THENA
THEmatic Network on Airport Activities

THENA Final Synthesis Report

Abstract

This report constitutes the final synthesis report of the THENA Project. It includes a set of recommendations for further Research and Development activities that may stimulate future research on the challenging airport domain fields. A set of information per each THENA Working Groups is including as reference of the work performed (i.e. state of the art, conclusions form Workshops and detected gaps). In addition, the results and conclusions derived from the exchange of opinions and perspectives during the three Workshops organised by the THENA Consortium, as well as further dissemination activities have been crystallised into this report.

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1. PROJECT OVERVIEW

The main objective of the THEmatic Network on Airport Activities (THENA) is to create and develop a coordination and collaboration environment for airport activities in order to gain transparency and effectiveness in the development of projects related to this issue. THENA aims at providing a focal point for collaboration between the different programmes where the stakeholders involved in airport operations will have the chance to meet and exchange opinions and points of view. This outcome will contribute substantially and effectively to the improvement of coordination and the avoidance of redundancy between completed and on going projects in the airport domain. In addition, some recommendations are inferred from the conferences organised and from the analysis done by the consortium.

Specifically, the THENA main objectives are:

- ✓ Provide a focal point for collaboration between the different programmes where the ATM stakeholders can meet and exchange views on Airport activities.

- ✓ Ensure that the exchange of information on Airport activities is conducted efficiently and effectively, in order to avoid internal redundancy (disruptive overlapping) of work and help concentrating on straightforward objectives for each of the already running or future projects, related to both airside and landside airport operations.

- ✓ Explore issues not yet covered by the R&D projects and propose recommendations for new R&D projects and/or on the need for complementary standardisation activities that could foster a potential industrial application.

To achieve these objectives, THENA was organised and implemented around the major airport issues and most challenging research areas pertaining to the airport domain studies and decision making needs. These areas relate to: i) Capacity and Efficiency, ii) Safety, iii) Policy and Regulations, iv) Simulation and Modelling, v) Information Systems / Technologies, and vi) Environmental Impact. This allowed consortium members to tackle the issues and research fields according to their expertise and experience, thus greatly facilitating co-ordination, achievement of research synergies, and harmonised integration of results. The partnership of the THENA Consortium consists of 14 partners from 6 countries. It includes the air service providers Aena and DFS (the former also manages airports), the aerospace research institutes NLR and Onera, the Athens University of Economics and Business (Transportation Systems and Logistics Laboratory) and the University of Padova (Department of Pure and Applied Mathematics), the manufacture of ATC and airport systems THALES ATM, the economic institute NEI, the transport consultants Ineco, Isdefe, Fedespace (non-profit organisation) and Slot Consulting, and the airlines Transavia (partially) and Martinair. The partners largely cover the range of skills required to perform the work of the project.

The organisational approach followed to reach the objectives of the project was threefold:

- ☑ Organisation of six working groups[1] on the particular identified subject areas, which have been identified as most important in the airport domain. These working groups allowed

[1] The six THENA working groups are: Airport Capacity & Efficiency (WG1.1), Safety (WG1.2), Policies / Regulations (WG1.3), Simulation & Modelling (WG1.4), Information Systems / Technologies (WG1.5), Environmental Impact (WG1.6). Additionally, and after the tragic September 11th events in USA, one specific analysis was devoted to airport security.

sharing and disseminating information and, most importantly, to identify research voids and gaps as directions for future and fertile research fields.

☑ Organisation of three dissemination workshops where, independently from the members of the consortium, appropriate experts presented different subjects related with the airport field. All the participants were invited to actively participate in the discussions which took place during the workshops in order to improve the information dissemination. The three workshops were:

- 1st THENA Workshop, *"European Airports: Current problems and challenges. How to increase airport capacity, safety & security based on existing infrastructure",* February, 4th-5th, 2002, Centre Borschette, 36 rue Froissart, Brussels, Belgium.
- 2nd THENA Workshop, *"European Airports towards adequate SAFETY and SECURITY"***,** November, 7th - 8th, 2002, Palma de Mallorca Airport, Spain.
- 3rd THENA Workshop, *"Green European Airports: A Balanced Approach"*, April, 28th - 29th, 2003, Crown Hotel Plaza, Brussels, Belgium.

☑ Design a web site where will be possible to find all the information related to airport projects together with the results from the different working groups and workshops (documents, working papers, agendas for future meetings and so on). Moreover, this web site allows a day-to-day exchange of data among all the involved members and a world-wide dissemination of the information.

The Web site URL is http://thena.aena.es. It contains information regarding the three workshops, document generated by the consortium and usual tools such as links, forum, contact and search.

The overall methodological framework governing the organisation and development of the project research outcomes is schematically illustrated in Figure 1 presented in the following page.

The current report represents the final report from the project, trying to cover the main results achieved during the whole life of the project. It presents, in the second section, the recommendations from the THENA consortium concerning new research and development subjects in the airport field. These recommendations have taken into account the members' background, the documentation review and the results from the several workshops in different topics but presenting as a whole.

The remaining of this report, section 3, is structured into six main sub-sections each dealing with the summary reports and results presented on a Working Group basis. The objective of this section is to summarize the results of the individual WG reports in the following directions: i) current state-of-affairs, ii) the results and conclusions derived from the exchange of opinions and perspectives during the three Workshops organised by the THENA Consortium, iii) research voids and gaps that may stimulate future research on these challenging airport domain fields, and finally, iv) recommendations about the specific topic.

The report is complemented by the Glossary of relevant terms and abbreviations (Section 4), as well as the list of references (Section 5).

The overall methodological framework governing the organisation and development of the project research outcomes is schematically illustrated in Figure 1 presented.

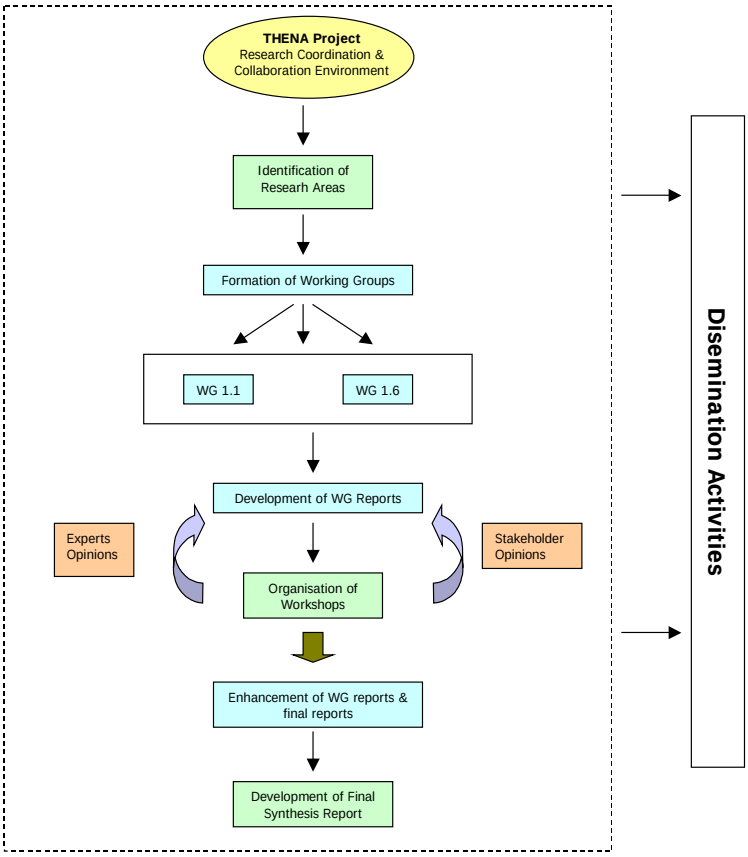

Figure 1-1 Overall THENA organisational and methodological approach

The herewith document presents the opinions of the authors and the interpretations of discussions and presentations given during the three THENA Workshops and does not necessarily reflect the position of the European Commission or the explicit position of the THENA Workshop speakers and attendants.

2. THENA RECOMMENDATIONS

This section summarizes the main recommendations drawn by the THENA consortium members based on their specific expertise and background as well as on the views and feedback received through the three workshops and on the knowledge acquired from literature review. The main global recommendations identified are described in the following paragraphs.

Further research is recommended in airport **CDM (Collaborative Decision Making)** applications its further implementation and wide harmonised adoption. In a simple way, CDM addresses information-sharing to allow stakeholders receive in good time the right information needed for their operations to efficiently utilise the airport capacity in a collaborative decision making environment between ATC, aircraft, ATFM, handlers and airport operations. In other words, what information needs to be where and when, and who is better positioned to take decisions. The complexities implicated in airport operations can be mainly attributed to the abundance of stakeholders involved in or affected by the airport operations. The various airport stakeholders represent different airport management and planning perspectives, while, in some cases, exhibiting conflicting objectives. Certainly, they are all interested, in different degrees though, in increasing airport throughput and other performances without compromising certain measures of airport effectiveness. However, they justify it from different viewpoints, propose different means, and eventually recognise different compromises or priorities. CDM applications must be developed in conjunction with other ATM innovative ideas in order to be consistent, as the System Wide Information Management (SWIM) concept, which has to be investigated in detail and exploited in the aeronautical world.

In addition, there is a need to pursue a social dialogue among all relevant stakeholders with the purpose of building consensus and establishing a close collaboration environment to promote the efficiency of airport and air transport operations under the prism of regulations / policies, technologies, management and strategic planning, as well as operations. A wide dissemination of the benefits in term of capacity, punctuality and efficiency, gained through a proper information exchange, will improve the willingness from the different stakeholders to make their information available.

In the short term, effort should be concentrated on enhancement of current procedures and the application of CDM principles to the current practices. In the long term, studies should address implementation of new applications. To give an example, the replacement of the “first come first served” process by an alternative CDM procedure based on “first on time, first served” would require negotiation of the off block time fulfilling restrictions of all involved actors and ensuring it allows the aircraft to comply with arrival constraints, agreed 4D trajectory and CFMU slot. An integrated management of arrival, departure and ground operations would contribute to the implementation of these principles by providing earlier and more accurate time estimates and collaborative decision making processes.

An **economic-driven approach** has to be developed and implemented in all solutions and measures employed to solve the current airport problems as well as in all proposed improvements. It is recommended to promote Cost Benefit Analysis within the technical solutions considered in further research to provide the society with quantitative evidence of the costs of improvements and the foreseen benefits of the changes in every aspect: e.g. reduce noise, increase capacity or reduce delay. Investment has to be optimised to maximise efficiency. In general, it is unanimously agreed that infrastructure projects and airport

investments / expansions should be closely monitored and evaluated under the prism of the overall effectiveness and efficiency by simultaneously considering qualitative and (even hardly) quantitative aspects of costs and benefits.

The role of **regional airports** has to be fully clarified and thoroughly exploited. Since regional airports might play an important role in facilitating airport growth it is recommended to devote further research to the factors influencing the use of regional airports and the possible impacts of using these airports (in term of increased accessibility, environment, economics, capacity and so on). In the same line, although re-hubbing and traffic redistribution into secondary airports are quite interesting options, their applicability and anticipated effectiveness are in question due to strong opposition expected mostly by airline operators. To avoid this opposition, the advantages and disadvantages have to be evaluated from different points of view: airlines, service providers, airport authorities and passengers, without forgetting the global network effects.

A drastic **revision of the slot allocation regime** needs to be promoted though studies that will analyse its impact on the air transport system in Europe, e.g. incorporating market-driven orientations for allocating scarce airport capacity with the aim of removing market entry barriers and discriminatory practices, ensuring transparency, equity and unrestricted access to airport resources, and boosting the operational (e.g., delays, level of service) and financial (e.g., revenues) efficiency of airport operations. It is imperative to establish new procedures and rules for allocating slots at congested airports by allowing more transparent exchanges of slots and criteria for allocation priorities with a clear orientation towards greater flexibility and increasing adoption of market mechanisms (i.e., pricing schemes). Moreover, it is imperative to strengthen the role of airports in the definition of criteria that drive the use of their infrastructures and any measure adopted.

The “law of the most restrictive factor” introduces a systemic perspective, directly applicable and quite useful to provide a deep insight into the aeronautical world, on the grounds that the global capacity is the capacity of the weakest link in the chain. The weak link can be an airport, a sector, part of an airport and so on. This implies the need of analysing the solutions and new ideas under a **network-based approach**, for individual airports, airport elements segments and for the entire airport network (or sub-network).

Regarding ATC at airports, the **use of A-SMGCS** (Advanced Surface Movement Guidance and Control Systems and its procedures at airports to increase safety and capacity in all weather conditions, especially to reduce runway incursions, is considered quite essential. Although substantial effort has been done (ICAO/AWOP, AOPG, EUROCAE) to improve the performances of A-SMGCS and to add new functions. Safety implications of its implementation should be further researched. Several aspects need further development in this aspect in spite of the fact that many projects have addressed it (e.g. BETA project). There are open questions on the safety effects due to lack of well-defined and standardised procedures, level of confidence for each level of implementation and responsibilities of each actor. Additionally, integration of this system with others (e.g. AMAN and DMAN) within the airport will have an impact on safety and capacity that needs to be studied.

The study and further implementation of new tools has to be complemented with a **safety analysis;** specially the step of identifying and assessing the risk modelling of systems and procedures (including the human factor) is of mayor importance. Risk assessment techniques with a quantitative result have to be further developed. Statistical data and simulations are needed to support the safety cases. Some technologies that need immediate application such as A-SMGCS, new datalink applications and communication technologies and use of satellite signal.

Within the context of a total system approach, future work should promote and support RTD projects focussing on security in the aviation system and procedures. These projects should contribute to ensure that the air transport system as a system of systems, layered, integrated and working together, provides the highest possible level of protection. A **total system approach** (airports, ATM, aircraft, personnel etc.) **for security** should be adopted. It is recognised the need to promote new technology for passengers positively identification (e.g. biometrics and facial-recognition technology) but without forgetting **privacy considerations**, in order to not violate those passengers privacy rights. Other means to baggage and passenger reconciliation to improve the security at airports are recommended. It is highlighted the need to properly balance security and **facilitation,** which should be considered in the research with especial care at this juncture. Besides, the implications of new security should be closely examined and quantified with the purpose of identifying the **capacity-side effects** along with alternative ways to cope with their capacity constraining implications.

Some **metrics** are quite common nowadays when analysing airport such as delay, taxi times, capacity of airport components or queue lengths. However, there is a wide field for enhancing or enlarge the spectrum and variety of data related to airport world, such as ground conflicts, fuel burn, pollution emissions, noise impact, taxi costs, safety metrics, security metrics. Logically their definitions and usefulness have to be agreed inside the airport community. In addition, these new metrics have to be added as output, results or information coming from airport models in order to provide analysis on capacity, efficiency, safety, security and environmental impact, as direct results from the airport analysis tools.

Most of existing approach and departure procedures for the majority of airports were designed without specific consideration of noise, taking into account only flight safety aspects. It is recommended development of specific noise abatement operational procedures in order to reduce impact on the areas surrounding airports by redistributing noise, without decreasing the required safety levels. However, the **trade-offs on capacity of new environmental restrictions** is a key factor to success in their implementation and it is essential to address in R&D phase.

There is a need of adopting and implementing a **commonly agreed regulatory Framework** governing the airspace and airports of the enlarged European Community in terms of slot allocation , safety, security and environment. Norms and standards should be harmonised to avoid unfair competition among airports due to specific regional situation. Furthermore, it should be taking in to account that the aviation is a worldwide business and that streamlining of measures and regulations with other geographical regions, mainly North America, should be kept in mind. In that sense, the need for a **level playing field** should be stressed, not only

within the EU, but also with regard to external relations Proposed regulations should not cause any distortions with regard to this playing field because this may lead to unfair competition.

