ACCHANGE: Lessons Learned and Way Forward

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***Abstract*—This paper presents an overview of the main lessons learned during the ACCHANGE project[1]. We have structured the discussion along a number of institutional elements which we consider key for understanding and boosting change in the Air Traffic Management (ATM) sector. These are: collaboration, regulation and liberalization.**

Based on different modelling exercises performed within ACCHANGE we provide a tentative way forward for the ATM sector in Europe. But we also go beyond the conclusions of ACCHANGE and explore how key messages and ideas from the project could translate into innovative ways for boosting change in the sector.

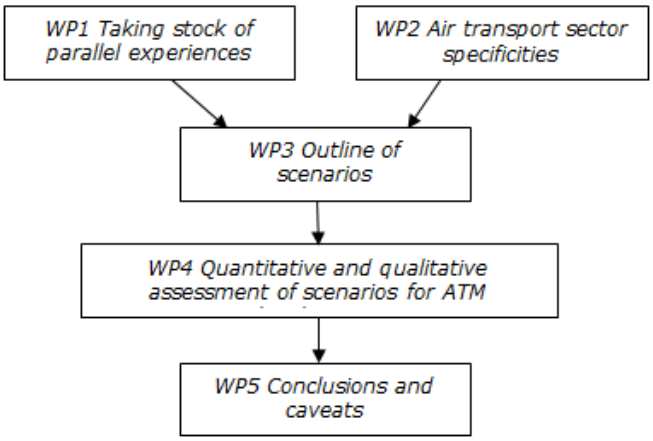
Institutional change; competition; collaboration; regulation; liberalization

I. INTRODUCTION & PRESENTATION OF ACCHANGE

The ACCHANGE project started from the observation that many attempts to restructure and modernize the ATM sector in Europe have been slow and have had only limited success [1], [12]. For instance, the implementation of Functional Airspace Blocks (FABs) has up to now not achieved the benefits that were initially anticipated. Also, the pace of technology adoption in the sector is often perceived as slow. Most attempts at restructuring the sector, such as FABs or the SESAR technology deployment program, have taken a rather top-down perspective. The idea of the ACCHANGE project was to explore whether bottom-up mechanisms could be found for stimulating change. These bottom-up tools can be complementary mechanisms in formulating effective transition policies towards a new, innovative and collaboration-oriented European ATM sector.

The ACCHANGE project was structured into five work packages – each of them linked to a separate Deliverable. This article mainly draws on the insights from the final work package and its deliverable D5 [8] which summarize the main conclusions and point to some caveats in our work that deserve further research. We also gave some ideas on how to move on with research and policy-making beyond the ACCHANGE project. To situate this work package in the overall project, Figure 1 gives an overview of its work package structure.

Figure 1 Work package structure of ACCHANGE



The study started with an analysis of the present developments in the ATM sector and in the aviation sector in Europe (WP2) [1]. These developments were compared with evolutions in other sectors (WP1) [6]. We focused on institutional factors that prevent change from taking place in the ATM sector: "Home bias" (protection of sovereignty and national interests), the "Status quo bias" (resistance to change), "Regulatory contradiction" (price cap regulation is not necessarily compatible with the adoption of new technologies if the associated costs are not compensated), and "Coordination complication" (the incentive mechanism is complicated by the necessary coordination of multiple stakeholders that all need to buy into the initiatives, and the imbalance in the distribution of costs and benefits across stakeholders).

In a third work package (WP3) [7], the main players and elements of the scenarios to be assessed were described. These scenarios were then assessed using quantitative models. The most important results of this project are based on the insights

[1] The ACCHANGE project was executed in the framework of the SESAR program (WP-E.02.31), co-financed by the European Union and EUROCONTROL. All deliverables of the project are available at: http://www.tmleuven.be/project/acchange/home.htm

drawn from WP4 [3]. In this work package, we developed four models to analyze the current situation in ATM and the potential paths for change:

1. a network congestion game
2. a union bargaining model
3. a public utility model
4. and its extension to a simple network setting

We come back to the scenarios and the model in section III.

II. PROBLEM SETTING

The European ATM system consists of 37 Air Navigation Service Providers (ANSPs). Among ANSPs, there is quite some heterogeneity in terms of the characteristics of the airspace traffic that they control and, associated with this, there is also variance in the systems, rules and procedures used. The ANSPs have monopoly power in their assigned airspace. Consequently, they are regulated or controlled by National Supervisory Authorities of the countries that have the national authority over that airspace. Since the Single European Sky program, the European Commission also has significant regulatory and oversight powers.

