructures is an archaic one. In fact critical infrastructures are interwoven to a much higher degree in in other sectors such as banking. Similarily cyber security is dealt with successfully in other sectors and safety is actually improved in several ways with the ATM technologies.

An important factor that is missing in ATM is the customer focus. Eventually most disruptive changes in other industries were the result of customers' demand. ANSPs are classically monopoly businesses that do not depend on "customer satisfaction" to stay in business. It was noted on several occasions that the customers of ANSPs namely the airspace users (airlines, most importantly) were not present at the discussion; however their pressure may be crucial and one way a possible step forward would be to form partnerships between airlines and ANSPs.

The emergence of civil drones has been of major concern for ATM over the past years. The main challenge in the drone sector is to develop technologies and procedures that allow their operation in regular airspace. It is not yet entirely clear which role traditional ATM actors and rules will play in this field. However, as both the supply and the demand for drones are accelerating there is pressure to create a system that allows the use of drones for both private and business purposes. The value of this emerging sector was exemplified by one number. According to a **report by Nokia on the commercial applications of drone technology** 127 billion US dollars will be spent on unmanned aerial vehicle applications by the year 2025 globally.

This is where telecommunication companies are currently leading, and their research has significant implications for traditional ATM. Especially with the prospect of allowing commercial drone operations they are actively working on ATM systems for drones that allow safe beyond line of side operations mainly be guaranteeing reliable collision avoidance and respect for no fly zones. This is done not by applying traditional ATM technologies (radars, transistor radios, etc.) but relying solely on mobile phone networks and satellite-based navigation. For the telecommunication industry this effort is not meant as a way to enter the world of aviation, but part of their strategy in the business area of the internet of things.

An example from the Netherlands showed that **an Unmanned Aerial Vehicle (UAV) traffic control centre has already been established**. This will allow extensive testing under real conditions. There are still several challenges that need to be overcome. To meet the high standards of Air Navigation Services, localisation and data communication need to

become more precise and reliable. There seems to be the need for some more time of development before these concepts are fully operational, yet it appears that existing concerns can be dealt with. Upcoming 5G network and improved geo localisation make it possible to integrate drones in lower airspace purely based on mobile communication technologies. The issue of security was often addressed; however, there is wide ranging experience in other, also safety relevant sectors such as automated train operations but also banking.

The discussion also added some caution to the general optimism; for instance it was pointed out that Google had to go back on their promise of delivering an ATC centre for UAVs in the US. The barrier for this is, of course, regulation. While several technological companies are eager to test solutions it remains difficult to obtain the necessary permits and overcome burdensome regulatory requirements. The activism of new players such as Google is, however, not only met with concerns from established aviation actors. Some of the established players actually welcome this development hoping that this can shake up the ATM industry from the outside.

## A Short Commentary on the 8th Florence Air Forum on disruptive Technologies in Air Traffic Management

NICOLE ADLER | The Hebrew University of Jerusalem

On the 21st of October 2016, I was fortunate to attend a roundtable discussion on the topic of disruptive technologies in air traffic management (ATM). Attending the meeting were many of the relevant stakeholders including European and state regulators, air traffic control organizations, airport and technology companies, union representatives, lobbyists and a smattering of academics. Perhaps surprisingly, the key missing link were the airline carriers who are expected to be the main beneficiaries of the new technologies. It may be that the airlines are not interested in increasing capacity, one of the main aims of adopting the new technologies, because it is likely to lead to greater competition. As a society, we need to remember that the final consumers are the passengers and freight hence the European regulators interested in encouraging the adoption of disruptive technology in order to maximize overall social welfare that accounts not only for producer profits but also consumer surplus, should indeed find the paths to incentivise the system accordingly.

What are the main issues preventing the adoption of ATM technologies that have cost to date around 3.5 billion euros in research and development in Europe alone? Political interference in the form of state protection of local producers, labour unions protecting the air traffic control personnel, customers in the form of airlines merely pushing lightly for lower costs and weak regulatory incentives encouraging air navigation service providers to reduce costs slightly rather than expend effort in increasing capacity through technology adoption. With respect to the latter issue, clearly moving regulation from the states to the European Commission has led to data collection which enabled a gradual move from cost based to price cap regulation. However, perusal of the data shows serious compatibility issues across the countries and weak power has

## *How can innovation be supported effectively and which are the most promising solutions that SESAR should be focussing on?*

SESAR is the European program for research and development of ATM technologies. The underlying objective is to support the rationalisation of European ATM by means of technological development.