It is required to develop a **global modelling tool or analytical model** that covers the complete airport: air-side and land-side, considering not only aircraft but also cargo and passenger. The aim of such a global tool/model is to find balanced solutions for an airport as a whole: efficient solutions for passenger movement, apron management, taxiway control, cargo organisation and so on. Currently there are quite few airport analysis models / tools that can provide study for the entire airport complex by considering a variety of measures of airport effectiveness (e.g., capacity, delays, noise, safety). This research gap can be successfully addressed by the development of seamlessly integrated computational platforms that will be able to support high-level political decisions (with focus on strategic-level decision making) related to airport planning and operations with respect to a variety of measures of airport effectiveness. Furthermore, this model or/and tool should be able to examine and quantify the trade-offs of airport operations by running “what-if” scenarios based on alternative decisions on airport performance metrics.

The current **environmental models have to be improved**. The models related to noise around airports should be enhanced considering aircraft configuration and better aircraft performance data, in order to produce more accurate and miscellaneous results. The environmental indicators have to be clearly defined at international level considering the output from the tools/models and other issues such as aircraft contribution to air pollution (emission), annoyance, sustainability and so on. In the same way, the existing and future models should be unified to share the same information. One important output from those tools/models should be dissemination data to support a communication programme with the neighbourhood.

The **ten states accessing the European Union** are harmonising their structure to the EU standards and they are trying to use the same models and procedures. Besides, it is expected that through the process of economic integration, the traffic growth will raise similar problems to the major present EU airports. However due to the significant differences of the past to find similar solutions to uprising and recent problems is not always possible. As they will be members of the European Union, their present problems in terms air transport will be the problems of the European Union as well. Therefore larger focus on their situation and joint solution for the problems are advised.

The recommendations are not presented following a prioritising scheme, but a random listing. It is really difficult to prioritise when the field is so wide and the points of view so broad.

In the next section, further detail in specific subjects can be found.

3. FINDINGS OF THE THEMATIC NETWORK

3.1. Airport Capacity & Efficiency issues

The purpose of this section is the presentation of the main conclusions of the first THENA working group, related to Airport Capacity & Efficiency issues. To achieve this goal, the section starts with a global description of the current situation, providing a summary and a brief insight into the findings and key discussion points of the Capacity and Efficiency Position Paper with respect to the major institutional / organizational and technical / operational factors associated with Airport Capacity and Efficiency.

Following, the main conclusions extracted from the different workshops are reflected and later completed with the detected set of research voids and gaps, giving also recommendations about these unsolved matters, considering the expert opinion of the THENA members.

For further reference and more complete information, the full version of the Capacity and Efficiency Position Paper is available in the THENA web page (http://thena.aena.es), as well as the proceedings and presentations of the three workshops.

3.1.1. Current State of Affairs

3.1.1.1. Demand

Among all different transport modes, air transport has shown by far the largest traffic increase and growth potential since the last two decades. Air traffic in the European Union has increased, by average, 7.4% annually since 1980 (in terms of passenger/km), while the traffic handled by the airports of the Fifteen EU Member States has shown a five-fold increase since 1970 [1]. During normal daily operations, more than 25,000 aircraft fly the skies above Europe, while further traffic projections expect this figure to double every ten to fourteen years [1]. Towards this direction, airlines in Europe expect air traffic almost to double by 2010 with direct implications on airspace, and particularly high demand growth and congestion phenomena concentrated around ground runway operations of major European airports [2].

In comparison with the U.S. practice, European airports enjoy a significant advantage in average aircraft size and serve fewer aircraft operations for similar number of annual passenger movements. More specifically, on the basis of 65 million passenger movements (2000), the aircraft operations are amounted at approximately 783,000 operations in Los Angeles, and 838,000 operations in Dallas/Ft. Worth, as compared to only 467,000 operations in London Heathrow. Similarly, on a comparable basis of 33 million passengers, the aircraft operations are amounted at approximately 517,000 operations in Miami, as compared to 358,000 operations in Madrid [2]. Nevertheless, such an operational advantage in the gain of the European air transport capacity might be very easily eliminated as a result of the anticipated growth in regional jet services, and primarily the deregulation forces, and their associated operational service patterns (e.g., hub and spoke operations, increasing frequency of service with smaller aircraft). In that respect, it seems that a significant increase in the average number of passengers per airport operation is quite unlikely, whereas the opposite may be soon true also in Europe [2].

It can be summarized that the exceptionally high growth rates experienced by the European air travel market between 1985 and 1998 (i.e., 6.3% annual growth between 1985 and 1989, 6.6% between 1989 and 1998) are rather difficult to be reached again, since forecasted rates of growth within the period 2002-2015 are amounted at approximately 4.3% per annum [3]. It is quite useful, in this point, to stress the fact that a strong decline, similar to the one encountered in the global travel industry after the September 11th attacks, was also observed during 1991 as a result of the combined effect of the Gulf War, the rising fuel prices, and the general economic recession (full recovery during 1992) [3]. In any case, the turnover of the air travel market is expected soon, and the industry should view the crisis as an opportunity to catch up with demand, thus pushing forward with all its efforts to improve capacity both on the ground and in the air.

3.1.1.2. Supply

On the supply side, the following distinct characteristics seem to dominate the European air transport industry: i) hub-and-spoke operational philosophy, ii) large partitioning of the European sky, iii) large degree of market fragmentation, iv) few number of airport development projects, and v) runway capacity shortages experienced during demand peaks in conjunction with contradictory figures of low runway utilization during non-peak periods.

As a matter of fact, airlines prefer to run more frequent flights rather than have a more limited schedule using larger aircraft. For this purpose, an increasing replacement of the direct by indirect flights was observed along the lines of the hub-and-spoke operational philosophy. Usually, hubs are airports hosting a major European carrier's operations with a dominant market share of the European traffic. These airports compete on the basis of a large variety of connections (e.g., 3 to 5 or more frequencies per day) to quite many destinations with high degree of punctuality and short connecting times. On average, passenger traffic encountered at European hub airports (e.g., Amsterdam, Frankfurt, Charles de Gaulle) consists of close to 50% transfer passengers out of their total passenger movements [3]. A direct impact of such a "bunched" traffic (i.e., passenger, aircraft) is reflected on the high congestion levels centred around big hub airports along with the associated pollution and air traffic management problems. The hub-and-spoke operational concept is expected to decrease in the forthcoming years, while the biggest European hubs (Heathrow, Charles de Gaulle, Frankfurt, Amsterdam, and one or two others) might pull away traffic from the national, regional hubs (e.g., Zurich, Brussels). On the other hand, new secondary airports that are adjacent to main population areas might constitute an additional air traffic channel (with even more rapid growth rates than hubs) especially for short haul, point-to-point routes. However, the major airport hubs are expected to continue to grow on the grounds that they will run the denser concentrations of long haul services resulted by the airlines' consolidation / merge wave in Europe [3].

Simultaneously, more efficient or more rational use of airport infrastructure seems that it is not sufficient to obviate the need for immediate increases in capacity [1]. The fact is that new airport projects were/are only few in number (e.g., Lisbon, Berlin, Paris, Athens) since it is hard to gain public support for environmental (i.e., pollution, noise) and safety purposes. More generally, it is clear that the policy makers in Europe will not be able to gain political and public support for building new or expanding existing airport sites, thus necessitating proper long-term planning at European level over the next twenty years [1]. This is in clear comparison with the U.S. airport planning practice in the long run, where fourteen out of thirty-one busiest airports plan a new runway by 2010 with expected capacity gains ranged between 17% and 50% [2]. It is clear that capacity shortages and low runway utilization, in conjunction with the currently limited airport site developments, create sharp problems and pressure for additional airport capacity as a

means of dealing with severe congestion and delay problems (one flight over six was late with an average delay of 22 minutes in 2000) [1]. It is quite certain that European airports will soon have to face substantially increased growth of demand for runway operations, which should be accommodated by a runway system of a relatively small practical capacity as compared to U.S. big airports' runway capacity [3,4].

3.1.1.3. Capacity Considerations

Because of the severity of the problem, airport congestion and delays have received a great deal of consideration from airport users, operators, and policy makers and from the different perspective of the supply and demand side solutions. The objective of this sub-section is to summarize the major factors contributing to the generation or worsening of the congestion and delays, thus creating the well-known "capacity gridlock" problem.

The search for remedies logically begins with an identification of the forces behind the problem of airport congestion and delays. Over the past 30 years, astonishing air transport growth has been evident in terms of both passengers and aircraft movements, which have been funnelled into fewer and fewer airports. The decline in the number of airports serving the large bulk of air travel demand, has undoubtedly contributed to congestion and delays, but the problem is much more complex. In particular, the unanticipated increase in passenger traffic is thought to have been the result of the continuously decrease in the relative cost of ticket prices, which, in practice, were fed by the deregulation wave and the changes it has initiated accordingly in the air transport industry. Among these changes, one could primarily list the differences in the aircraft fleet through the introduction of more efficient new aircraft to accommodate increasing demand figures, as well as a more economically healthy air transport industry governed by market based rules promoting competition and eliminating market distortions, thus posing pressures upon airline tickets' prices.

The growth of hub and spoke route networks has resulted in a significant concentration of airline operations at a relatively small number of commercial airports. The hubbing concept and the passengers' desire towards greater flight frequency have caused the airlines to use smaller aircraft, while flying more often. The airlines continue to add flights into and out of their hub airports because each additional spoke results in a geometric increase in the number of potential passengers. Growth in the number of hub carrier operations adds to congestion and typically increases the carrier's market share, both of which impose costs on society, through extended delays and higher passenger fares due to the market concentration and the undue influence exerted by the hubbing carrier to the airport authority, respectively.

The airport congestion and delays problems would be certainly fewer if air travel were spread more evenly throughout the day or the period under consideration. As a matter of fact, airport use is “bunched” into particular time periods (e.g., early mornings, early evenings, weekends), while it might operate considerably under capacity for the remainder of the given period. For the passengers, the major determinant of demand is the ticket price, while for the airlines or the general aviation user, a large part of the flight expenses are the out-of-pocket costs involved in operating the aircraft plus a rather small fee charged for using the airport (e.g., landing, takeoff). When delays are present at peak hours, however, the total travel cost is augmented by the extra congestion costs of increased use of gasoline, greater risk of collision, and lost time from waiting. It is the sum of these costs that should be imposed to passengers and airlines for using the airport at peak hours causing congestion, delays, and generally inefficient use of the scarce airport resources. In contrary, the current fares' structure system usually charges uniform prices

throughout the day, thus generating a greater amount of service to be demanded during the preferred travel hours irrespectively of the airport capacity to accommodate this traffic.

The complicated capacity problem is significantly affected and attributed also to pure supply-side inefficiencies, and mainly the airside infrastructure and operational policy. In practice, the relationship between the demand for and the supply of airport capacity is strongly affected by weather conditions and winds experienced in the airport thus indicating the operating flight rules of approach (VFR vs. IFR), the air traffic control procedures and separation requirements, and eventually the airport infrastructure and geometry. The former is not practically manageable and exhibit a rather stochastic behaviour, while, on the other side, the latter can be effectively managed or affected by the number and configuration of the runway system, the sufficiency of the apron capacity, the availability of speed-exit taxiways, and generally the various peculiarities and limitations of the airport site itself [5,6].

Similarly, air transport trends and industry forces in conjunction with new management practices and operational philosophies, partly stimulated by the advancement of technological infrastructure of the airport service providers, have posed new challenges for those actors regulating and formulating policies, as well as for those supplying the airport services. Globalization, deregulation, and privatization have been major industrial trends of the late 20th century. The deregulation of the air transport industry has triggered the internal need and pressure for increased efficiency and close monitoring of airport performance. Airport stakeholders have a vested interest in having a finger on the pulse of their operational and financial performance with the use of [3]: i) technologies and operational concepts for the improvement of airport efficiency and the modernization / harmonization of airport and ATC operations (e.g., A-SMGCS, ADS-B, RVSM), ii) the appropriate combination of performance assessment models / tools, and iii) the appropriate data / information sources for airport benchmarking.

From a different perspective, airports are rapidly turned into open and flexible business entities that increasingly recognize the importance of airport benchmarking as a valuable airport management practice and decision support tool. Airport benchmarking involves the smooth, efficient and mutual exchange of comparable and harmonised data between airports with view to effective management decisions and proper long-term planning. Collaborative Decision Making (CDM) as an operational philosophy and a tool for promoting cooperation and information sharing within airports draws the increasing attention of relevant airport stakeholders, while the steps of introduction and initial implementation are considerably accelerated in both Europe and the United States already having delivered substantial benefits to users [7].

3.1.1.4. Airport Capacity & Efficiency: Demand vs. Supply Dilemma

Supply-side Solutions

Options towards increasing capacity through expansion of existing or building of new airports, or alternatively through air traffic management (ATM) programmes address the supply side of the problem. All potential remedies to the congestion problem seeking to equate the supply of airway and airport services with the demand for these services can be classified under three major alternative approaches: i) airport improvements / developments, ii) airspace procedure improvements, and iii) aircraft improvements.

Although the construction of new airports and airport improvements have been considered the most effective and direct way to increase airport capacity, such a solution involves a lengthy and rather costly process, while simultaneously several political and environmental barriers should be overcome in the course of the decision making process. The time it takes to implement these constructions and improvements along with the projected rapid growth of the air traffic are all factors pointing to the need for examining also alternative solutions. Another also important issue that should be considered is the location of the new airport, and generally the social pressure and politics involved in the decision upon the selection of an economically affordable, and socially and environmentally acceptable site. Even when suitable locations for the new airport can be found, several problems and political resistance may arise from the airport users of the current airport (e.g., airlines) for competitive reasons, as well as the costs involved in the relocation of their major hub operations in the new airport. Finally, there are other problems as well with new airports' construction, which mainly address safety and environmental considerations. More specifically, the congestion problem in many cases is also clearly evident in the airspace sectors "pushing" congestion phenomena from the ground to the airspace and vice versa. Pressures upon squeezing separation requirements and parallel operation of airports in the close vicinity of major urban areas undoubtedly put also pressures upon safety margins (within the acceptable range of safety margins though) and leave less margin for error both for the pilot and the air traffic controller. In a similar basis, political opposition and resistance have been the result of systematic efforts towards new airport developments or expansions in densely populated urban areas. Noise problems, automobile traffic congestion, air and noise pollution in conjunction with prerequisite safety considerations constitute major opposition arguments against the implementation of such projects [1,8].

Furthermore, air transport policymakers and the airline industry in general opt for large aircraft that can absorb portion of the anticipated traffic growth and provide short to medium term solutions in the airport congestion and delays problem [1]. The Airbus A380 Family Aircraft bring new standards of comfort, better economics and seat capacity by seating 555 passengers in a typical three-class interior layout, while Boeing 747-400ER Version allows operators to carry up to 6,800 kg. more "payload ", extra cargo or a full load of 416 passengers. However, this transition period to carriers transporting more passengers and/or freight via larger aircraft should be accompanied by substantial efforts towards achieving airport compatibilities and harmonized operations under the new service standards and infrastructure specifications. Airports must be adapted to cope with the new operational standards (e.g., separation requirements, turnaround times, apron specifications) and the new "overloaded" service requirements stemming from the embarkation and/or disembarkation of quite more passengers (more than 500 passenger movements) as compared to only 150 to 200 per normal operation today [1,9].

As an alternative means of balancing capacity with the exceptionally high demand levels, especially in the short run, many experts propose operational improvements and advanced technological equipment to increase system capacity and allow for more loose separation requirements. Such measures towards increasing capacity are relatively inexpensive and fairly easy to implement in order to respond quickly to capacity shortages, but they are rather site specific, while the necessary testing phase to experiment on the new operational procedures and rules (e.g., reduced spacing, simultaneous operation on interdependent converging or intersecting runways) requires substantial effort from air traffic controllers and pilots to adapt to and restore the temporary capacity bottlenecks. In addition, the benefits obtained by the operational improvements (up to 20 percent additional capacity) are rather short-lived, and they will not significantly relieve from severe congestion experienced by highly congested airports [2,10].