The European ATM system remains fragmented along national boundaries and there is a need for overarching harmonization. This should enable ATM to better cope with coming challenges for the sector. According to the European Commission (MEMO/13/525)[9], the main challenges are:

1. congestion with regard to a predicted capacity crunch as the number of flights is forecasted to increase by 50% over the next 10-20 years;

2. cost inefficiencies of an estimated 5 billion Euro each year to airlines and their customers caused by Europe's fragmented airspace;

3. pollution due to sub-optimal flight profiles;

4. delays and longer routes forcing aircraft to burn excess fuel, generate unnecessary emissions, pay additional user charges and suffer greater delays;

5. falling behind peers: the United States controls the same amount of airspace, with more traffic, at almost half the cost[2].

We also identified five sources of problems which prevented the modernization of the European ATM sector:

1. ATM, from the very beginning, grew out of military services and hence was and still is nationally organized. In Europe this has led to a large **fragmentation**, in which each country has at least two ANSPs (civil and military[3]). These many European ANSPs operate with important variations in cost effectiveness [16]. The fragmentation has led to high costs and compatibility problems as different systems are in use in parallel. This makes it more difficult to cooperate and has been a great hindrance in, for example, implementing the Functional Airspace Blocks (FAB).

2. A second problem is the **home-bias** each country shows for its own ANSPs. Even though cooperation and mergers between ANSPs can be more cost-efficient, none of the countries would like to see their ANSP disappear. The impact on revenues, employment and the security issues play an important role in this home-bias. Military interests also play a role. States lose part of their control over civil/military cooperation[4] and airspace design if the civil ANSP is not in national hands.

3. ATM is de facto a **geographic monopoly**. This has several consequences. Firstly, as there is no competition, there is little incentive to innovate (**incumbent inertia**), based on external requirements. Secondly, in order to prevent excessive pricing, the service charges need to be regulated. Today, charges are based on determined costs, which is already an improvement of the full cost recovery basis it used to be. However, as we have shown the modelling, the incentives for the ANSPs to invest in new technologies remain low. Finally, they seem to have a varying notion of client orientation.

4. Another issue is the **network character** of most ATM technologies. This means that the technology becomes more effective when a larger proportion of the users adopt it. This leads to problems of coordination and underinvestment.

5. **Split incentives** are a final source of problems. In most of the cases the ANSPs are required to undertake large investments, whereas the benefits accrue to the users. Most of the benefits (higher capacity, lower costs, etc.) will be passed on to the airlines. The end users will pay via the user charges, but this will only be over a long period of time. In other cases, for some of the technologies (mainly the enablers), the airlines will also have to invest directly, while they have no direct or immediate benefits.

[2] This statement should be interpreted with caution as multiple factors (such as structure of the airspace and other specific considerations) can account for part of the observed differences in performance.

[3] Military providers are not always classified as ANSPs per se, despite the strict logic of doing so.

[4] There are examples of regional/national and international (eg. MUAC) civil/military cooperation.

III. SCENARIOS AND MODELS

In this section we briefly outline the core idea behind the scenarios and the set-up of the models. It is not possible to discuss the models here at length, hence the idea is to provide a description which will help to understand the conclusions discussed in section IV.

A. Scenarios

We planned to analyse potential transition paths from the current equilibrium of fragmented ATM provision towards more efficient provision of ATM/CNS services. We searched for market conditions that enable bottom-up changes, emerging from the actions taken by the ATM/CNS participants rather than top-down regulatory approaches. We explored possible pricing schemes and regulation requirements in order to assess which framework elements are most desirable and which ones are most likely to accelerate change.

The questions that we wanted to answer in the economic models are related to three dimensions: the level of cooperation, technology and the relevant pricing mechanisms. These dimensions were thus also present in each of the scenarios. We proposed three types of collaboration: one with limited **collaboration** such as it is today and two scenarios with collaboration between various airspace actors. In the latter we distinguished between multi-stakeholder collaboration versus collaboration between ANSPs.