Discussions on the future of SESAR mainly focussed on existing projects and technologies in ATM that are part of the ATM Masterplan, the document guiding the research under SESAR over a period of five years. The most prominent example for this may be the remote tower, a technology where Europe is leading, and the example of Budapest illustrated the cost savings that are possible: especially when high investments in the renovation of physical infrastructure are due there can be an opportunity for such an approach. This example could be seen as a first step towards the virtualization of the system. From the manufacturers perspective it is important to know whether this will be the future path for ATM so they can invest in technologies for which there will eventually be a market.

led to standardized cost reduction requirements of 1-2% annually instead of individual targets per Air Navigation Service Provider. The Single European Sky initiative, whilst eminently sensible as an attempt to enjoy economies of scale on a continental basis and reduce costs by an estimated 50%, has failed to materialize for all the reasons aforementioned.

This leads us to the question: what could help achieve the goals set out in the European ATM Masterplan including a reduction in revenues of 50% matched by a similar cost reduction, a tripling of airspace capacity and an improvement of 20% in flight efficiency? First, the Masterplan must disaggregate the cost benefit analysis to consider the individual companies in the air traffic control supply chain because the summation masks the reality that parts of the chain are expected to lose hence are unlikely to permit change without financial incentives. Second, after some analysis of the ATM market, it is clear that any impact on airlines is likely to be marginal because the expected reduction in air traffic control charges and congestion costs is almost equivalent to the required investments in technology and training. In other words, the costs of the new technologies are too high for the expected benefits to the intermediate customers, namely the airline carriers. Third, the price cap system currently in place needs to be strengthened and linked to the air traffic control investments in disruptive technologies, as the British have instigated with the public-private partnership NATS. Finally, it would be helpful to stop promoting the Functional Airspace Block approach and instead privatize the air traffic control provision thus (i) enabling the companies to collaborate or merge on a commercial basis and (ii) reducing the impact of political interference. The process of setting Reference Period 3 targets is now in place and it is time to accept that the top down approach has failed. A preferable approach towards change may be to introduce competitive forces through the tendering of ATM services in order to encourage horizontal mergers and alliances between ATM companies and vertical collaboration between airlines, hub airports and ATM companies, known as the regional forerunner approach. Sadly, this will only occur if the individual states agree to place consumer rights as equal to those of the producers in the ATM supply chain.

Most of the suggestions draw from two European funded projects: ACCHANGE and COMPAIR .

SESAR has several innovations in the pipeline and will increase the exchanges with smaller companies outside the usual ATM industry environment. The program is highly appreciated as it has developed a functioning and close partnership with the industry. Nevertheless there is a risk that diverging interests of different national providers prevent harmonised deployment of technologies across Europe. At the Forum there were also warnings that a lot of tax payer money (circa 3.5 billion) is actually at risk if the benefits of these technologies never materialise. One argument that was raised is that SESAR needs to revise the basis for the cost benefit analyses of SESAR technologies on the basis of individual ANSPs. This could reveal that they are currently not properly incentivised to pursue this transition (see comment by Nicole Adler and section four).

## Disruptive Technologies in Air Traffic Management

KENNETH BUTTON | George Mason University

The roundtable discussions of the October 21st 2016 regarding the effects of disruptive technologies on air traffic management (ATM) highlighted many of the challenges of integrating network industries. The efforts to update air traffic management on both sides of the Atlantic have been moving forward, but at a much slower pace than had been hoped for, and at a higher financial costs. These two failings are not unconnected.

Focusing on Single European Sky initiative – the US has its own particular issues – the value chain that provides air navigation services (ANSs) involves a series of nationally controlled, and largely state owned monopoly agencies. The individual suppliers in this succession of vertically independent geographical entities have little incentive to integrate without some form of external incentive. There are market rents, in financial and other forms, to be enjoyed by the individual incumbent suppliers of these services with the retention of the *status quo*. Investment in new technologies or, and equally important, innovative practices provides little by way of financial gain to the agencies or the stakeholders immediately involved, and the costs can be considerable. There are also few external benefits for any individual ANS supplier in investing; indeed, in many cases the benefits from doing so are enjoyed as external gains by the ANSs either side of the value chain. Added to this, there is little competition from outside the ANS market. Unlike airlines, and, albeit to a lesser extent, airports, the technical nature and economies of scale in providing most ANS services mean multiple supply is inefficient, a situation exacerbated because there are no real substitutes technologies. And, on top of all this, the diverse ownership and governance of the various national ANSs means that, at the micro level common objectives are absent.

The effort so far to reap the benefits of the network economies associated with more integrated systems, and of deploying a common state-of-the-art delivery platform, has been stymied by these intrinsic problems worsened by a lack of serious political commitment. This is despite the expenditure of billions of Euro in seeking out common technologies suited to an integrated system. The idea of the shaming of countries to stimulate them to move forward using a Performance Review Body to benchmark, and, at a meso-level, designating Functional Airspace Blocks (FSBs) to foster "local" coordination of contiguous ANSs, has clearly failed. Diversity in efficiency remains, and the pecking order little changed, and the FABs, while perhaps seeing some internal coordination within Blocks, has done little to bring about greater overall European coordination and efficiency.