These programmes, however, are focused on confronting a multidimensional, complicated problem by shedding light and devoting efforts only to one side (i.e., supply / infrastructure) of the problem. Actually, research programmes and policymakers on air traffic management (ATM) and airports to date have concentrated primarily on the technologies and operating procedures that can enhance system capacity, while maintaining the requisite exceptionally high level of safety. Unfortunately, the experience of the last decade suggests strongly that, by concentrating on increasing capacity, we may be fighting a losing (and extremely expensive) battle. According to figures, the overwhelming increases in demand in conjunction with technical constraints in providing sufficient capacity to satisfy all anticipated future demand render such a solution rather impossible. Since well-publicized delay problems encountered by metropolitan European and U.S. airports entered the political arena, there is an unprecedented pressure experienced by policymakers and civil aviation authorities upon investigating and adopting demand management strategies to cope with the well-known “aviation capacity gridlock” [10,11,12].

Demand-side Measures

Demand management strategies involve two ways of handling demand: i) by limiting in some way the demand for access to busy airfields or to congested airspace (traffic diversion), and/or ii) by modifying the spatial and temporal distribution of this demand to bring it closer to available capacity [8]. The first approach can be achieved through administrative means that will ease the congestion by diverting some traffic on the basis of certain slot allocation criteria where it can be handled more promptly or efficiently, while the second alternative dictates the design of a pricing system so that market forces allocate capacity (mostly on a temporal basis) among competing users by considering the real market value of access to scarce / congested airport facilities [10,11,12,13].

Several administrative measures can be adopted to manage demand at individual airports or at metropolitan region. Among these are [8]: i) required diversion of some traffic to less busier airports, ii) more balanced use of metropolitan airports, iii) restriction of airport access by aircraft type or use, and iv) establishment of quotas either on the number of operations or on passenger enplanements. Finally, at the national level, demand might be managed by administrative actions to encourage “re-hubbing” or redistributing transfer traffic from busy airports to underused airports. All of the above described actions deny some users free or complete access to the airport of their choice, which, in a sense, might be viewed as a violation of the traditional policy of freedom of the airways to allocate the use of airport facilities, that is, a distortion of the concept of “freedom to accord unrestricted access to any and all users”. Moreover, there are criticisms for adversely affecting the growth of the aviation industry. Nevertheless, since demand has by far outpaced supply in most metropolitan airports, several practices approximating pure administrative demand management (e.g., quotas per type of user, capacity segmentation per aircraft class, declaration of capacity, IATA-driven slot allocation) [5] have already come into use, and many industry observers agree that these measures have a great potential in successfully and immediately dealing with congestion and delays, as well as a more efficient airport capacity utilization [8].

Certainly, the objective of these measures should be to enhance the efficiency of airport operations, while interfering to the least possible extent with the aim of developing a competitive, market-driven air transport system [8,14]. The current administrative efforts on applying demand management measures (such as those used by the IATA schedule coordination procedures) undoubtedly distort the market nature in the long run, and they might constitute a step back toward re-regulation of the air transport industry [14,15]. The potential demand management strategies that are oriented towards market mechanisms include purely economic incentives and instruments (e.g., congestion or peak period pricing, slot trading) or

combinations of administrative measures and market-based policies (e.g., initial allocation accompanied by secondary trading, slot auctions) [16,17].

Administrative options, in many cases, although offering immediate and relatively low-cost relief of airport congestion may not be as attractive and efficient as compared to market-based approaches to demand management. The opinion of several economists is that this situation occurs because administrative options tend to bias the outcome towards the maintenance of the status quo when applied over a long period of time [16,17]. The real problem with administrative options is that they are not indicative of the true economic value that incumbents and new entrants place on available capacity. In response to these problems, many policy makers and economists favour a scheme of allocating airport access that relies on the mechanism of price. By definition, all economic demand management approaches involve pure economic instruments and are based on the market mechanism as the only access control mechanism under the common objective of discouraging users from requesting slots during peak periods. This fundamental observation and purpose of the market-based approaches is essentially reflected on the most dominant strategy of peak / congestion pricing, as well as other complementary solutions (e.g., direct passenger surcharges).

In addition to pure economic instruments, hybrid demand management measures (i.e., initial allocation, secondary trading) aim to integrate the contextual framework of market-based approaches with pure administrative measures. Initial allocation addresses the different ways of allocating new or released capacity that is not subject to “grandfather rights” or historic slot holdings. It is clear that initial allocation methods aim at rationally allocating scarce capacity to more than one potential user, while avoiding discriminatory or exclusive practices. Under this classification, one may consider slot auctions, “first-come first-served” approaches, and lotteries. Initial allocation mechanisms are subject to practical difficulties that might be overcome only through the adoption of secondary trading processes and “follow-up” market adjustments. These measures can be implemented either on an independent basis or as a secondary action complementary to initial allocation. In particular, these involve transfer of slots between airlines as a means of improving the outcome of the initial allocation in the form of: i) bilateral exchanges of usage rights in monetary terms (i.e., slot trading), and ii) slot exchanges based on non-monetised terms (i.e., barters). Conceptually, an integrated approach of initial allocation complemented by secondary trading in monetary terms has the potential to produce a positive and fair outcome. This is because secondary trading of slots implies that users obtaining the usage rights will be the ones mostly valuing this available capacity.

3.1.2. Feedback from THENA Workshops

Within the framework of the THENA Project, there was a clear intention to establish focal points of collaboration and active research liaisons between the different programmes and stakeholders involved in or affected by airport operations. In particular, three workshops were organised, each of them addressing the quite challenging and contemporary areas of airport capacity, safety and security, as well as environment. This chapter highlights the feedback and perceptions drawn by these workshops with respect to a number of airport capacity related issues that have been addressed in the review of this section. In particular, a number of observations and conclusions from the workshops are summarized below:

- The airport system management involves the synthesis and consideration of a large number of different stakeholders (e.g., ATC, ATFM, airport, airlines, handlers, passengers) with different and, in many cases, conflicting objectives (e.g., maximise runway throughput, flight punctuality, optimisation of resource / infrastructure usage, avoid sector overload).

- Airport capacity problems are in close interrelation to en route capacity problems. In many cases, reducing airport capacity problems does not result in a "total" solution on the grounds that it just "pushes" congestion problems on the airspace and vice versa. To this end, a network approach is needed to deal with airport and en route capacity problems. A System-Wide Manager, supported by a Global System Traffic Monitor, is necessary in order to consider the objectives of all actors involved and produce a commonly acceptable, system-optimum solution. This network / system approach requires the establishment of strong collaboration liaisons and cooperative approaches of airport decision making (e.g., Collaboration Decision Making).
- Collaborative Decision Making as an operational philosophy and a tool for promoting cooperation and information sharing within airports draws the increasing attention of relevant airport stakeholders, while the steps of introduction and initial implementation are considerably accelerated in both Europe and the United States. As a result, the anticipated benefits derived by the implementation of the CDM operational philosophy include increase in capacity / reduction of delays, improved utilization of infrastructure resources (e.g., apron), improved slot management, reduction in airline costs, proactive management of turnaround processes, etc. In this direction, Collaborative Environmental Management at airports is considered to play a critical role in performance management and information sharing between actors (i.e., airports, airlines) with various or conflicting objectives and requirements. This collaborative environment will build a consensus on performance targets and metrics, along with the establishment of a monitoring and reward system to deal with environmental issues under the prism of capacity.
- Operational improvements and advanced technological equipment to increase system capacity and allow for looser separation requirements are relatively inexpensive and fairly easy to implement in order to respond quickly to capacity shortages, but they are rather site specific, while the benefits obtained by the operational improvements are rather short-lived, and they will not significantly relieve from severe congestion experienced by highly congested airports. Whatever future improvements are, ATC capacity remains a constraining factor that cannot or should not be considerably "squeezed".
- Increasing aircraft movements (albeit with decreasing passenger movements) put significant pressures on airport and en route capacity. Pressures upon squeezing separation requirements and parallel operation of airports in the close vicinity of major urban areas undoubtedly put also pressures upon safety margins, thus leaving less margin for error both for the pilot and the air traffic controller. In any case, safety should remain a non-negotiable requirement in airport operations.
- Airport enhancement and infrastructure improvement projects are continuously increasing in Europe. Certainly, this solution involves a time-lengthy and rather costly process, while simultaneously several political, public and environmental barriers should be overcome. What really remains to be thoroughly and systematically examined is the overall effectiveness and efficiency of infrastructure improvement / expansion projects. To this end, a number of strategic questions should be addressed. In particular: Is it enough to deal with projected growth figures? Are infrastructure projects sufficient and capable of coping with capacity shortages? Is it proper and wise to concentrate efforts on big airports? Rehubbing and traffic redistribution into secondary airports are quite interesting options, but their applicability and anticipated effectiveness are in question due to strong opposition expected by (big) airline operators and alliances that have concentrated their operations on major hub airports, as well as the significant (direct and indirect) costs involved in the relocation of their operations in the new airport.

- Capacity improvement projects through expansion of infrastructure represent a direct action and relief to congestion problems. However, when these supply expansion projects are fully environmentally-driven, in practice, their direct capacity benefits are seriously questioned with reference to their suitability and effectiveness as a capacity measure.
- Increase in the runway capacity should be accompanied by the modernization and harmonization of ATC procedures, the use of more technologically sophisticated ATC tools, and the adoption of high-capacity operational standards (e.g., converging runways, mixed operations, reduced separation minima), and the improvement of all weather operations on the ground.
- The adoption of new surface management concepts supported by A-SMGCS, will come to fruition and will maximize the anticipated benefits when the appropriate integration of airside with ground traffic management will be operationalised.
- The European Community should try a drastically revised regulation on the mechanisms and instruments for the allocation of slots that will move towards the context and purpose of market-based and hybrid demand management approaches placing a market valuation on airport capacity.
- The implications of new security measures and the growing environment-dictated operational standards (e.g., noise) should be closely examined and quantified with the purpose of identifying the capacity-side effects along with alternative ways to cope with their capacity constraining implications.

3.1.3. Research Voids & Gaps

Airport stakeholders and policy makers involved in or affected by the airport decision making process are asked to make decisions, draw policy directions, and operate in a quite complicated institutional and operational setting. Decisions related to airport planning, design and operations are highly complex since they involve a large and diverse number of processes, multiple actors involved representing different perspectives and objectives regarding the optimal use of airport resources, and most importantly an abundance of airport performance metrics. The decision making and implementation process for dealing with the complexities of contemporary airport management and policy formulation necessitates the deployment of advanced capabilities in the form of technical / operational field expertise and managerial competence accompanied or supported by the appropriate mix of models / tools, technologies, and the surrounding policy environment. Based on the in-depth review of the aforementioned issues vis-à-vis the airport capacity and efficiency and the workshop feedback, a number of interesting conclusions have been drawn by WG1.1 members, which are summarized in this section.

The overview of the state-of-the-art and state-of-practice suggested that currently available models and tools provide decision support to all levels of decision making, while successfully addressing all airport elements and flows pertaining to airport capacity and delays, as well as the efficiency of airport operations in general. Airport decision makers and various airport stakeholders can select among a “pool” of available models / tools that provide decision assistance and perform various airport related studies in order to monitor and assess the effectiveness and efficiency of airport operations. On the other hand, there seems to exist a significant knowledge gap on the analysis and modelling of airport freight operations and accessibility/intermodality issues. In addition, the state-of-the-art and state-of-practice review shed light upon the lack of available models and tools capable of capturing in a satisfactory manner the total airport operations in terms of both airside and landside, as well as models and tools explicitly monitoring and quantifying the implications and effectiveness of airport demand

management strategies on critical airport performance parameters (e.g., capacity, delays, environment). Although there is a very rich experience in both models / tools and their specific application to support strategic, operational and design decisions for airports, there are a number of research voids and gaps that have been identified through this review. These major gaps essentially constitute rather fertile research fields to be further studied in the future:

- Limited integration between models / tools capable of performing total airport capacity analysis with view to a number of interrelated and interdependent airport performance metrics. Currently there are quite few airport analysis models / tools (practically only OPAL) that can provide analyses for the entire airport complex by considering a variety of airport performance metrics (e.g., capacity, delays, noise, safety).
- Lack of harmonized and user-friendly computing environments capable of assisting strategic airport planning and decision making with respect to airport capacity and efficiency issues.
- Lack of models / tools directly assessing in a quantitative manner the implications of demand management strategies on capacity and delays, as well as other airport related parameters (e.g., noise, safety).
- Lack of models and tools capable of performing various airport analyses in the form of network-wide (i.e., system-optimum) solutions rather than solutions pertaining to a single airport.
- Lack of integration of airport capacity models addressing both cargo and passengers.
- Lack of methodological tools and analytical models directly integrating macroscopic demand forecasting with schedule generation mechanisms as a means of estimating the necessary infrastructure (i.e., supply-side) requirements and identifying possible operational bottlenecks or future points of inefficiencies

Furthermore, the examination of the policy environment and institutional setting has revealed the following policy gaps:

- The current regulatory framework governing capacity / slot allocation suffers from a number of drawbacks and weaknesses in the form of: i) vagueness of policy objectives and local interpretations of the proposed regulatory framework that distorts the common character of the framework itself, ii) lack of clarity over what is being allocated (i.e., rights and obligations that go with holding slots), iii) potential arbitrary slot allocation and discriminatory practices by the slot coordinator, which might favour incumbents in the expense of new entrants and free market competition, iv) declining effectiveness of the “new entrant” measures with shrinking slot pools, and therefore, limited access in highly congested airports, and, last but not least, v) inefficiency of administered rules in allocating scarce capacity to the highest value use (i.e., market-driven valuation of capacity).

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- shrinking slot pools, and therefore, limited access in highly congested airports, and, last but not least, v) inefficiency of administered rules in allocating scarce capacity to the highest value use (i.e., market-driven valuation of capacity).
- There seems to exist a considerable knowledge and information / data gap concerning the availability of easily accessible, reliable, comprehensive, and validated data / indicators capable of assisting airport decision making for policy formulation, strategic capacity planning, and monitoring airport efficiency.
- Lack of airport benchmarking studies and methodological tools capable of monitoring and assessing the efficiency and effectiveness of airport operations.
- Lack of harmonized / standardized measures of effectiveness describing the performance of the airside and landside airport elements based upon consensus of airport stakeholders and policy makers.

3.1.4. Recommendations

Some recommendations are presented as likely R&D approaches to cover major gaps that have been identified in the field of capacity and efficiency issues at airports:

- More efficient or more rational use of airport infrastructure seems that it is not sufficient to obviate the need for immediate increases in capacity. Although the construction of new airports and airport improvements have been considered the most direct and effective way to increase airport capacity without compromising safety or environment, such a solution involves a lengthy and rather costly process. What really remains to be thoroughly and systematically examined is the overall effectiveness and efficiency of infrastructure improvement / expansion projects. To this end, a number of strategic questions should be addressed. In particular: Is it enough to deal with projected growth figures? Are infrastructure projects sufficient and capable of coping with capacity shortages? Is it proper and wise to concentrate efforts on big airports? Re-hubbing and traffic redistribution into secondary airports are quite interesting options, but their applicability and anticipated effectiveness are in question due to strong opposition expected mostly by airline operators.
- New airport projects are only few in number due to strong political and public opposition for environmental (i.e., pollution, noise) and safety reasons. An important issue that should be considered is the location of the new airport, and generally the social pressure and politics involved in the decision upon the selection of an economically affordable, and socially and environmentally acceptable site. Finally, there are other problems as well with new airports' construction, which mainly address safety and environmental considerations. More specifically, the congestion problem in many cases is also clearly evident in the airspace sectors "pushing" congestion phenomena from the ground to the airspace and vice versa. Pressures upon squeezing separation requirements and parallel operation of airports in the close vicinity of major urban areas undoubtedly put also pressures upon safety margins (within the acceptable range of safety margins though) and leave less margin for error both for the pilot and the air traffic controller. Similarly, political opposition and resistance have been the result of systematic efforts towards new airport developments or expansions in densely populated urban areas. Noise problems, automobile traffic congestion, air and noise

pollution in conjunction with prerequisite safety considerations constitute major opposition arguments against the implementation of such projects. In conclusion, it is clear that policy makers in Europe will find it quite difficult to gain political and public support for building new or expanding existing airport sites, thus necessitating proper long-term planning at European level over the next twenty years.