In ACCHANGE, we analysed in particular the elements of **technological** implementation for which some indicative cost-benefit figures are available, at the aggregate level and at the level of individual stakeholders. Beyond data availability we do not impose any restrictions on the proposed technological implementations for European airspace, as outlined in the European ATM master plan. Detailed data on cost-benefit figures is only available for the Pilot Common Projects (PCP), and only to some extent for the SESAR Master Plan, and for Centralized Services and Virtual Centre models. Therefore we analysed the PCP and Step 1 in more detail, using a quantitative modelling approach.

We drawed on economic theory and explore the potential of the following **price mechanisms** in enabling change; be it through more efficient service provision, more efficient use of existing airspace capacity, enabling technology implementation to expand capacity limits and/or providing incentives for efficiency increasing collaboration agreements:

- The current regulated pricing system which resembles a hybrid system with elements of cost recovery and price cap regulation.
- Peak-load pricing and congestion prices which are related as both types of prices aim at providing actors with incentives for avoiding scarce capacity use in congested areas and/or during peak hours. The difference is that peak-load pricing focuses on stimulating a temporal shift in demand and in allocating fixed capacity costs, whereas congestion pricing focuses on external costs that multiple users of scarce capacity impose on each other.

Using these three elements, different scenarios were constructed and analysed using four economic models[5].

B. Models

As said, we used four different models to analyse the current situation in ATM and the potential paths for change: a network congestion game (model 1), a union bargaining model (model 2), a public utility model (model 3) and a simple economic network model (model 4). The first model focusses on computing the effects of given scenarios. The other models focus more on the "why" question: what can explain the present inefficiencies in air navigation service provision and which incentives may encourage changes to the current status-quo. To answer this "why"-question two approaches were investigated: a union bargaining modelling (second model) and a public utility model (third and fourth model). A qualitative assessment of alternative levels of cooperation currently occurring in the ATM sector complemented the quantitative economic analysis.

1) Model 1: the network congestion game

The network congestion game is developed to test multiple scenarios. A two stage game is assumed in which the ATC providers make decisions in the first stage and then airlines respond in a second stage. The first stage requires ATC providers to set their user charges either en-route or at the airport according to particular objectives such as revenue or profit maximisation. In the second stage of the game, the airlines choose their flight paths given their flight schedule and the charges from the first stage such that they minimize their operational costs. The costs include variable costs specifically labour and fuel, congestion costs and ATC charges, all of which are impacted to some degree by the ATC provision.

The case study network focuses on six ANSPs, namely AENA (Spain, Belgocontrol (Belgium), DFS (Germany), DSNA (France), LVNL (the Netherlands) and NATS (UK). In addition we also include the Maastricht Upper Airspace Control Centre (MUAC), which is in charge of the upper airspace (above 24.500 feet) in Belgium, the Netherlands, Luxemburg and Northwest Germany. In 2011, these ANSPs were responsible for 48,9% of European traffic (in terms of flight hours controlled) and 52.3% of total en-route ATM/CNS costs [1]. Airlines were clustered into three groups: airline alliances (represented by three airlines: Lufthansa, British Airways-Iberia and Air France-KLM), low cost carriers (represented by Easyjet) and non-aligned carriers (represented by Emirates). Despite being a clear simplification of reality, the network game should be sufficiently rich as to enable an understanding of how the players will react to changes in institutional or regulatory rules. For each scenario, the effects on the users (different types of airlines) and on ANSPs is computed taking into account possible rerouting behaviour of

[5] Not all scenarios were assessed in all four models.

airlines. Five scenarios were analysed and for each scenario four subcases were discussed. The subcases included the user optimal cost recovery approach, the system optimal cost recovery approach, the user optimal price-cap approach and the system optimal profit maximisation approach. The five scenarios include (1) the base-case, (2) a central manager to provide all ATC services, (3) integration across ANSPs (FAB approach), (4) introduction of technology via the PCP and SESAR step 1 projects; and (5) the regional forerunner approach in which ANSP providers and a specific airline together cooperate.

2) Model 2: The Union Bargaining model

In the second model, a union bargaining model, we assume that the behaviour of an ANSP is the result of bargaining between a national authority and the ATC union[6]. The simplest model has only one country, one air traffic control centre, perfectly competitive airlines and airports that sell services at marginal costs. The union strives for higher wages and protection of its members. The objectives of the Government are lower prices and better ATC service. Salaries and work conditions (technology and number of controllers) and therefore also average costs are the result of bargaining between Government and ANSP unions. The game is a two stage game. In the first stage, one chooses the type of technology. In the second stage one determines the price of ATC services, the wage and the number of controllers. The outcome depends on the bargaining power of the two players.