## *The role of regulation: Do we need to rethink the regulatory approach to ATM in light of new technologies?*

Certainly rules in the area of ATM need to adapt as new technologies emerge. This had become obvious already at the discussion for a regulatory framework for drones[3]. The 8th Florence Air Forum also addressed how regulation can set the right incentives for the adoption of new technologies. Several ideas were discussed and the issue of economic regulation had been somewhat in the centre of attention in this final discussion. Disruptive technologies mainly need to be seen as a tool to make ATM more efficient. As part of the Single European Sky legislation the performance scheme is the mechanism that should drive such technological change: through multiannual performance plans

3. Florence School of Regulation Transport Area, 2015, Regulating Drones – Creating European Regulation that is smart and proportionate, European Transport Regulation Observer, 2015/03

Moving forward, given the political history of the Single Sky, and the fact that the use of significant public monies has been to little avail, it seems unlikely that "more of the same" will succeed. The challenge is to get the stakeholders in the ATM sector incentivised to optimise the degree of integration across European airspace. The introduction of a common basis for charging has been one move in this direction. However, the accountancy style, cost-based approach offers minimal incentive for embracing the advantages of genuine economic pricing. It may currently have the objective of reducing annual costs by 1.7%, but there is no incentive, as there would be with genuine price capping in a commercially oriented market, to go further.

The unilateral actions by some governments to step back from direct control of ANSs by corporatizing, to use Canadian terminology, or privatizing them provides some de-politicization of decision-making. There remains however, in virtually all cases where this occurs, limited incentive for full efficiency, and the process does little to stimulate or imitate market forces. In particular, not-for-profit constraints that typify many corporatized ANSs are akin to zero rate-of-return regulation with the prospect of gold plating of systems. The UK's NATS system of price capping in this case has advantages. But in all cases, what is lacking is any degree of horizontal integration in the inter-European value chain; the measures in place tend to act at the local national level with local interests at their heart.

While the distancing of ATM from national political interference is increasingly possible as technology evolves – currently a single European ASN provider could handle all *en route* control and satellite, rather than radar based systems, could extent the divorce further – the strategic significance of controlling national airspace remains a reality. But accepting this, it should not be beyond the wit of man to come up with institutional structures that redistribute the wider benefits away from the various service providers and towards the users. The case studies offered at the roundtable illustrated what can be done in terms of new technologies, albeit at more specific, micro levels, but extending these experiences to a large, multi-national context is perhaps another matter. Disruptive technologies there may be, but the main feeling one is left with after attending the roundtable is that the main disruption to enhancing ATM lies in the institutional system that regulates ANSs. Circumventing this would seem to require a significant champion in the political arena, in addition to the availability of technology.

Member States agree to improve their performance in safety, delays and cost efficiency at a specific rate. But does this lead to a push towards new and better performing technology?

The performance scheme is close to reformulating its targets for the upcoming reference period 3 (2020-2025). **The formulation and enforcement of the performance scheme is a complex mechanism** in which Member States play a crucial rule. It was prominently discussed how to make the performance scheme more effective. A proposal that was discussed was to move from the current performance based approach to a stricter price-cap regulation. Such an approach has been successful in other sectors; among others the price-cap regulation for airports in Ireland was mentioned as an example.

### *From economic regulation to competition?*

The performance scheme is a means to create performance incentives in the absence of open market competition. As was discussed at previous Forums some ATM services can be unbundled and opened to competition[4]. It was agreed that, whenever a segment of ATM has successfully moved to competition (that is when a certain service has been put out to tender), this segment should be exempt from the performance regime.

Economic regulation should generally be as straightforward as possible and not prescribe specific technologies.

One specific proposal to change the performance scheme was to modify the Key Performance Indicators in a way that they reflect the extent to which ANSPs have moved towards new technological models. This could be done by measuring the relationship between capital expenditure and operational expenditure of ANSPs: new technologies go in the direction of 'serviceisation'. This means that instead of investing in building up their own systems, modern ANSPs increasingly buy ATM services from externals. This has implications for the financial planning and is reflected in the capex-opex relation, which could therefore serve as a proxy for an ANSP's willingness to embrace new technologies.

A more systematic flaw with the performance scheme was seen by some at the Forum in the fact that ANSPS are owned by the governments that effectively regulate their performance. Therefore, one could speak of a form of regulatory capture as governments have no true incentive to reduce the revenues of their own companies. Non-European examples such as Canada, New Zealand and Australia could be seen as cases that support the full privatisation of ANSPs.

4. Florence School of Regulation Transport Area, 2014, Markets in Air Traffic Control and the Evolving Role of Eurocontrol, European Transport Regulation Observer, 2014/02

### *Competition or Cooperation?*

Some noted that there is a certain contradiction in the current regulatory approach as it tries to incentivise both cooperation and competition at the same time.