- A principal law governing systems' operations is also in effect to highly complicated airport operations. The "law of the most restrictive factor" introduces a systemic perspective, directly applicable and quite useful to provide a deep insight into the airport operational entity on the grounds that an airport global capacity is the capacity of the weakest link in the chain. This, in turn, generates important implications and extensions in the airport system planning and management, while simultaneously underlining the imperative need for harmonised airport elements' development and expansion, and balanced growth between airside and landside, ground and en route capacity, as well as among the various performance metrics (e.g., capacity, safety, security, noise, aeronautical Vs. non aeronautical revenues).
- Air transport trends and industry forces in conjunction with new management practices and operational philosophies, partly stimulated by the advancement of technological infrastructure of the airport service providers, have posed new challenges for those actors regulating and formulating policies, as well as for those supplying the airport services. Airport stakeholders have a vested interest in having a finger on the pulse of their operational and financial performance with the use of: i) technologies and operational concepts for the improvement of airport efficiency and the modernization / harmonization of airport and ATC operations (e.g., A-SMGCS, ADS-B, RVSM), ii) the appropriate combination of performance assessment models / tools, and iii) the appropriate data / information sources for airport benchmarking.
- The complexities involved in airport operations can be mainly attributed to the abundance of stakeholders involved in or affected by the airport operations. The various airport stakeholders (e.g., airlines, airport operators, ATC, ATFM, handlers) represent different airport management and planning perspectives, while, in some cases, exhibiting conflicting objectives. Certainly, they are all interested, in different degrees though, in increasing airport throughput and performance without compromising certain measures of airport effectiveness, however, they justify it from different viewpoints, propose different means, and eventually recognise different compromises or priorities. There is a need to pursue a social dialogue among all relevant stakeholders with the purpose of building consensus and establishing a close collaboration environment to promote the efficiency of airport and air transport operations under the prism of regulations / policies, technologies, management and strategic planning, as well as operations.
- It is imperative to establish new procedures and rules for allocating slots at congested airports by allowing more transparent exchanges of slots and criteria for allocation priorities with a clear orientation towards greater flexibility and increasing adoption of market mechanisms (i.e., pricing schemes) in conjunction with a decreasing public / administrative intervention to slot allocation and management. The European Community should try a drastically revised regulation on the mechanisms and instruments for the allocation of slots that will move towards the context and purpose of market-based and hybrid demand management approaches placing a market valuation on airport capacity.
- A new and widely adopted concept in aviation environmental management is the environmental capacity, which is strongly dependent on political attitudes / priorities, organizational and institutional issues (e.g., the role of airport operator, legal / regulatory provisions), and other practical / technical factors in estimating airport capacity. There has

been a strong debate in charging capacity with reference to environmental concerns and associating capacity (e.g., slots) with environment (e.g., noise). In any case, environmental requirements are deeply considered should be a prime determinant of airport capacity.

- The implications of new security measures and the growing environment-dictated operational standards (e.g., noise) should be closely examined and quantified with the purpose of identifying the capacity-side effects along with alternative ways to cope with their capacity constraining implications.
- Currently there are quite few airport analysis models / tools that can provide analyses for the entire airport complex by considering a variety of measures of airport effectiveness (e.g., capacity, delays, noise, safety). This research gap can be successfully addressed by the development of seamlessly integrated computational platforms that will be able to support high-level political decisions (with focus on strategic-level decision making) related to airport planning and operations with respect to a variety of measures of airport effectiveness. Furthermore, these models / tools should be able to examine and quantify the trade-offs of airport operations by running “what-if” scenarios based on alternative decisions on airport performance metrics.

3.2. Safety and Security

The purpose of this section is the presentation of the main conclusions of the second THENA working group, related to Airport Safety issues. The Safety workgroup of the Thematic Network for Airports provided an open forum for presentation and discussion of current and future R&D on safety and security at airports. Initially the thematic work covered the safety subject only. During the THENA active period the terrorist attack of the World Trade Centre in New York City took place and it was clear that the security subject had to be added to the discussions and reporting. Both subjects are summarised below with emphasis on the observations during the workshops and the consortium view on the R&D needed.

Security and safety are very much similar in the aspects of operations, systems and R&D. This statement was proven by the THENA workshops and the contributions given. The commonality between safety and security is continued in this final report.

For further reference and more complete information, the full version of, both, the Safety and Security Position Paper are available in the THENA web page (http://thena.aena.es), as well as the proceedings and presentations of the three workshops.

3.2.1. Current State of Affairs

The current situation of safety systems and procedures is described in the THENA Safety Position Paper version 2.0 (ref. THENA document 12W01NLR20, 9th August 2002). The following overview is extracted from that reference, in order to provide an overview of the treated issues in that reference.

The development of an airport safety risk management system is described as a key factor to improve safety at airports. It contains a strategic approach to improve airport safety with the use of failure and hazard analysis techniques. As a result of that analysis, it is conclude that fast time simulation modelling is supporting this development and the establishment of procedures and organisational structures at all airport operations is recommended. Introduction of new technology in the ATC (e.g. by Advanced Surface Movement Guidance and Control Systems) and on board systems should be accompanied by the corresponding operational and procedural measures. And, the development loop is closed by the assessment of the safety via safety analysis models and methodologies, and the means to record permanently safety in terms of reported incidents and accidents.

Safety technology is emerging, covering better airport surveillance and visual guidance means (ground based and in the cockpit). Recommendations have been done to improve secure communication facilities, rescue and fire fighting technology and wildlife hazard abatement. In the cockpit on board alerting systems like Ground Proximity Warning System and Traffic Collision Avoidance System are already available and can be further improved. And technology for wind shear and wake vortex prediction, detection and modelling is described having also potential benefit for capacity increase, in addition to the safety benefits.

Moreover, it is included one analysis of the runway incursions. Runway incursions have been considered a particular worry in the States in the last decade, while Europe did not consider so urgent. However, this situation is changing due to the rapid growth of the traffic. Under those premises, programs to reduce and prevent runway incursions are given with runway incursion facts and a summary of work in European, FAA and ICAO context. From this it is concluded that adherence to the procedures is of utmost importance to reduce runway incursions. Furthermore

a structured approach for assessment of the incursion risks and hazards analysis is promoted with modelling of both systems, and human actions and procedures in order to obtain insight qualitative and quantitative information on critical components.

In addition, a chapter is devoted on safety of land side operations with work in progress on safe apron design and installations, markings and signs, land side operating procedures, training and licensing procedures, the promotion of safety consciousness, and better ground incident and accident reporting

At last certification aspects are summarised that are in line with ICAO SARPS and upcoming EASA and the Group of Aerodrome Safety Regulators (GASR).

Regarding **security**, it was produced a report specially dedicated to this issue after the tragic event of September 11th in USA. THENA was very concern about this aspect, not considering at the beginning of the project, and a position paper was prepared to analyse the current threats and concerns. The following conclusions were extracted from this report, as more remarkable.

Although it is devoted to aviation security in general, it has special emphasis on security implications at airports. Today's aviation security is based partly on the systems and procedures set up in the 1970s against hijackers and on recommendations made by the Commission on Aviation Security and Terrorism, created by the United States Transportation Department, in the wake of the bombing of Pan Am 103 over Lockerbie, Scotland. Consequently, the measures taken need a new depth analysis and update. Additionally, those improvements in aviation security have been complicated because governments and industry often find difficulties to resolve disputes over financing, effectiveness, technology, and potential impacts on operations and passengers. It is highlighted the need to properly balance security and facilitation. Another emphasis is put on the need to internationally agree on measures, procedures and standards to protect airports operations (and aviation in general).

The terrorist threat is changing and growing. Therefore, it is important to improve security not just against familiar threats, such as explosives in checked baggage, but also to explore means of assessing and countering emerging ones, such as the use of biological or chemical agents, electronic actions or the use of missiles. While these do not represent significant threats at present, it would be short-sighted not to plan their possible use and take prudent steps to counter them.

3.2.2. Feedback from THENA Workshops

This section contains suggestions and issues discussed during the three workshop organised by the THENA consortium. Most of the suggestions on safety and security come from the second THENA workshop. The other two workshops, however, produced also valuable material. More precisely, the below paragraphs summarise the feedback recorded in the proceedings of the thee workshops

It was advised firstly to monitor accidents, incidents and to perform analysis with focus on the main airport safety areas and the runway incursions issues. Secondly one should predict future hazards and establish action plans to be proactive. Accurate surveillance is a prerequisite as is the need for cockpit equipment. Safety validation methods are needed prior to introduce new technology or operational procedure. Procedures (cockpit and tower) have to be developed and

validated accordingly appropriate methodology. A safe airport traffic control system should serve non-equipped aircraft and vehicles also.

A total programme approach was explained to reduce runway incursions: establishment of a universal database, implementation of preventive measures and prevention as advised by FAA was brought into attention. Clear communications and 100% adherence to the procedures are of top priority. Attention was paid to the airport design and lay out and to the training of pilots and drivers.

The airport security subject of another session of the 2nd workshop demonstrated that security has much commonality with safety. However, security deals, with a complete new and very broad spectrum of unfamiliar threats. Security gets utmost attention after the terrorist attack of September 11th, 2001. Disputes are going on over financing, effectiveness, technology, and potential impacts on operations and passengers, capacity, cost benefit of safety and security measures. A layered, integrated and total system approach is advised with biometrics and passenger screening long before the terminal as focal points.

The workshops gave the vision that safety and security management consists of a cyclic approach in which safety and security goals are specified, planned, introduced, but also checked and validated with corrective action if needed. Safety (or security) working methods start with specification of operations and assumption of relevant external risks. Then hazards are identified and risks assessed. The expected risk is derived and adapted operations developed with safety policy in mind. After changing and introducing new systems and operations, the results are monitored and recorded. It makes it possible to account for better procedures and working methods.

Especially, the step to identify and assess the risk modelling of systems and procedures (including the human factor) was considered of mayor importance. Fast time simulations are the only way to obtain statistically significant results and real time trials are done to validate the models used. Especially quantitative risk assessment techniques are under development. Statistical data and simulations are needed to support the safety cases. Procedures should drive technology, and not vice versa. The A-SMGCS is seen as a tool for improving safety at airports.

Both for safety and security it was concluded that one should strive for an integrated approach and in case of distributed R&D one should work together in a network; the results should be shared. The human factor is the key driving force and overall there is need for better models and better info flow, better communication, harmonisation, implementation and validation.

Several organizational, technological, and modeling issues that contribute to either minimization of accident probability or emergency response effectiveness have been identified on the workshops. The transition from the current compartmentalized way of imposing safety measures to integrated system thinking could improve the safety performance of airports. The development of efficient airport safety assessment tools would enable the Airport Management authorities to safely expand or implement capacity management practices

3.2.3. Research Voids & Gaps

This section aims to present research voids and gaps concluded from the literature reviewed by the consortium and the feedback from the workshops. They do not content necessarily the opinion of the THENA consortium, what is included in the conclusion section. Most of the

following recommendations aim to acquire further knowledge in areas that could affect security and safety of operations. In addition, there are some fields to be further studied to enhance the current level of safety and security.

The nature and the variety of the airport operations impose upon a large number of fields where safety and security could be improved. Many different stakeholders operate on airports, including among others, handling agents, airlines, several airport bodies with different points of views and interests involved in a large number of processes. In addition, the complexity of those operations makes the study of the safety issue at airports a complex issue. All parties interacting around airport are part of the safety problem and part of the potential solution. Once said that, it can be concluded that gaps and voids on safety of airport operations can affect several fields and actors.

The need to increase airport capacity and efficiency, together with the need to reduce the environmental impact of operations at airports, e.g. noise impact, forces actors to apply new operating procedures and to use new technologies. This results in the emergence of new hazards, in addition to the existing ones. But upgrading of airport capacity must not jeopardise safety and security of the system and also environment around airport. Most of the times, the new hazard situation at airports is unknown due to a lack of essential knowledge of the issues involved in that safety.

The following issues are considered relevant to require further research:

- **Advanced Surface Movement Guidance and Control Systems (A-SMGCS) and Procedures:** Safety implications of implementations of new technologies should be researched, in particular A-SMGCS, in order to maintain or even increase capacity in all weather conditions with equal or better safety. Several aspects need further development in this aspect in spite of the fact that many projects have addressed it (e.g. BETA project). However, there are open questions on the safety effects due to lack of well-defined and **standardised procedures**, level of confidence for each level of implementation and responsibilities of each actor. Additionally, integration of this system with others (e.g. AMAN and DMAN) within the airport will have an impact on safety that needs to be studied.
- **Wake Vortex**: Research in the area of wake vortex (currently being modelled for some projects, e.g. ATC-Wake, I-Wake, S-Wake or WVWS among others) with the use of sensors on ground and airborne will enable to model, identify and locate wake vortex and the development of associated procedures. In addition, the rationalisation of current wake vortex criteria within Europe is an issue. The wake vortex effect determines the minimum distance between aircraft in sequence. Tendencies to reduce the minimum separation to increase runway throughput, use of parallel runways and the introduction of New Large Aircraft (NLA), leads the community to study the risk of loss-of-control accidents in these situations.
- **New Large Aircraft:** The introduction of NLA will bring problems of compatibility with exiting design and infrastructure in many airports. Problems to access to ground services equipment in congested aprons may increase the risk of damage. Those aspects should be investigated and complemented with cost benefits analysis for different airport categories.

- New **noise abatement procedures**, such as Continuous Descent Approach or reduced flap approaches, may cause a reduction in safety margins that needs careful assessment, particularly when involving mixed runway modes.
- Optimisation of **airfield infrastructure design**, taking into account the local constraints, including both apron area and manoeuvring area. The standardisation of marking and signs need to be promoted to improve safety in apron operations and prevent runway incursions. In this area, the integration of ground operations needs to be carefully considered due to the safety benefits that it could bring. That means fewer vehicles within the apron, thus reduction of risks collision.
- Evaluation of **emergency plans**. It would be of major importance to be ready for any traumatic aftermath around airports. Therefore, some studies are needed to evaluate the situation in Europe to show how airport are prepared to react to any kind of disaster at or near an airport. In particular, it is important that such an emergency plan ensures accessibility to potential accident sites near the airport for emergency vehicles, involving airport staff and other emergency bodies.
- Activities to promote the **integrated safety management systems** and common methodologies for risk assessment developed at European level. The way to manage safety over Europe is quite different from one site to another. There is a need to break with the compartmentalised way of imposing safety measures. It is recommended to create an integrated safety management system involving all organisations operating at the airport, using common databases for incidents and other relevant safety information, and co-operatively defining achievable corrective measures. Moreover, there should be a common frame of reference for the risk assessment where new technologies and procedures are implemented.
- A growing aspect of interest is the reduction of **runway incursions**, which has an enormous impact on safety. Although there are many factors that affect this problem (e.g. procedures, marking and signs, enhancement situational awareness with help of new technologies) it should be addressed in a comprehensive manner. For instance, Eurocontrol has recently launched a European Runway Incursions Plan containing important points about recommendations and future work.
- Air-ground **datalink communications** and **advanced sensor systems** (Precision Runway Monitor, Mode S multilateration, etc.) will improve the situational awareness of both controllers and pilots. Those technologies will need to be studied from safety point of view in terms of their performances, but above all the procedures that have to be introduced and the changes to existing procedures
- For both airborne and ground side, the need is to improve the situational awareness of pilot/controller/vehicle drivers and reduce workload. **Human Factors** on these issues are considered critical and they need more investigation and study.
- Safe and secure approach procedures and precision landings using **satellite signals** (EGNOS, DGPS, etc.) will require further study from a safety perspective. Also the robustness of GPS against jamming should be improved.
- Promotion of best practices with respect to runway, taxiway and apron operations need to be supported. For instance, the adoption of universal practices associated with High Intensity Runway Operations (**HIRO**).
- Last but not least, it is required to work on the development and dissemination of safety and security awareness material among actors involved, i.e. airports operators, airlines and handling agents, in order to promote **safety and security consciousness** in the

aviation community on the airport operations. Manuals, bulletins or seminars are initiatives to be organised among with repetitive training and audits on safety procedures.

- Development of advanced **software for enhanced training** of security personnel is needed as is the assessment of the effect of security measures and the assessment of the consequences of security measures on the efficiency and costs.