To empirically validate this model we used an econometric analysis to estimate the union bargaining power. We collected a dataset containing information on ANSP performance for the Eurocontrol area over 9 years (2004-2012). Our dataset covers all ANSPs of the Eurocontrol area, except for the following ones which have been excluded due to problems of data availability: MUAC, ARMATS, Avinor, MoldATSA, HCAA and Finavia.

3) Model 3: The Public Utility Efficiency model

The third model is a standard economic public utility model which explains the interaction between a regulator and a private firm subject to economic regulation. Our model fits within the traditional theory of regulation (surveyed in Laffont & Tirole (1993)), often applied to public utilities in a monopoly position. The theory focuses on the imperfect information of a regulator in comparison to the regulated entity. This is the case if the performance of the firm cannot easily be compared with other firms. This is indeed the case for the provision of air navigation services in Europe. The wide difference in operational practice and the divergence in the structure of air traffic charging zones make the application of yardstick competition or benchmarking between ANSPs difficult. Still, the regulator can apply price regulation and, dependent on the type of regulation, provide stronger or weaker efficiency incentives for the ANSP. The regulator faces a trade-off between cost-efficiency incentives and quality of service provision.

The model studies the implications of the incentive mechanisms that have been implemented in the SES II regulation. Cost risk and traffic risk have been introduced to provide performance incentives to air navigation service providers. We first analyse the effect of cost risk, which is imposed by limiting the redeemable ANSP cost to a pre-determined level such that the ANSP is accountable for costs above this level which is equivalent to imposing a price cap on ANSP charges. Next, we study the effect of traffic risk. This mechanism ensures ANSP accountability for surplus revenue or surplus costs due to an increase or decrease in air traffic movements. Finally, we consider the regulatory preferences as a function of a regulator's objectives.

These theoretical derivations were complemented with a numerical illustration.

4) Model4: A simple economic network model

The fourth model, a simple economic network based model, draws the labour union and efficiency aspects together. It introduces a simple air transport network to study the effects of interactions between the various airspace users. The networks are deliberately kept simple to focus on analysing interactions between ANSPs that operate on a serial link and/or a parallel link. We developed two approaches to model interactions between the airspace users: a Nash bargaining approach and a Lobbying approach. The approaches diverge in their assessment of the costs and benefits that collaboration can provide as the assumptions underlying the models are very different. The Nash bargaining model is well-suited to model the union 'strike weapon' and its impact on economic outcomes. The additive lobbying model is suited to define a negotiation where none of the players can interrupt the service, because striking is not allowed (as in the US), or where strikes are unlikely (perhaps because of a tradition where disputes are settled through negotiations rather than through strikes).

We use this simple network set up to study two stylized problems. First, we discuss the benefits of cooperation between an airport and an ANSP of one country. Both cooperate to offer better services and this allows them to increase their market share in the air travel market. It is called the regional forerunner scenario. The second stylized problem we study is the competition between two pairs of ANSP's that compete for the same transit traffic.

IV. THE WAY FORWARD

Using these four economic models, we investigated what could be the most effective approach for overcoming the barriers and addressing the challenges listed in section II. As said, we mainly focused on the following dimensions of the ATM sector institutional framework: collaboration, regulation and liberalization. Competition is another important driver for performance incentives, which interacts with each of the elements above. Based on the outcome of the modelling, we

[6] Because the Government owns the ANSP's we assume that the national government plays a major role in the bargaining process.

will discuss each institutional element in turn and always address what could be the effect on performance incentives.

A. Collaboration & performance

We came to the conclusion that striking an effective balance between Air Navigation Service Providers (ANSPs) collaborating and competing for ATM service provision would be the most effective leverage for market-oriented change in the sector. Currently, given the importance of the network structure of airspace traffic, ANSPs already collaborate at international level to a greater or lesser extent. There are international consortia of ANSPs working on topics such as data sharing, joint procurement or technological research and innovation. Examples are the A6 alliance, NORACON or the SESAR deployment group[7]. On the other hand, the FAB initiative, aimed at boosting cooperation within geographical zones in Europe, has experienced relatively limited success.