Overall in spite of the imperfections it was pointed out the existing performance scheme takes credit for improving the performance significantly over the past years and for making the necessary data available on the basis of which the regime can be developed further. It appears, however, that the current system may have reached the limits of performance improvements that are possible without fundamentally changing the system.

# Further readings

Adler, Nicole; Hanany, Eran; Proost, Stef, 2015, "Managing Change in European Air Traffic Control Provision", conference paper

The paper develops a network congestion game to test a series of scenarios in order to analyse potential paths for change in air traffic management in Europe. The two stage game models en-route and terminal Air Traffic Control (ATC) providers that set peak and off-peak charges and in the second stage airlines that choose flight paths given an airline schedule and the charges from the first stage. The scenarios analysed in the model include (i) the impact of privatization and deregulation; (ii) defragmentation of the set of current providers; (iii) introduction of technology via the common projects and SESAR step 1; and (iv)the regional forerunner approach in which ATC providers and a specific airline co-operate. The results show that horizontal integration across ATC providers, known as functional airspace blocks, would appear to be problematic with respect to incentives hence regional forerunners in a bottom-up institutional process would appear to be a preferable approach. Vertical integration between companies may succeed in accelerating change as long as the ATC companies are permitted to charge for improved quality, such as reduced congestion. Institutionally, a clear separation of the ATC providers from the Member States and subsequent franchising of the support services and ATC services could further encourage efficiency, consolidation and technology adoption.

Blondiau, Thomas; Delhaye, Eef; Proost, Stef; Adler, Nicole, 2016, "ACCHANGE: Building economic models to analyse the performance of air navigation service providers", Journal of Air Transport Management, Volume 56 part A p.19-27

This research develops an economic public utility model to analyse the effects of the Single European Sky performance regulation on Air Traffic Control performance. It investigates incentives for air navigation service providers through the development of a high level economic model. It assesses impacts at a strategic level and derives high-level results. The economic model provides insight into the mechanisms through which regulation can drive air traffic management performance improvements, as well as its limitations.

Christensen, Clayton M.; Raynor, Michael E.; McDonald, Rory, 2015, "What Is Disruptive Innovation?", Harvard Business Review

For the past 20 years, the theory of disruptive innovation has been enormously influential in business circles and a powerful tool for predicting which industry entrants will succeed. Unfortunately, the theory has also been widely misunderstood, and the 'disruptive' label has been applied too carelessly anytime a market newcomer shakes up well-established incumbents.

In this article, the architect of disruption theory, Clayton M. Christensen, and his coauthors correct some of the misinformation, describe how the thinking on the subject has evolved, and discuss the utility of the theory.

Florence School of Regulation Transport Area, 2016, 8th Florence Air Forum "Disruptive Technologies in Air Traffic Management", Summary of presentations

This document offers summaries of the presentations given by the speakers at the 8th Florence Air Forum "Disruptive Technologies in Air Traffic Management". The presentations were structured along four discussion questions:

- What are disruptive technologies and how does the concept apply to ATM?
- What can ATM learn from other sectors to address the challenges connected to the rising need for innovation speed?
- How can innovation be supported effectively and which are the most promising solutions that SESAR should be focussing on?
- The role of regulation: Do we need to rethink the regulatory approach to ATM in light of new technologies?

### PwC, 2016, "Clarity from above - PwC global report on the commercial applications of drone technology"

The report seeks to quantify the impact of drones by examining commercial applications of drone technology across industry sectors. Of interest are not only the machines (drones), but their broader applications for business, such as in the ability to capture unprecedented levels of data. When discussing the constant development of new drone applications, it is important to consider the regulatory and technological perspectives. Airspace governing bodies are facing the crucial challenge of ensuring the safety and privacy of citizens without suppressing innovation and growth. In many countries, regulations are being implemented to require pilots to pass practical and theoretical tests and medical examinations, as well as receive permission to fly in particular areas and beyond visual line of sight (BVLOS). These regulations are accompanied by technological improvements in avoidance and air-traffic management systems. The lack of such solutions may constitute a barrier to the development of commercial drone applications in a given territory.

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## FSR Transport

The Florence School of Regulation (FSR) is a project within the European University Institute (EUI) focusing on regulatory topics. It works closely with the European Commission, and is a growing point of reference for regulatory theory and practice. It covers three areas: Communications and Media, Energy (Electricity and Gas), and Transport.

The FSR-Transport Area's main activities are the European Transport Regulation Forums, which address policy and regulatory topics in different transport sectors (Rail, Air, Urban, Maritime, Intermodal transport and Postal and delivery services). They bring relevant stakeholders together to analyse and reflect upon the latest developments and important regulatory issues in the European transport sector. These Forums inspire the comments gathered in this European Transport Regulation Observer.

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