Security, being the 'new kid in town' deserves the appropriate attention in future R&D programmes. Up to now it was not a focal point in the European programmes. Luckily the R&D working methods to improve security are quite similar to those applicable to safety. Actually all what can be recommended on safety R&D voids and gaps is mainly applicable to security at airports. Security R&D differs in work-out if arriving at the level of technical and operational details: it deals much more with land side and the detection and monitoring techniques differ. European programme is needed to increase the professionalism of the aviation security workforce, including screening personnel. In relation to this topic the following conclusions have been extracted as more relevant:

- **Security with respect to sabotage:** Communication, navigation and surveillance means have to be analysed on the threat of sabotage. If sabotage happens a secure **contingency** should become active. This aspect requires detailed functional analysis of the ways CNS can be sabotaged. Development and simulation of contingency plans to face aviation crisis situations due to navigation signal degradation and interference (jamming), attacks against control centre installations or communication networks.
- Secure communication lines by application of cryptographic keys, consisting of **communication codification** using cryptography, for civil aviation do not in the first instance seem too appropriate due to its high cost and complexity for a wide distribution within airlines. It also implies more avionics equipment on-board. However, it could be a field for research since cryptography can be used to code communications between air traffic controllers and pilots.
- Regarding new technologies to reinforce security at airports and other public areas. Concepts should be sought to ensure that all passengers are **positively identified** and subject to security procedures **before they board** the aircraft: Biometrics and facial-recognition technology can be used to match real-time scans against a database of wanted criminals.
- Technologies are available but need further integration and benefit analysis on the subject of the **detection** of explosives or chemical and biological weapons as tools of terrorism. Examples are bomb-sniffing technologies to detect molecular-level evidence of explosives and firearms, and image matching: software that takes a step beyond metal scanning to process relational matches for weapons. It can be used to detect plastic knives, for example.

3.2.4. Recommendations

Safety and security have much commonality in their approaches and goals for further R&D:

- The chance of having an accident on airports or a break through of security are and should stay particular small, and
- Human factors and procedures are the most important parts of the whole collection of measures to prevent safety critical situations and attacks on security.

In fact the requirements on safety and security are extreme: chances on accidents like runway incursions should be as low as 10^{-7} and the security analysts should really expect the unexpected.

The main conclusion is thus easily drawn that only a broad and total approach in safety and security R&D can be successful. At the same time airport should be as efficient as possible and handle capacity demand figures that might double in the year 2020. In order to meet these requirements an R&D programme for safety and security at airports is proposed. The action items are given in the next two paragraphs **in descending order of priority**.

Airport safety recommended initiatives

(Saf 1) Holistic and integrated approaches are recommended to keep safety on the same or even better level as today with capacity demand figures growing. The existing compartment type of safety thinking and measures should be changed into a total system and procedure approach.

(Saf 2) A runway incursion prevention programme should be accomplished complementary to the already running initiatives on recording of runway accidents and incidents and the European Runway Incursion Plan by Eurocontrol. Such a programme should be in line with above recommendations. Safety consciousness of all actors should be an important component in the runway incursion prevention programme.

(Saf 3) Especially in the step to identify and assess the risk modelling of systems and procedures (including the human factor) is of mayor importance. Fast time simulations are the only way to obtain statistically significant results. Real time trials are done to validate the models used.

(Saf 4) Quantitative risk assessment techniques are under development. Statistical data and simulations are needed to support the safety cases. Procedures should drive technology, and not vice versa.

(Saf 5) The A-SMGCS is seen as a tool for improving safety at airports. It is not the system that deserves attention but also the corresponding procedures. New datalink and communication technologies should favour situation awareness of all operators. Secure and reliable communications would lower the changes of misunderstanding.

(Saf 6) Adherence to procedures and the human factor in aviation is of utmost importance. Methods should be developed to train pilots, drivers, operators and controllers to an even better degree of safety conscience than today.

(Saf 7) Optimisation of airfield infrastructure design will lower the risk of incidents and accidents. Methods should be sought to improve airfield design on this aspect.

(Saf 8) The safety of using satellite signals in aviation should be studied with the aim to improve the robustness against jamming.

(Saf 9) The safety aspects of capacity increasing (wake vortex, separation) and noise abatement procedures are seen as necessary components of these procedure research items.

Airport security recommended initiatives

(Sec 1) Within the context of a total system approach future work should promote and support RTD projects focussing on security in the aviation system and procedures. These projects

should contribute to ensure that the air transport system as a system of systems, layered, integrated and working together, provides the highest possible level of protection. A total system approach (airports, ATM, aircraft, personnel etc.) for security should be adopted.

(Sec 2) The airport security subject of another session demonstrated that security has much commonality with safety. Security deals, however with a complete new and very broad spectrum of unfamiliar threats. This implies that the aviation system should be screened again with a collection of threat scenarios never thought of.

(Sec 3) Discussion on financing security measures should not delay or harm security.

(Sec 4) The effectiveness, potential impacts on operations and passengers, and cost benefit of security measures deserve appropriate attention.

(Sec 5) Biometrics and passenger screening long before the terminal are other focal points.

(Sec 6) Methods are to be developed for passenger and freight to be positively identified and subject to security procedures before they board and freight is loaded.

(Sec 7) Contingency plans should be developed to reduce the damage if the security chain is broken.

(Sec 8) Route adherence monitoring should be developed and integrated, and as a possible next development step remote control of highjack aircraft.

3.3. Policies / Regulation

The purpose of this section is the presentation of the main conclusions of the third THENA working group, related to policies and regulations with impact on airport. Firstly, the current status of policy and regulations in aviation, in the context of the European Union, is presented shortly. This subsection includes a table summarising the status of the different legislative and regulatory initiatives recently taken by the European Commission, extracted from the THENA Policy Position Paper. Secondly, it is presented the conclusions from discussions during the three consecutive THENA workshops, in terms of the current developments in policy and regulations in the aviation domain and, finally, voids & gaps experienced by the workshops and the literature reviewed.

For further reference and more complete information, the full version of the Policy and Regulations Position Paper is available in the THENA web page (http://thena.aena.es), as well as the proceedings and presentations of the three workshops.

3.3.1. Current State of Affairs

It has been widely recognised that air traffic and airport congestion is a worldwide problem. Due to the fact that many airports are lacking capacity (partly because of environmental restrictions) to deal with increasing demand for additional infrastructure, we need to think about how to make the best use out of existing airport capacity. Furthermore, it remains uncertain when, where and how to provide new capacity. In general, several issues could be causal to changes in airport capacity. The most important are summarised below.

In Europe many airports are fully co-ordinated. In 1993 the European Commission created a system[2] to allocate **slots**[3] **on airports** with scarce capacity. Over the years a more efficient allocation of existing slots is considered an important goal (e.g. better match supply and demand for slots). In case of abuse or poor use of existing slots, new entrants have equal chances to obtain these slots from the slot co-ordinator (the "use-it-or-lose-it" rule[4]). Despite new measures more adapted to changing circumstances, the issue of how to use slots efficiently remains on the political agenda.

In order to clarify the term of *SLOT* and avoid any misleading interpretation, it has been recorded both kinds of slots, airport slot and ATFM slot, used currently to manage demand in Europe.

> **'Airport slot'** means the scheduled time of arrival or departure available or allocated to an aircraft movement on a specific date at an airport co-ordinated under the terms of the Council Regulation (EEC) No 95/93 of 18 January 1993, Article 2, paragraph a, on common rules for the allocation of slots at Community airports. The main purpose of the airport slots is to prevent airport congestion and enable AOs to plan their schedule with

[2] Council Regulation (EEC) No 95/93 of 18 January 1993 on common rules for the allocation of slots at Community airports

[3] These regulations deal with airport slots, which should not be confused with the ATFM slots. A brief description and explanation is given in the text box in section 3.2.

[4] "Use-it-or-lose-it" – rule: a scheduled airline has to use 80% of its allocated slots each year. If the airline fails to do so, the slots can be withdrawn and will become available, via the slot co-ordinator, to interested airlines (including new entrants).

reasonable guarantees of receiving acceptable level of service by the airport. In addition, they will allow the airports to plan their resources in order to provide that right level of service, preventing of congestion situations, above all at busier airports. These slots are assigned by the airport coordinators following impartial, transparent and non discriminatory rules (initial assignment is made in the seasonal IATA conference with later adjustment in the season when the real operation can vary due to special situations).

'ATFM slot' means a Calculated Take-Off Time (CTOT).It is a departure time sent when a flight is subject to regulation based on the first available entry time in the most penalising regulated airspace area (i.e. the one giving the greatest delay) along the entire route of a flight. It is defined by a time (CTOT) and a tolerance window (-5 to +10 minutes) during which period the flight is expected to take-off. The Central Flow Management Unit (CFMU) in Brussels is in charge of delaying departure slots. The main objective of ATFM slots is ensuring that ATC sectors do not become congested which occur when the number of aircraft within an airspace sector exceeds the capacity of the sector (other important objective is to reduce delay costs by absorbing airborne delays on the ground, assuming that airborne delays are much costlier than ground delays).

There are obviously similarities between the two kind of slots, although they are not the same and have fundamental differences. On the one hand, both try to ensure that congestion does not occur. However, they operate at different levels. Airport slots are allocated months in advance, due to the AO's need for stable schedule, and they are usually apply to repetitive movements. ATFM slots are allocated 2 hours prior to the estimated of block time (EOBT) presented in the flight plan.

Several initiatives have been taken to enhance *Air Traffic Management* on a European level and to integrate Member States' regulations in this field. The High Level Group in this respect promotes the use of EU institutions as the appropriate regulatory body for the EU and Member States. The ultimate objective aimed for in an EU context is the establishment of a "***Single European Sky***". This would increase the efficiency of the use of the *European Sky* substantially and at the same time the costs would decrease.

Environmental concern has traditionally been a subject to national policies and regulations. ICAO ("Annex 16") has provided guidelines that are used in EU-Directives and Regulations to tackle the main problems of noise and emissions. In 2000, The European Union issued a policy paper in which it recommended more stringent rules than agreed under the ICAO-framework.

Liberalisation and privatisation are keywords when looking at developments within global industries in general. With regard to the concepts of liberalisation and privatisation of airports and in particular ground handling, especially the UK provides useful examples of improved efficiency in operations. Another feature has been the global formation of strategic airline-alliances, and airports joining forces.

In most Member States, ***airport charging regimes*** are determined by the competent national authorities or regulatory bodies. The European Union is planning to gradually introduce a framework including charging based on marginal costs. A final issue covered in the present paper concerns the growing implications of airport capacity problems on *passenger protection*. Although protection of passengers at this moment is a matter of contracts with individual airlines and dependent on national rules, the EU has issued several regulations and proposals to protect the interests of air passengers (e.g. on denied-boarding and air carrier liability in case of events). Airports should also play an important role with regard to these issues.

European Commission: status of legislative and regulatory initiatives

Traditionally, aviation was being regulated through national governments and international bodies (e.g. ICAO, IATA). However in the past period the role of the EU has increased.

The table below includes the status of (recent) legislative and regulatory initiatives taken by the European Commission and grouped in five sets, attending different issues: Economic and Strategic, Security, Environmental, Air Traffic Management and, finally, Technical & Operational Safety.

SECURITY ISSUES			
FIELD	**REFERENCE**	**STATUS**	**COMMENTS**
Civil Aviation Security	EC 2320/2002	Establishment of common rules in the field of civil aviation security	The Committee will complete the Regulation and will supervise its implementation.

AIR TRAFFIC MANAGEMENT ISSUES			
FIELD	**REFERENCE**	**STATUS**	**COMMENTS**
Single European Sky	COM (2002) 658	Adopted	Amended proposals for creation, organisation, use and provision of air navigation services. It includes an amended proposal for a regulation on interoperability.

ECONOMIC AND STRATEGIC ISSUES			
FIELD	**REFERENCE**	**STATUS**	**COMMENTS**
Infrastructure charging	--	Proposal of a basis for the drafting of legislation on airport charges.	Expected in the second quarter of 2003.
Information exchange	--	Adopted	
Community agreements with third countries	COM (2003) 94	Adopted	It includes a proposal for a Regulation and implementation of agreements.
Protection against subsidisation and unfair pricing practices	COM (2002) 110	Adopted	In the supply of airline services from countries not members.
Insurance requirements for air carriers and aircraft operators	COM (2002) 521	Adopted	Proposal for a Regulation
Trans-European transport network	COM (2002) 542	Adopted	Proposal for a Decision amending Decision 1692/96/EC
Airport capacity and airport charges	--	Communication expected in the forth quarter of 2003.	It includes the environmental modulation of charges.
International air transport	--	Adopted	Legislative measures on agreements with third countries and information exchange.
Allocation of slots	COM (2002) 623	Adopted	Proposal for a regulation amending of ECC 95/93.
European air transport policy	COM (2002) 649	Adopted	Consequences of the Court judgements of 5 November 2002 for European air transport policy

Compensation and assistance to air passengers	COM (2002) 717	Proposal for a new Regulation	In the event of denied boarding and cancellation or long delay of flights.
Ground Handling	EC 96/67	Review of the implementation of the directive.	Proposal for legislation expected in the end of 2003.

TECHNICAL & OPERATIONAL SAFETY ISSUES			
FIELD	**REFERENCE**	**STATUS**	**COMMENTS**
Safety of third countries aircraft using Community airports	COM (2002) 664	Adopted	Amended proposal for a Directive.
EASA	EC No 1592/2002	Adopted	Regulation on common rules in the field of civil aviation and establishing a European Aviation Safety Agency

ENVIRONMENTAL ISSUES			
FIELD	**REFERENCE**	**STATUS**	**COMMENTS**
Establishment of a framework for noise classification of civil subsonic aircraft	COM (2002) 683	Adopted	Amended proposal for a Directive, for the purpose of calculating noise charges.
Establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports	2002/30/EC	Adopted	Directive
Assessment and Management of Environmental Noise	EC/2002/49	Adopted	Directive
Noise measurement and noise monitoring	--	Proposal for a Directive.	It introduces harmonised minimum criteria, combining measured noise levels with flight path monitoring by radar.

Regulatory initiatives of the Commission have been undertaken to contribute to the Commission's objective on Sustainable Development (economic, social, environmental). The focus of the recent EU regulation has been mainly to:

- Create a level playing field, in other words give all actors a fair and equal chance in a sense that no unfair competition advantage arises. Examples are found in regulation with respect to airport slot allocation, unfair pricing practices, insurance requirements, civil aviation security, aircraft safety, environment, etc.
- Develop an own EU aviation policy (e.g. Single Sky, pax protection, community agreements instead of bilateral, environment, EASA)

3.3.2. Feedback from THENA Workshops

The THENA project promoted three workshops where a wide coverage of stakeholders involved in airport operation interchanged ideas and points of view about the proposed subjects (i.e. Capacity and efficiency, Safety and security and environment impact). The next paragraphs summarise the main conclusions obtained in each workshop from the experts that took part in the discussions related to policy and regulation matters on each of those areas that arose within the different Open Forums. The feedback is grouped in the main conclusions (highlights) of the workshops and the suggestions for follow-up actions as indicated by the participants at the workshops. This feedback does not per definition correspond with the opinion of (members of) the THENA consortium. In order to facilitate the understanding of the findings , they have been classified in three categories, which mainly correspond to each workshop:

Capacity & efficiency:

- People tend to use and mix different definitions with respect to slots. It is important to notice that there is a distinction between two different types of slots: viz. airport slots and AFTM slots. Both are important means with respect to managing air traffic demand, agreed and accepted, but different strategies can be followed . Slots are important tools for designing methods to improve the use of the airside and landside capacity at airports.

- It might be possible to closer co-ordinate airport slots and ATFM slots, and it is needed this coordination. This is seen as a key issue to better use the scarce capacity at airport and airspace in Europe.

- In general, policy-making for airports is subject to complex operating processes (aircraft management- and passenger guidance processes). Airports can be considered Complex Adaptive Systems (CAS). ATC/ATFM procedures are often characterised by fragmented approaches (e.g. arrivals isolated from departures), not taking into account airside processes.