We investigated the potential of increased collaboration between multiple air navigation service providers (ANSP collaboration) as a tool for driving bottom-up change in the sector. We have further also explored more unconventional, "Multi-stakeholder collaboration" approaches, consisting of agreements between two or three of the following actors within a certain region: ANSPs, airports and airlines. We have called such type of agreement within a certain geographical boundary the "regional forerunner" approach.

Collaboration should be interpreted here as cooperation at strategic level. In the economic models, it boils down to an evaluation of whether strategic interests of each actor is served best when it acts in isolation, or whether it acts (to a certain degree) as a joint entity with other actors. In reality, it could take the form of directors being present in each other's board, explicit consultation of each other's interest, strategic investment decisions being jointly taken, etc. It could also materialize in several forms of operational agreements, but we have not detailed our analysis up to that level.

1) ANSP collaboration

From the ACCHANGE economic (network) models, we learned that the potential of ANSP cooperation for stimulating bottom-up change is limited. The underlying reason for this is the limited performance incentive for the ANSP (management) in comparison to many other economic sectors. Competition for airline traffic between various air navigation service providers is relatively weak in the current constellation with ANSPs as monopolistic suppliers within well-defined geographical boundaries. After all, the ATM cost represents only a small share of the total flight cost, of less than 10% of the final ticket price [11]. On the other hand, fuel costs typically account for about 30% of airline operating costs [10]. Therefore, minimizing the distance flown is a much more important concern for airlines, when they optimize flight routes, than using ATM services from one or another ANSP[8]. This results in a demand for ATM services that is relatively inelastic to changes in ANSP performance. Performance regulation of the ATM industry can, to a certain extent, replace competitive incentives. However, our models have shown the limits of the effectiveness of these regulatory instruments; in particular in the presence of special interest(s) (groups).

The ATM sector is an industry which is relatively prone to special interests, in comparison to many other, more liberalized economic sectors. This is why we elaborated a union bargaining model to investigate the influence of labour unions on sector performance. However, other elements are also present, such as national sovereignty concerns or industrial interests from specific national manufacturers.

The presence of vested interests, in combination with limited performance incentives, does not stimulate effective collaboration between ANSPs. We therefore believe that most top-down cooperation initiatives for the ATM sector in Europe will likely lead to collaboration pro-forma, but with very limited performance improvements in practice. This is corroborated by the limited performance improvements that were realized through the functional airspace blocks up to now. Cost savings through economies of scale have not materialized, cooperation on technological research and innovation is slow, and progress in standardization of equipment is sluggish. In this context, ANSP cooperation can be analysed as a zero-sum game. This is an economic concept in which the benefits for any actor can only arise from the losses of another actor. Such a pay-off scheme makes the effective realization of cooperation agreements highly unlikely.

We consider the existence of some competitive, market-based incentives as essential for the emergence of effective cooperation agreements. These incentives drive the search for more effective air navigation service provision at competitive prices and of high quality. In other economic sectors, it is this search for a better, more competitive market offer that leads to the emergence of cooperation and technological innovations.

2) Multi-stakeholder collaboration

A first attempt towards increasing performance incentives could be through cooperation between an ANSP, an airport and/or an airline. The idea is based on the observation that collaboration between ANSPs in the ATM sector suffers from limited performance incentives due to limited competition and (partly) ineffective regulation. On the other hand, research has shown that liberalization of the airline and airport sectors has been successful in introducing elements of competition and as a driver for performance improvements, see for example [14] or [15]. Thus, the formation of strategic alliances between ANSPs and actors who are exposed to competition (airlines and partly airports) could be an effective way to draw in performance incentives in the ATM industry.

[7] More information on some of these (and other) alliances can be found in [13]

[8] Even though many airlines do take ATM charges into account when deciding on their flight route, as shown by Delgado [5].

When talking about multi-stakeholder cooperation, we have in mind mainly the formation of alliances at strategic level. It could take the form of mutual participation in each other's board meetings, joint decision making in relation to research and innovation or investment priorities, decisions related to price setting or cost charging. The focus of the project was on exploring the potential of such type of alliances on the performance incentives which various actors are facing.

In the ACCHANGE models, multi-stakeholder cooperation resulted in more effective ANSP performance in comparison to collaboration between ANSPs. The extent of expected performance improvements did depend on the exact nature of the environment and of surrounding framework conditions. The more promising results, in comparison to collaboration between ANSPs, can mainly be attributed to the presence of stronger performance incentives and competition elements in the 'multi-stakeholder approach'. The ANSPs 'feel' part of the competition to which airlines and airports are exposed in a multi-stakeholder alliance and are therefore more inclined to act in their local partner's interest.