- Collaboration is an important condition for the realisation of enhanced integration in policy-making between end-users (airlines, airports and ATC). For instance, end-users could modernise existing procedures, share information and link databases.

Safety & Security:

- Prior to the events of 11 September 2001, there was limited EU legislation on aviation security, but the tendency is changing and currently this issue has become a key issue in the policy directives, some of them quite controversial.

- ECAC has already important legislation and procedures in place in the field of aviation security (Doc Nr. 30, Part II). This has been the basis for the new EU framework Directive.

- Humans are really important in guaranteeing security. This should remain an important element in drawing up new legislation. However, the legislation on aviation security can lead to delays problems at airport, if requirements in terms of baggage screening or passenger identification is not done with the appropriate means and with procedures well designed.

- Often European rules are not compatible with International (ICAO-) rules (e.g. flight crew licence rules). At the same time, national rules are not always compatible with European

rules. JAA regulations, so-called JARs (Joint Aviation Requirements) need to be in accordance with ICAO rules. In fact, JARs are in depth rules of the ICAO Annexes.

Environment:

- The EU legislation in the field of aviation and environment is already quite mature (this is demonstrated by Article 6 of the EC Treaty: it requires integration of environmental protection in all Community Policies).

- The Commission White Paper "European transport policy for 2010 : time to decide " describes air transport as the largest increase of all transport modes over the last two decades. Integration, standardisation, introduction of environmental friendly technologies and a reward system are important topics of the EC policy.

- Monitoring noise is described in Directive 2002/49/EC. By 30 June 2007, member states have to prepare noise maps, by July 2008 member states must have drawn action plans. Gaseous emission directives are in premature stage, also due to no-ratification of the Kyoto Protocol by US. Emissions could be charged like route charges.

- The new ICAO certification standard was followed by a European directive (2002/30/EC), which follows the *balanced approach* as discussed in ICAO:
  - Reduction of aeroplane noise at source
  - Land-use planning
  - Application of noise abatement operational procedures
  - Local noise related operational restrictions

- With regard to the environment issue, it seems that there are differences between the focus of the EU- and US policies. Results of Chapter 4 aircraft ruling will be detected after a few years.

- New and more stringent rules on aircraft-requirements could negatively impact on the competitiveness of airlines from developing countries

3.3.3. Research Voids & Gaps

Accomplishing other of the THENA project objectives the different workshops provided ideas and suggestions about the gaps and voids that need to be covered in future R&D efforts, and are included in the next paragraph.

- Slots are important tools for a better utilisation of the available infrastructure. At present the different types of slots use different planning and allocation mechanisms. Research is needed to which extent slot-mechanisms could be further improved and integrated. In particular, it would be valuable efforts dedicated to further investigate the following two fields:
  - Improve real-time monitoring and adaptation process within airport operations, adjusting the plan the current situation to react much earlier to the traffic variations. CDM concept is undoubtedly helping in this sense.

  - Coordinate both slot mechanisms, or integrate them if possible, to solve significant problem that pro-active actions would have predict (advanced

planning follow by real-time monitoring and adaptation thanks to all actors involvement is a key issue to achieve it).

- Slot management could take into account various criteria for allocating and awarding slots, such as aircraft size, noise emissions etc. The effects and suitability need to be further studied.

- Policies in which more attention is given to the role of regional airports and of low-cost carriers can, at this moment, be considered a possibility for dealing with increasing demand on a European scale. An important condition for success is the way in which we succeed in improving intermodal transport to and from (secondary) airports (e.g. high-speed rail connections), in order to prevent travellers from suffering delays to and from these airports. More research on the role of hubs versus regional airports is welcomed.

- European- and nationally based policies that aim for more airport capacity, should be designed taking into account the position of all the users of the system. For instance, with regard to safety and security, a trade-off should be made between the optimum level to society, and the competitive position of the EU airline-and airport industries. Moreover it is most important for the EC, before presenting a new proposal, to have an assessment of the impact of this proposal (practical and cost wise) on the aviation industry.

- A level playing field should be created for different actors in the aviation sector.

- The security-issue has become crucial after 11 September. Security should not be “adequate” but “not-compromisable”. In case of future R&D or legislative processes, it is important to find a balance between capacity and security (increasing capacity should not mean decreasing security), or better said, between security and facilitation.

- Safety and security could very well be combined, and CBA should be a part of the overall decision to draw up new legislation.

- R&D (e.g. biometrics) can play a big role to provide solutions to the security-problem. New solutions should be weighed against privacy-issues.

- The EC’s proposal for a “framework Regulation” on aviation security should be the tool to bring about improvements throughout the EU as a whole. This Regulation should encompass all aspects related to the security-issue, and should lead to harmonisation on a European scale. The financing issue is a big (political) problem, which the EC leaves to the member states.

- The competency of ECAC based on Doc Nr. 30, should be put against the EC competency based on the new Regulation. How will ECAC rules be implemented? It takes time and space.

- The JAA is currently being transformed into EASA. EASA should in the future become a serious player (together with the FAA) with regard to the globalisation of safety rules. Research can be done with regard to a possible role of EASA in ICAO.

- Issues like land-use planning or differentiation of charges are outside the EC competence. There is no well-defined EC policy in this area, so EC can only support the studies, but there are a number of local initiatives possible to explore.

- Aspects like the inclusion of new charges related to environmental sustainability are under study, but the inclusion of new charges in greenhouse gases emissions can not lead to a decrease in the competitiveness or lead to a disturbance in competition.

- Requirements to emission-levels in ICAO legislation could possibly be lowered for third world airlines operating in the European area. However, EC needs to create a level playing field.

- An option could be to link the environmental performance with slot allocation. The question remains though whether slots and slot allocation are effective.

- Directive 2002/49/EC is an example of a schedule and definition of noise capacity of airports. Environmental assessment processes at airports also appoint the noise capacity of airports. Land-use planning should be implemented including building construction rules and mitigation measures. Research priority advises are in line with earlier EC studies. They concentrate on the different sorts of annoyance: sleep disturbance, annoyance in general, and speech interference.

- Regulations (e.g. a ban of Chapter 2, night bans or quotas, operational constraints and emissions trading) are questioned on effectiveness, social, regional impact, impact on competition, and international obligations. Taxation can be done by means of noise charges, fuel or carbon charges or emission charges, with questions to what level, effectiveness etc.

3.3.4. Recommendations

This section summarizes the main conclusions and recommendations drawn by the THENA Consortium member's part of WG 1.3 with respect to the field "Policy & Regulations". In doing so it draws on the views expressed in the workshops, knowledge gained from literature review and the consortium members own views based on their specific expertise and background. In this section also the theme specific (e.g. environment, safety, etc.) recommendations of the THENA consortium as expressed in the separate thematic reports of the other groups have been collated, in order to present an overall view regarding policy and regulatory recommendations. Other than the other working groups the recommendations in this WG are more directly focused on potential policy areas, although this will lead directly to themes for further research.

Before presenting the main conclusions and recommendations one should ask himself why the EC should be involved in the design of new regulation and policies. The basic motive of any government intervention is that it should contribute in reaching its objective. In case of the EU this is directly related to the facilitation of a Sustainable Development. Sustainable development in the EU is characterised by the joint realisation of economic, social and environmental criteria. In addition to the direction (the objective or overall strategy) to which the interventions should contribute the **subsidiarity** and **proportionality** principle are two main principles **guiding the need to intervene at a EU level**. Subsidiarity addresses the issue whether measures are best taken at a EU level or for example at a national level. As we saw already in chapter 2, creating a level playing field between actors in all members' states is a rather important element in this respect. Proportionality relates to whether a measure is in line with the meant impact (in other words "don't shoot with a canon at a bug").

Themes for further policy development and research

The pressure of growing demand for air services on the available capacity of airports are recommended to be directed at integrating long term capacity expansion with the simultaneous introduction of demand management in the air transportation sector. The primary aim of the latter would be to better utilize the **existing capacity without detrimenting the development of air transport**. Research themes in this respect are related to:

- The establishment of a common/balanced approach and a formal consensus on performance targets and metrics, as well as to establish a monitoring and reward system to deal with capacity problems by also considering the trade-offs with security / safety, noise etc. This could be supported by introducing new policy on charging mechanisms reflecting criteria as safety, environment, scarce capacity etc., but also through a better integration of the various components of the air transport system.

- The promotion and adoption of Collaborative Decision Making as an operational philosophy and a tool for promoting cooperation and information sharing in the airport community and between key actors (i.e., airports, airlines, ATC). It is recognized that much can be gained by integrating decision making in the various components of the air transport system, which until now, are considered too much in isolation of each other. A possible more integrative between airport slots and ATC (CFMU) slots is illustrative in this respect. The facilitation of an efficient use and a unified, reliable, valid and comprehensive exchange of data between the various actors in the air transport system would certainly be beneficial in this respect.

- Adoption and implementation of a commonly agreed regulatory framework governing the airspace of the enlarged European Community in the light of the Single European Sky Initiative.
- Promotion of a drastic revision of the slot allocation regime that will also incorporate market-driven orientations for allocating scarce airport capacity with the aim of removing market entry barriers and discriminatory practices, ensuring equity and unrestricted access to airport resources, and boosting the operational (e.g., delays, level of service) and financial (e.g., revenues) efficiency of airport operations.
- There appears to be large uncertainty about the possible role of regional airports. This is strongly influenced by the dramatic increase of the share of low cost carriers. Since regional airports might play an important role in facilitating airport growth it is recommended to devoted further research to the factors influencing the use of regional airports and the possible impacts of using these airports (in term of increased accessibility, environment, economics, capacity etc.)

It is considered **safety** and **security** as crucial issues in the further research activities in the policy framework. In particular it is recommended: Translating new improved security and safety procedures into regulation to facilitate the swift introduction of new measures. Attention should focus on strengthening the weakest link in the system.

More research (and possible regulatory change) into the field of privacy considerations versus more advanced technological security methods (e.g. biometrics) it clearly needed in order to not violate those privacy rights.

Facilitating a fair distribution of the safety and security economic burden amongst the various actors in the air transport system.

Environment is still an area, which is strongly dominated by national, regional and local government, especially with respect to the environmental consequences of airports on its surrounding area. EU intervention is mainly aimed at supranational issues (e.g. phasing out of chapter 2 aircraft) and to a limited extent to the streamlining of national initiatives (e.g. 2002/30/EC). It should be realised that different environmental norms and standards applied to each individual airport could strongly influence the competitive position of the different airports toward each other. From the viewpoint of creating a level playing field it is recommended that the Commission establishes (minimum) harmonized norms and standards too avoid unfair competition between airports in the EU. Before doing so it is advised that an inventory is being made of presently used norms and standards both at major and regional airports.

A similar viewpoint could be taken with respect to land-use planning. It is not advised that the Commission plays an active role in land-use planning since, on the basis of the subsidiarity principle, this is best left to the Member States. However, from an environmental, safety and health motive, the Commission could consider introducing a limit (norm/standard) on building activities in the vicinity of airports.

Essential to all new policy & regulatory changes is the assessment of the impacts of the proposed intervention. In this respect it is promising to notice that the Commission recently has adopted a new guideline on impact assessment (COM(2002)276 Communication on Impact Assessment). However, in relation to the present guidelines it is suggested to apply a more active use of cost-benefit analysis. This should serve both to illustrate the balanced approach of the Commission with respect to economy, environment, safety and social aspects but also shed light on the individual cost-benefit balances for each individual actor in the air transport system (ATC, airlines, airports, third parties).

In designing new policy and regulation the Commission should pay attention to create a level playing field between competing parties. Until now the Commission has clearly shown that it pays much attention to this respect, but also future regulatory changes should be considered in this respect if relevant.

It is advised that the Commission is well aware that aviation is a worldwide business and that streamlining of measures and regulations with other geographical regions should be kept in mind.

3.4. Simulation & Modelling

The purpose of this section is the presentation of the main conclusions of the fourth working group, titled: “Airport Simulation and Modelling Issues”, of the THENA project. To achieve this goal, the document starts with a global description of the current situation going through the classification of models and tools and providing a preliminary set of recommendations and improvements. After that, the main conclusions extracted from the different workshops are reflected and later completed with the detected set of research voids and gaps, giving also recommendations about these unsolved matters, considering the expert opinion of the THENA members.

Along the description of the current situation a generalist point of view is given, but it could be detailed with the support of the THENA Simulation and Modelling Position Paper which is available in the THENA web page (http:\\thena.aena.es) as well as the proceedings and presentations from the three THENA workshops.

3.4.1. Current States of Affairs

The airport world faces up to continuous problems, due to new needs and to the evolution, to cope with users demand related to quality, security, safety and efficiency. The resolution of these problems, together with the design of new airport elements and the selection of the best alternatives, are carried out using several analysis techniques.

When analysing or attempting to validate future airport solutions, three techniques are advisable to combine into a three-step validation method:

- ✓ Theoretical models: performing analytical or statistical analysis to get first indicators of the advantages of the solution,
- ✓ Fast Time Simulation: entering reality into a logical model (usually computer-based) which imitates airport operations getting accurate results from this virtual world, and
- ✓ Real Time Simulation: which involves human in-the-loop techniques using existent interfaces and actual technology elements, and show any potential drawback in the real world.

The simulation and modelling processes are used to solve questions “What if?” which appear in the improvement processes of the airport infrastructure, systems and operational procedures. Its principles are very simple. Experts build a model of the system to be analysed (airport or elements of the airport) and then a computing programme is used including this model. These programmes imitate the reality step by step, reproducing all the events when they happen. Using the computer, the most promising options to solve a problem can be chosen. The simulation results depend on the level of detail of the model.

One important step in the simulation and modelling is the validation of all kind of models and big effort should be consider in that direction.

All the simulation and modelling techniques has reached, nowadays, a level of maturity that makes them support tools absolutely necessary in the design and planning of airport

management and optimisation, although some of them are very young, for example, the Fast Time Simulation techniques supported by computer were developed initially in the 60s.

Several modelling and simulation techniques has been found available and suitable for airport infrastructure improvement and, in general , for solving problems. A good evidence of that is the huge amount of models and tools that exist nowadays in the airport and air navigation fields. Another evidence is that most of the important companies and research institutions have a department working with modelling or/and simulation.

This huge amount of models and tools can be classified, in the airport field, according to different viewpoints. From the user perspective, there are Real-time simulators (procedure optimisation, situation assessment, incident detection and resolution, …); training simulators for controllers and pilots; specific simulators (noise, pollution, wake vortex, …); Fast time simulations (evaluation of capacity and economic or social decision making); and New concepts simulators (CDM, A-SMGCS, Free Flight, ADS-B…).

Considering the useful output for the aeronautical world, these models and tools can provide a wide spectrum of information, for example regarding capacity and delays, detection and conflicts resolution, boarding strategies, luggage tracking, human factors and integration man-machine, economic data and so on. However another outputs are becoming more and more important.

Although the maturity achieved by these tools and models is high, some constrains have been identified, mainly related to their lack of flexibility and modularity. That makes difficult to use them in future concepts or when the changes or modifications are not standard. Most of these limitations or drawbacks have been identified and the means to solve them are in process. The future goal is to develop new highly flexible platforms.

The huge amount of tools and models is a testimony of the wide use of these techniques but also of the lack of complete suitability of any of these tools. Every tool and model has a specific use but there is not a tool that can be used for all the problems to be simulated.

As a global conclusion and from a methodological point of view, it is highly recommended more compatibility and interoperability between models and tools, generic and open simulation infrastructures facilitating integration of further components and common design methodologies and utilities.

3.4.2. Feedback from THENA Workshops

The THENA project promoted a set of meetings where stakeholders could explain and interchange ideas about present research, helping and giving feedback to those matters selected for the different workshops. This liaison of point of views between the stakeholders involved in or affected by airport operations, and directly involved in the topics selected, supply a set of valuable observations that are going to be summarised through this chapter. In particular, 3 workshops were successfully organised, each of them addressing the quite challenging and contemporary areas of airport capacity, safety and security as well as environment. The conclusions summarised below pretend to highlight the main aspects arisen within these workshops.

- Pre-planning tools with very accurate models, used for CDM and slot allocation (considering the implications in both, airside and landside). The models have to bear in mind an integrated demand and supply.

- When developing new tools or using the existing, both aspects should be covered: new infrastructure and operations. Sometimes, changing slightly the way of working the capacity of the airport can improve without compromising the safety levels. It is an important issue to investigate and can be easily done, most of the times, with the existing tools and methods.

- Create models that allow the analysis of the security levels in airports and the impact on capacity of different options.

- Environmental impact issues. Nowadays these issues are more and more important and they should be taken into account in the tools and studies for simulations. For example, tools that allows to show a relationship capacity and noise/emissions levels.

- Economic issues. In the same way, it is an important issue to take into account in the models and simulations. For example, adding CBA post-processors to the current and future simulators.

- Intermodality. When trying to look for solutions, a more global model including different means of transports should be considered. Of course, these models could not be very detailed because many systems with a lot of information should be measured at the same time and that implies a huge amount of work: preparation, simulation/modelling, post-processing and data analysis. The same can be applied to the current European hub structure.

- The noise models are very poor modelling approach, and aircraft configuration is not taken into account.

- There is a difficulty to obtain noise and performance data from manufacturers based on two aspects: industrial secrecy; and the fear of the use that general public might make of specific numeric values. But EEC is taking part of the ANCAP working group that is trying to improve the models with better configuration data.

- The future models of emissions will: take into account the dispersion model of all sources; do emission computations (application s/w); and use continuous measures with correlation between aircraft movements and spectroscopic measurements.

- The FAA looks at the problem of noise and emissions together, and facing the difficulty of trade-off decisions are thinking to develop better tools for decision making.

- About safety and security, no modelling or simulation conclusions appeared. This situation could lead to consider some effort to be done to fill this gap.

3.4.3. Research Voids & Gaps

Simulation and modelling tools are often used to help decision making in a wide spectrum of activities. Day after day these models and tools are enriched and enhanced, helped by technological developments related to computer performances, but there are still voids and gaps to

fill or cover through further research activities. Some of these holes are summarised in the next paragraphs, but this list is not extensive and we should assume that new needs and lacks will be detected even before these problems are solved:

- A model to provide analyses for the entire airport (landside and airside) taking into account the different performance metrics, such as capacity, delays, environment or safety. Actually is OPAL the only tool facing this problem.
- Integrated models and tools providing an overall study of the airport, including not only capacity, delays, environment and safety but also a financial analysis. The accessibility and intermodality issues are not taken into account.
- Lack of harmonisation of computing platforms to help sharing results between different models.
- Guidelines about the parameters that should be taken into account and the effectiveness measures to describe the airport performance in both airside and landside.
- Inclusion of cargo and passenger handling activities into the models.
- Effective methodologies for validating models.
- A reliable model to check interactions and propagation of problems through an airport network. For instance, to provide support to Single Sky concepts
- A reliable model capable of performing network-wide system-optimum solutions, not only for an airport network but also for the different processes present at each airport.
- A model or tool able to integrate macroscopic demand forecasting into a schedule generation mechanism, to estimate future infrastructure requirements and foresee operational bottlenecks and inefficiencies.
- Tools to monitor and quantify implications, measures and effectiveness of the new strategies and solutions proposed.
- There is a lack of models and tools to analysed safety and security issues at the airport.
- Integrated applications to perform analyses based on individual models and tools
- New models and tools to validate new concepts or standards, or the development of new capabilities for present tools to allow these new cases.
- Airport benchmarking studies and systematic performance monitoring tools will be soon increasingly demanded by the industry policymakers and stakeholders in the pursuit of identifying opportunities for operational improvement and system inefficiencies in view of the new competition landscape
- The establishment of a set of performance targets and metrics, that promotes cooperation and information sharing between key actors.
- Improvement of the existing environmental tools to include new parameters (for example, emissions). The existing models should be enhanced with aircraft noise and performance data, with topography information and using dispersion model for all the sources. The trade-off between noise and emissions should be also considered.

This approach should be enriched with the different vision obtained by the continuous use of different tools and models, that suggests slight differences in the R&D approaches in order to deal with all the likely analysis requirements in airport system.

3.4.4. Recommendations

As it was commented before, model based analysis of airports is strongly developed based upon both analytical and/or fast time simulation means. Nevertheless, several gaps can be considered as to be covered by future model based tools and techniques in order to deal with all the likely analysis requirements in airport system. Some major gaps have been identified in the field of model based analysis of airports, and the following topics summarise the likely R&D approaches to cover these gaps:

- Land-side and air-side integration:

  The aim of such integration is to take into account the interaction between land-side operations and air-side operations in order to find balanced solutions for the airport at a whole, e.g.: efficient solutions for passenger movement, apron management and taxiway control.

  Several models, analytical and fast time simulation tools are available for the analysis of both land-side (passenger, freight, luggage movement) and air-side (aircraft or flight operations) separately. Some recent initiatives, such as OPTAS project (EC IV Framework Program) or OPAL project (EC V Framework Program), have faced the integration of these different tools, achieving success to some extent.

  Field is still open for research and development within this issue. Proper analysis and simulation of both the terminal movement of passengers, fully integrated, interfering and impacting on aircraft movements, is still to be developed.

- Airports within networks:

  The aim of this approach is to take into account, when simulating airside airports operations, the impact of delays in the airports-airspace network system.

  Several times, when simulating the operation at a single airport, delays are produced as an output of the exercise. This result is then provided for the airport isolated from the rest of the world. This might be quite a good metric when delays are not that high or, even when they are too high, if results are used in a comparative way. Nevertheless, in real world congestion at one single airport could impose also delays at destination airports, origin airports, ATFM regulations, use of alternative airport for arrivals, so affecting nearby airports.

  Some initiatives such as the AND model attempt to analyse the airports as a network, even some ATFM simulators and network-delay models can include airport capacity as a capacity node within a sector capacity network. Nevertheless there is still much work, investigation and development to carry out in order to achieve a complete model integrating all the actors generating delays and the impact of each delay upwards and downwards, taking into account that every change in the schedule of one flight means a change in its use of the apron, the taxiway, the runway, the TMA departure sectors, the en-route airspace sectors likely imposing regulations to the scheduled flights, some of them congested and maybe not accepting that flight out of its scheduled time at the sector, due to overtaking capacity, and the same for TMA feeders and approach sectors, runway capacity and taxiway usage at destination airport, and also apron occupancy, since gate or stand might be available or not when the aircraft finally arrives, then the aircraft is used by a departure flight at the same airport, whether connecting to other flights or not, and all those flights are delayed consequently., and so on.

So, real delays are difficult to analyse if the whole network of airports, airspace and ATFM are not integrated together, taking into account each relationship and links between flights and capacity nodes (read airports, runways, sectors, etc.). There is a wide field within this area for research and development.

✈ Airfield analytical model:

The aim of such a model would be to provide quick and high level results supported by analytical model of airport.

Several initiatives, such as CAMACA, MACAD and many others, deal with using analytical models to analyse runway, taxiway and apron capacity, mainly runway. For the time being, CAMACA deals with all these three parts of the airport, providing, in this sense three separated models to analyse three different aspects of the airport movements; while MACAD is an analytical tool (hybrid, macroscopic and stochastic) for estimating airside capacity and delays by simultaneously capturing all airside elements (i.e., runway, taxiway, apron).

The field is still open for research on this, as there is room for improving a full (runway + taxiway + apron) airport analytical model covering in an integrated way the three components of the airfield.

✈ Additional metrics:

Some metrics such as delay, taxi times, capacity of airport components, queue lengths,… are quite common metrics when analysing airport.

Even if some analysts or projects take into account more and more metrics: ground conflicts, fuel burn, pollution emissions, noise impact, taxi costs, safety metrics, security metrics, among others, these are not usual output data from airport models.

There is a wide field for enhancing or widen the spectrum and variety of data, output, results or information coming from airport models in order to provide analysis on capacity, efficiency, safety, security and environmental impact, as direct results from the airport analysis tools.

3.5. Information systems / technologies

The purpose of this section is to provide the main conclusions obtained by the fifth Working Group of THENA project, dealing with Information systems and technologies. To achieve this goal, the section starts presenting, in brief, the “key issues” respect to Information Technology applied to support Airport Operations. Once a general description of the current situation has been presented, the main conclusions extracted from the different workshops carried out within THENA Project are reflected and completed with the detected set of research voids and gaps, providing some recommendations about these unsolved matters, considering the expert opinion of the THENA members.

Further information regarding this subject is available in the THENA web page (http:\\thena.aena.es).

3.5.1. Current state of Affairs

The next paragraphs summarise some current trends in the information system and technologies domain.

- Information Systems and Communications-technologies / Surveillance-technologies are applied at various degrees to assist controllers and pilots to better utilize the existing aeronautical infrastructure at the Airport.

- Providing and sharing the needed information to key actors is the ultimate goal to boost capacity and operational efficiency. Harmonisation efforts for collecting and sharing information are underway in Europe.

- The concept of Collaborative Decision Making (-CDM-) is under development and is expected to provide additional gains in capacity and efficiency. It may take quite some time, until CDM is accepted and widely applied. Besides the reluctance to share “sensitive” data, a “fair” scheme for cost-benefit allocation/compensation is needed.

- Peak capacity at certain European Airports is not sufficient to match current and predicted demand and must be increased. Demand Management (slot-management) is currently practised to prevent system-overloads and to mitigate airborne delays. Demand management must more shift to Capacity management in future.

- Doubling the Airport capacity to match predicted future needs, definitely requires also infrastructure additions / expansions (mainly runways). Expectable gains from Information Systems and Technology applications (at already busy airports) are approx. below 20%.

- European GNSS initiatives (EGNOS, GALILEO) will significantly improve the navigation and surveillance capabilities at medium-size and smaller Airports (without expensive Radars). This adds “IMC-capacity” to the network.

- Better and less expensive surveillance capabilities coupled with powerful “safety-net software” will provide the required safety-margins. Providing traffic information to the cockpit further improves the situational awareness and lessens the dependence on Ground-control. Precision navigation capabilities provided by “affordable” GNSS-technology provides additional safety-margins especially for IMC operations (CAT I , II , III).

- Still existing safety hazards at European airports are mainly due to lack of application of available systems and technologies (for economical reasons).

- Safety related CBA – models are not yet available to support sound investment decisions.

- Systems and technologies exist to positively identify and track passengers (biometrics).They are not yet widely used and resulting added operating-expenses and operational disruptions still must be analysed. It is not yet clear what level of security is adequate and who should bear these costs . There is no such thing as 100% security.

3.5.2. Feedback from THENA Workshops

The next lines provide those conclusions obtained from the three THENA workshops and related to information systems and/or technologies.

- Applying the latest "CNS/ATM" technologies helps to better utilize the existing airside infrastructure and produces capacity increases of approx. 10 to 20% for busy Airports. Runway additions / expansions will be required to double airside capacity at major European Airports.
- Airside Capacity increases are in order to solve the Demand – Capacity Imbalance over time. Currently prevailing Demand Management then shifts to Capacity Management. Some Demand Management will always be required to handle peaks.
- Sharing of operationally significant data is an essential prerequisite to achieve the planned capacity and efficiency targets. Such information must be accurate and available when needed. It must be protected against "misuse". Its economical value needs to be properly assessed and dealt with accordingly. There still seems to exist significant reluctance to share certain information between stakeholders at the Airport. Without "meaningful" information sharing, the expected improvements will not be achieved.
- Collaborative decision Making "CDM" in combination with Decision Support Systems "DSS" will further improve operations . It largely depends on the quality of the available / shared information. Fair cost / benefit allocation rules still must be developed to make it work.
- Satellite based navigation and surveillance (GNSS) will represent the primary means of navigation for all phases of flight within a decade. In combination with ADS-B, this offers less expensive capabilities to support IMC operations also to smaller Airports. Weather and visibility related capacity constraints in IMC-conditions will be reduced. Redefining Controller & Pilot roles will be in order and further enhance operations.

- Runway safety and thus Runway-incursion Monitoring is a major issue at European Airports.

- Air – Ground Datalinks in combination with enhanced surveillance capabilities for ground-movements will raise the safety levels of airside operations. Safety-net Systems (mainly Software based) will further assist pilots and controllers to detect problems and to prevent incursions or accidents. DSS should be the right outcome of such systems!

- Providing more traffic situation data to the cockpit (CDTI) improves the safety margins.

- Revisions of the prevailing safety regulations may be acceptable due to improved CNS / ATM technologies (i.e. PRM)
- 100% Security is not achievable. The answer is not technology , its human factor.
- Security measures have to be balanced with capacity and operational efficiency.
- Technology is available for positive passenger identification (biometrics).
- 100% Hold baggage screening mandates significant operational changes.
- Significant progress in the past to reduce aircraft noise levels. Additional improvements can be expected in future (but not at the same magnitude) .

3.5.3. Research Voids & Gaps

An important output from THENA project through its Open Forums is the possibility of interchanging ideas between experts from every field in the airport operation, this dialog and comments sometimes led to the detection of some aspects, concepts or ideas that need to be carefully and deeply studied in order to cover the detected voids and gaps through future R&D effort. The next set of voids and gaps were detected about information systems and technologies.

- Clear Definition of the relevant operational information requirements (content, precision , timeliness , format etc.)
- Research on expectable capacity gains resulting from improved information availability (case studies for particular operational segments)
- Research on expectable capacity gains resulting from Airport – CDM
- Research on expectable capacity gains, resulting from enhanced surveillance capabilities (PRM , ADS-B , …)
- Airport Capacity Benchmark Reports for the major European Airports (comparable to the FAA reports for US-airports)
- Establishment of “integrated” (ARR + DEP) Runways – capacity models for the typical Runway-configurations (4 - 5 generic models).
- Research to assess the “true” passenger demands for end-to-end travel in space and time and comparison with present traffic offerings by airlines. This may help to identify the really needed capacities for given regions.
- Research to assess the economic values of significant operational information. This helps to share information on a “fair-value” basis.
- Collection of actual traffic data and comparison with planned data (Europe-wide) to verify the quality of the applied tools &models.

- Research on capabilities and procedures from use of augmented GNSS in all weather airport operations. technology for prediction and monitoring of meteorological conditions at airports.

- Assessment of existing biometrics technologies for application for Airport security enhancements

- Assessment of current separation minima regulations (ICAO) with respect to current CNS / ATM performance enhancements.

- Development and trials of planning and routing function tools integrated in A-SMGCS and research on better ground safety nets (GCAS).

3.5.4. Recommendations

Some major gaps have been identified in the field of Information Systems and Technologies, and the following topics summarise the likely R&D approaches to cover these gaps:

- Integration of arrival and departure systems with A-SMGCS (for example, Ground Collision Avoidance System) in order to improve capacity, safety and environmental aspects.
- The surveillance capabilities at airports should be enhanced using new or improved technologies, such as PRM, ADS-B and integrated sensors, in order to increase the capacity without decreasing the safety levels.
- Research on augmented GNSS capabilities and associated procedures to improve the airport operation in all weather situations. This research should be focused for both international/big airports and regional/small ones.
- Research about use of cleaner technologies in airport operations: land side (heating, waste, water usage,) and air side (vehicles in platform).
- The existing biometrics technologies (methods of recognizing or verifying the identity of a person based on a physiological or behavioural characteristic) should be assessed for application for Airport security enhancement. Some examples are: Finger-scan, hand-scan, iris-scan, facial recognition, eye pass.

- Further research in airport CDM. The dissemination of the benefits (in term of capacity, punctuality and efficiency) will improve the information availability. Exploitation of the System Wide Information Management (SWIM) concept.

3.6. Environmental impact

The purpose of this section is to provide the main conclusions obtained by the sixth Working Group of THENA project, dealing with Airport Environmental Issues. To achieve this goal, the section starts presenting the legal framework applicable in the European Union, as well as the most important R&D initiatives carried out in this domain both in Europe and the States in the last years. Once a general description of the current situation has been presented, the main conclusions extracted from the different workshops carried out within THENA Project, in particular 3rd WS, which dealt with Environmental Issues, are reflected and completed with the detected set of research voids and gaps, providing some recommendations about these unsolved matters, considering the expert opinion of the THENA members.