We observe indeed some kind of regional coalitions (multi-stakeholder collaborations) emerging in Europe. For instance, in the UK and also in Spain the sector of tower control has been liberalized, opening competition for tower control at many airports. This has also led to the emergence, at some airports, of airport authorities taking over themselves the tower control function. This evolution is an example of the multi-stakeholder cooperation alliances which we studied in the ACCHANGE models. Lower degrees of strategic alliances may exist, with airport and airline representatives being represented in the ANSP board as for example in the case of NATS. This also depends on the ownership type of air navigation service providers.

For policymakers, our analysis would imply that policies enabling multi-stakeholder cooperation are important. These can be complementary to the more classic, top-down 'collaboration between ANSPs' programs and initiatives that are taken today. The liberalization and public tendering of tower control is an example of such a policy that will likely lead to more competition and stronger performance incentives in the ATM industry in Europe.

B. Regulation & performance

In section II, we discussed how the structure of the ATM industry leads to limited competition and performance incentives in Europe. In economic terms, ANSPs operate in a natural monopoly market setting. In such a situation, the lack of competitive forces makes some regulatory oversight a necessary condition for obtaining performance improvements. This regulatory oversight can take multiple forms: economic theory typically distinguishes between cost-plus or price-cap regulation. Cost-plus regulation is a very simple form of price regulation in which regulated entities are allowed to cover their costs and to realize a small profit margin. Price-cap regulation is more incentive-based and only allows covering a certain level of costs that fall below the cap. The regulation on ANSP charges was very similar to a cost-plus regime in the past. Since the introduction of the SES performance regulation, and in particular the cost risk incentive mechanism, the charging regulation has become much like a price-cap regime.

In the ACCHANGE project, we investigated the Single European Sky performance regulation and its likely impact on the ATM sector. We evaluated the shift from a cost-plus regulatory regime towards a price-cap as a positive development. After all, the cost-plus regulation yielded very limited performance incentives for rewarding cost-efficiency improvements. The cost-plus approach was in place for many years and led, in our view, to negligence by the ANSP (managers) of cost-efficiency concerns. In contrast, the risk elements introduced in Reference Period 1 of the SES II performance regulation reward ANSPs for cost savings and punish them for cost overruns.

On the other hand, a simple price-cap approach also has a number of downsides. First and foremost, a price-cap regulation can give the regulated entities an incentive to drive down costs by letting quality deteriorate. Related to this, a strong price-cap provides very limited incentives to invest in new technology adoption, in innovative activities or in research. In the long run, a strong price-cap could therefore lead to cost-efficiency but at the expense of service quality. This is not desirable in an ATM context with important quality dimensions such as safety, the environmental performance of the airline industry and providing capacity to avoid delays.

Therefore, the project participants propose the concept of hybrid price-caps where cost risk for ANSPs is coupled to a bonus-malus system for out- or underperforming with respect to certain quality related performance targets. This is effectively also the direction in which the SES II performance regulation has been going under Reference Period II. Depending on the generosity of the bonus-malus system, hybrid price-caps do provide incentives to invest in quality and new technology adoption if this is effective in reaching the quality targets[9].

We conclude that performance regulation can be designed in such a way as to promote both cost-efficiency and technology adoption at the same time. The effectiveness of the regulation obviously depends on the quality of the target setting process. The ACCHANGE economic models have further shown the limitations of performance regulation, as inspired by European oversight. In the presence of strong specific/national interests, regulatory oversight may become less effective for driving performance improvements in comparison to what one would derive from a simple regulatory efficiency model. One could end up in a situation with national government budgets that cover the losses of ANSPs, effectively leading to 'hidden subsidies'. This has occurred in many other economic sectors with natural monopoly characteristics and fragmented service provision along national borders, such as railways for instance.

[9] We have not discussed the topic of target setting in our research project, as this merits a whole research topic in itself.

C. *Liberalization & performance*

After discussing cooperation frameworks in section II and regulatory approaches in section III, we will now go beyond these topics and discuss elements which we think are promising avenues for further development. Our discussion here is not necessarily tied to model results from ACCHANGE.

The economic models developed embody the idea that competition is a very powerful driver for boosting performance. Liberalization of the ATM sector could be a powerful mechanism for introducing more competitive dynamics in this industry and for boosting customer-oriented performance improvements. There are, however, many different ways in which (parts of) the sector could be liberalized. Most of them do not only have benefits, but also downsides. We discuss a number of them which emerged as potential ways forward during the concluding stages of the ACCHANGE project.

One way to introduce more competition in the sector would be to impose the obligation on national governments to award the right to provide ATM services through an open tender procedure. The contract to be tendered can take a variety of forms depending on its length in time and its geographical range. Parts of the charging zone could be tendered separately, or it could be tendered in its entirety. Time length could be 5 years to allow for sufficient certainty for the ATM providers, while also maintaining the competitive element throughout the time-based tenders. In addition, minimum quality targets for the ATM provider can be included in the contract as in a service level agreement. Examples of this process can be found in the public tendering processes for tower control. This approach could be extended to terminal and en-route ATM. However, this is probably less straightforward to implement in practice. Also the acceptability of such a shift for national governments is an issue.

A second approach could be to unbundle part of the ATM functions and to open competition for these unbundled, liberalized services. A likely candidate for unbundling is the separation of support services from the core ATM activities such as Air Traffic Flow Management (ATFM) and Air Traffic Control (ATC). This is also the idea of the centralized services concept as recently promoted by Eurocontrol. In comparison to centralized services, a less ambitious (but in the long run perhaps equally effective) strategy could be to mandate the unbundling of support services at national level. The right to provide these support services could then be publicly tendered for a certain time period at national level. Over time, consolidation of support service providers may occur in Europe, with a few providers benefiting from economies of scale and successful experiences. In this scenario, economies of scale may be realized following consolidation of the industry, rather than imposed ex-ante as in the centralized service scenario. In addition, some competition between a few providers may still exist at European level; a situation that is often to be preferred over one monopolistic service provider.

As third and final element, we discussed the potential of virtual centers (VCs). New technologies allow many ATC functions to be executed from remote locations, such as in the case of remote towers for tower control. A similar concept exists for en-route ATC: one ANSP could, in theory, entirely take over the ATC function of another ANSP; the two providers do not even need to be located adjacent to each other. Such developments have the potential to become radical innovations that disrupt the current status quo in the industry. In the ACCHANGE economic models we have investigated how this could change bargaining positions of various national actors as opposed to more European-minded policy makers. It is clear that the potential implementation of the virtual center concept can have important effects. Even if the VC set-up would not be in use, its sheer existence and potential use can already have a strong impact on decision powers. Therefore, one idea developed in the project would be to facilitate the implementation of contingency services for air traffic control. This could then consist of an ANSP that contracts another ANSP for supplying a certain level of ATM services in case the first ANSP cannot deliver them due to unexpected circumstances; i.e. a power outage, a system breakdown, an unannounced industrial action, etc.

V. CONCLUSIONS

From the ACCHANGE project we learned that the current institutional structure (national ATC monopolies and strong union powers) hinders the adoption of better and state-of-the-art technologies, more efficient procedures and mergers between service providers of suboptimal size.

We think that the introduction of some performance incentives is a key driver for stimulating market-oriented change in the ATM sector. Price regulation and charging regimes will continue to be a cornerstone for change but they will likely be insufficient. Multi-stakeholder cooperation alliances could help in stimulating modernization of the sector, and could stimulate a complementary policy-approach to the more common, centralized plans stimulating collaboration between ANSPs. In addition, liberalization of (parts of) the ATM industry could be necessary for effectively boosting a change in attitude. However, there are many ways to proceed in liberalization attempts and liberalization also carries a number of potential downsides, besides the potential benefits. Therefore, we believe that this topic merits specific research attention, to have a clear idea about expected effects.

The models developed within ACCHANGE are based on economic theory. The focus of these models is on providing an insight into the main mechanisms and drivers of the results obtained. In order to keep the ideas and the modelling traceable, this includes the use of simplifying assumptions and a lack of operational detail with respect to the solutions. The complexity of the real world makes stylized models an appropriate tool to study certain aspects of reality and to

understand cause-effect relationships. The models are hence not meant to be an exact replication of reality. In some cases it would be possible to add more detail to the modelling, but this would come at the cost of clarity without really altering the main messages.

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