For further reference and more complete information on the current situation, both the WG1.6 Position Paper or a summarised version of it are available in the THENA web site (http://thena.aena.es), as well as the proceedings and presentations of the three workshops.

3.6.1. Current State of Affairs

The air transport industry is growing at rates above the average growth of the economy of the European Union, with the subsequent increase of the environmental impact of air transport.

Globally, air transport contributes to the greenhouse effect and at a regional level to acidification, eutrophication and to the formation of tropospheric ozone by emissions of air pollutants. At local level, in the immediate vicinity of airports, concerns focus on the potential health and environmental effects of noise and air pollution from emissions such as oxides of nitrogen (NOx), volatile organic compounds and particulates.

Since maintaining safety, improving efficiency and delivering capacity, cannot be done at the expense of the environment, aviation has already taken measures to reduce significantly its environmental impact, whether through restrictions on noisy aircraft, improvements in airframe and engine technology, the retirement of older less fuel-efficient aircraft, or the introduction of modern aircraft as the airline fleets expand.

However, the growth in air transport, and hence noise and emissions, has outstripped technological improvements and the industry's considerable own efforts to reduce the impact of aviation. As a result, carbon dioxide (CO2) and other emissions continue to increase in absolute terms (although lower than the foreseen rate of traffic growth). Similar trends exist for aircraft noise.

In general, the increasing significance of environment as a constraining factor on the aviation industry, and hence air traffic management, is due to such issues as:

- An aviation growth rate exceeding that of most European economies;
- The improving environmental performance of other industries;
- The diminishing ability of technology to off-set the environmental impact of aviation's growth;
- Increasing public awareness and expectations concerning quality of life issues.

This increasing potential for constraint puts at risk the considerable sustainability benefits that aviation brings to society such as Trans-frontier mobility, economic development, onward investment, employment, business links, transportation of goods, security, leisure and cultural enrichment. This tension between positive and negative impacts conspires to ensure that

aviation's environmental effects remain high on the political agenda, and that ATM has an important role to play in achieving a balanced outcome.

Fortunately, it is still possible to do more and this aspect is being built into ATM-decision making. Therefore, aviation has to de-couple its impact on the environment from the increasing demand for its services – that is breaking the direct link between economic growth and resource use. Indeed, that is the basis for both sustainable development and an increased return on investment.

3.6.1.1. Policy Considerations / Framework

International Civil Aviation Organisation (ICAO)

The International Civil Aviation Organisation policy pursues to achieve a balance between the benefit to the world community through the development and growth of the air transport and the adverse environmental effects of civil aviation.

Several initiatives can be highlighted:

- Balanced Approach to Aircraft Noise Management. In this point, the ICAO resolutions are focused in: reduction of noise at source, land-use Planning and Management, Noise abatement Operational Procedures and Operating Restrictions.
- Aircraft Engine Emissions, in terms of expanding scope of Policy-making, Engine Certification Standard and Operational Practices.
- And finally, Market-based Measures, mainly noise charges and Emissions trading, voluntary measures and levies.

European Commission (EC)

The European Commission attaches great importance to mitigation of environmental nuisance caused by air transport activities. The Treaty establishing the European Community provides in Article 6, that environmental protection requirements must be integrated into the definition and implementation of specific Community policies and activities with a view to promoting sustainable development and in Article 152 that a high level of human health protection shall be ensured in the definition and implementation of all Community policies and activities. For air transport policy this legal obligation towards integration implies that an appropriate balance has to be made between environmental protection requirements and economic performance of air transport operations.

The Commission presented the details of its strategy integrating environmental concerns into air transport policy in its communication COM (1999) 640 "Air Transport and the Environment. Towards meeting the Challenges of Sustainable Development", identifying four main pillars:

- ✈ improving technical environmental standards on noise and gaseous emissions
- ✈ strengthening economic and market incentives
- ✈ assisting airports in their environmental endeavours
- ✈ advancing long-term technology improvements (Research and Development)

Aircraft noise and emissions are regulated by transposition to community and national normative throughout directives and decrees. There are also established dispositions setting up dates of relief among aircraft which correspond to certifications following different chapters of the Annex 16 to the Chicago Convention.

In fact, aiming at cutting down the level of nuisance from air transport, the European Union adopted in 1992 a directive, based on an agreement of the ICAO to ban the noisiest aircraft from European airports. These aircraft - defined in Chapter 2 of Annex - were no longer allowed to operate in the European Union after April 2002.

In March 1998 the Commission proposed a new directive aimed at limiting the operation in the European Union of Chapter 2 aircraft fitted with "Hushkits", muffler devices fitted to engines to make them less noisy. These devices enabled these aircraft to meet the stricter standards for "Chapter 3", but by such a small margin that the overall effect on aircraft noise was reduced and such aircraft were noisier than aircraft originally certificated to Chapter 3 standards. The ensuing Regulation was repealed on 28 March 2002 following the adoption of a new Directive (2002/30/EC) which enshrined the ICAO Resolution A33-7 on the use of a “balanced approach” to noise management around airports.

Since most of the current production aeroplanes are already compliant to the Chapter 4 standard, this will not be sufficient to improve the noise situation because the phase out of Chapter 2 aeroplanes has been completed. To safeguard the environmental protection after 2002 in a way that is compatible with internal market requirements, a new Directive was adopted on 26 March 2002 on the establishment of rules and procedures with respect to the introduction of noise related operating restrictions at Community airports (2002/30/EC). This Directive implements in European Community legislation the “balanced approach” to noise management, comprising four principal elements, including reduction of airplane noise at source, land-use planning and management measures, noise abatement operational procedures and operating restrictions.

The new Directive repealed the Hushkit regulation and has put in place a harmonised definition of marginally compliant aeroplanes (aeroplanes that have a cumulative margin of no more than 5 decibels in relation to Chapter 3 certification limits). In addition, the Directive contains principles and rules on how to carry out a noise assessment process which is mandatory prior to the introduction of noise related operating restrictions.

With a view to avoid a proliferation of noise charging schemes and to enhance transparency, fairness and predictability of the noise component in airport charges, a proposal for a Directive on the establishment of a Community framework for noise classification of Civil subsonic aircraft [COM(2001)74] for the purpose of calculating noise charges was tabled. It is based on a methodology that was agreed in the TANC group (ECAC). The proposed Directive aims at giving incentives to use less noisy aeroplanes by modulating noise charges on the basis of the certificated noise characteristics of the aircraft. Monitoring of noise is described in Directive 2002/49/EC.

3.6.1.2. Current State of Research and Development Initiatives

European Commission Initiatives

In Europe, a co-ordinated strategic approach is essential if European industry is to match this effort and maintain its competitive position in the global marketplace. Co-operative effort is necessary to address the issues in a broader sense than would be affordable under separate proprietary or national programmes.

Therefore, the European Commission launched at the beginning of 1998 the X-noise project, a cluster of research projects involving 32 organisations in nine European countries, aiming at delivering an aircraft noise abatement of 6 dB over eight years. The size of ground areas affected by given noise levels would thus be cut by more than a half.

The overall initiative comprised three industry-led projects: RESOUND (Reduction of Engine Source noise through Understanding and Novel Design), RANNTAC (Reduction of Aircraft Noise by Nacelle Treatment and Active Control) and RAIN (Reduction of Airframe and Installation Noise), together with the purely research-oriented DUCAT, investigation of duct acoustics and radiation.

In addition, close links were established with SOURDINE I & II (Study of Optimisation procedures for Decreasing the Impact of Noise around airports), an examination of take-off and landing procedures supported by the European Commission's DG Transport.

With all efforts directed towards a common end, X-noise has already led to the framing of a technology platform supported by 14 EU countries and a consortium of 51 companies as the basis for a four-year integration phase, known as SILENCE(R), the largest ever European aircraft noise research project, which was launched on April 1st 2001.

Within SILENCE(R) partners will carry out a large-scale validation programme, focusing on noise reduction technologies. Then, an assessment will be made of the applicability of these technologies within the European aeronautics industry, including their effects on cost, weight and performance. Finally, the associated achievable noise reduction will be evaluated.

SILENCE(R) is build upon the results of other projects carried out under the Fourth and Fifth Framework Programme, including the X-Noise related projects DUCAT, RAIN, RANNTAC, RESOUND and SOURDINE, as well as JEAN, concerned with the prediction of jet exhaust noise, and TURBONOISECFD, using Computational Fluid Dynamics (CFD) software to predict engine noise during the design phase.

Regarding emissions, the European Commission launched in March 2000 its largest-ever aero-engine research programme. The purpose of the Efficient and Environmentally Friendly Aero Engine (EEFAE) project is to develop the advanced technology needed to maintain European industry's competitive position as a supplier of advanced turbofan engines for next generation of commercial jet aircraft.

Its objective is to achieve a step change in both the efficiency and environmental friendliness of gas-turbine-based aero engines, so that customers and operators world-wide can benefit from cleaner, quieter, safer and more economical travel conditions.

The EEFAE technology platform has 19 partners from nine countries and involves two applications:

- The ANTLE engine (Affordable Near Term Low Emissions), and
- The narrow-body group CLEAN (Component vaLidator for Environmentally friendly Aero eNgine)

A number of fundamental technology projects will complement the proposed activities.

Eurocontrol Initiatives

Environment is one of EUROCONTROL's key business drivers. It is emerging as a critical constraint on ATM system-wide capacity, particularly at airports.

Within the European Air Traffic Management Programme (EATMP) directorate, which funds the majority of the Agency's environmentally related activities, "Environment" is now an integral part of the EATMP portfolio.

It is EUROCONTROL's view that its environmental work will add value in the areas where it deploys its acknowledged expertise, covering the operational, technical and R&D aspects of air traffic management (ATM). In parallel, however, EUROCONTROL must keep abreast of the other issues and contribute as appropriate. For example, since there is much discussion on the use of economic instruments to enhance the environmental effectiveness of noise charges levied at airports, EUROCONTROL has a clear interest in making its views heard, since it manages a comprehensive and effective route charges collection system.

In response to the above challenges and opportunities, EUROCONTROL has developed tools to measure aviation's environmental impact, supported stakeholder activities and progressed measures with significant environmental spin-off benefits.

In April 2001, the Member States unanimously approved the EUROCONTROL Environmental Policy and Strategy. Its General Strategic Objective with regard to environmental issues is:

"to work with ICAO and its Member States to obtain improvements in ATM, in particular the accelerated implementation of CNS/ATM concepts, procedures and systems which help to mitigate the impact of aviation on the environment."

Accordingly, the following specific environmental targets for ATM were set:

- To permit daily aircraft operations in such a way that all ATM-related environmental impact is minimised;
- To be compliant with the appropriate international standards, statutory and regulatory requirements in respect of environmental demands;
- To support actions which will contribute to reduce or limit noise and aircraft emissions.

In addition to the activities carried out by the Agency in the Operational, Economic and International (Policy) domains, EUROCONTROL is specially focussed on R&D initiatives, which can be summarised as follows:

- Development of ENHANCE - a noise impact assessment tool and validation platform that provides an enriched means of measuring the impact of noise, based on real aircraft trajectories;
- Development of a model to assess environmental benefits of CNS/ATM systems, jointly with FAA under Action Plan 13, in support to ICAO-CAEP;
- Work on assessing the impact of new approach procedures to minimise environmental impact while not reducing safety or capacity - within the EC SOURDINE II project;
- Development and validation of the Advanced Emission Model, which calculates fuel burn and emissions;
- Development of TEA, a Tool set for Emission Analysis - integrating AEM – to provide a more sophisticated toolset for estimating emissions from aviation, including a basic capability to predict the formation and persistence of contrails;
- AERO2K – major participation in an EC Fifth Framework Programme project that will develop a new global inventory of emissions and fuel usage from aviation for the year 2002 and a forecast for the year 2025;
- Local Air Quality - a project to measure the impact of aviation emissions around airports;
- Sustainable Aviation – a series of projects to assess how air traffic might evolve on the assumption that air transport cannot continue to grow without constraints, including
  - Environmental Capacity;
  - Attitudes to Aircraft Annoyance Around Airports (5A);
  - Environmental Indicators (KPI);
  - Environmental impact of future ATM scenarios.

A number of opportunities are emerging, through which EUROCONTROL can better understand aviation's impact on the environment and determine the fraction of that impact that can be attributed to ATM. It is proposed that the following activities would be pursued to achieve that objective, building on the substantial capabilities developed in recent years. Some potential new areas include:

- Further develop EUROCONTROL's ability to understand the potential for environment to constrain future en-route and airport capacity;
- Developing new assessment tools and methodologies for 'Ground Noise' arising from airfields which is an area of increasing concern and one that is relatively under-developed;
- Identifying solutions both within ATM and closely related sectors with the potential to alleviate capacity-constraining environmental factors;
- Carry out innovative research in the environmental field;
- Complete the tasks included in the Environment Annex to the EUROCONTROL-ESA Co-operation Agreement, covering the use of Earth Observation techniques to assess contrails, emissions, land-use and other appropriate issues.

Federal Aviation Administration (FAA) Initiatives

The unifying mission of the FAA Environmental R&D Program Area is to support the agency's Environment Goal: "Prevent, minimise and mitigate environmental impacts, which may represent the single greatest challenge to the continued growth and prosperity of civil aerospace."

Research within this area develops information, tools, methods, and technologies that, when applied to the establishment or improvement of aviation safety standards and acceptable practices mitigate the adverse impacts of aircraft noise and emissions upon the environment.

The Environmental R&D Program Area Strategy can be outlined as follows:

- Enhanced Knowledge Base:
  Develop and validate methodologies and models to assess aircraft noise exposure, aviation emissions and impact on air quality, and greenhouse gas emissions.
- Minimisation of Noise Impacts:
  - Develop data, requirements, standards, rules, and technical guidance addressing certification of new and modified designs for reduction of aircraft noise.
  - Prepare technical documentation and training materials for use by aircraft manufacturers and others.
  - Provide computer models and impact criteria for use by civil aviation authorities in environmental assessments.
- Minimisation of Air Quality Impacts:
  - Develop emission reduction data, requirements, standards, rules, and technical guidance for certification of new and modified designs.
  - Prepare technical documentation and training materials for use by aircraft manufacturers and others.
  - Provide computer models and impact criteria for use by civil aviation authorities in environmental assessments.

It is foreseen that this strategy will result in the following results and milestones in 2004:

- Aircraft noise:
  - Promulgate new federal noise certification standard for subsonic jet and large transport airplanes.
  - Release new INM database of aircraft (including helicopters) noise and performance values/ parameters.
  - Conduct first annual Noise COE (Center of Excellence for Aircraft Noise Mitigation) conference.
  - Continue to examine and validate methodologies used to assess aircraft noise exposure and impact.
- Engine emissions
  - Develop and publish harmonized, simplified engine exhaust emissions certification test procedures and technical guidance materials that will increase efficiency and reduce costs of the tests.
  - Conduct testing and analysis of particulate matter emissions from aircraft engines to support development of SAE E31 AIR.
  - Continue to assess potential benefits to be achieved from incorporating emissions reduction technologies emanating from NASA research programs; identify technology goals for long term reduction of aircraft engine emissions.
  - Continue to examine and validate methodologies used to assess aviation emissions and their impact on air quality; identify and implement enhancements to EDMS (Emissions and Dispersion Modelling System).
  - Complete development of the SAGE (System for assessing Aviation Global Emissions) model, version 1.1 for assessing aviation's global emissions; complete design of SAGE versus 2 including an economics module.

- Publish guidance document for estimating and reducing emissions from ground support equipment.
- Continue development and enhancement of the SMAAQ (Screening Model for Airport Air Quality).
- Develop and publish resource and guidance materials for addressing issues related to toxic air pollutants in the aviation environment.

3.6.2. Feedback from THENA Workshops

Within the framework of the THENA Project, there was a clear intention to establish focal points of collaboration and active research liaisons between the different programmes and stakeholders involved in or affected by airport operations. To achieve this, 3 workshops were successfully organised, each of them addressing the quite challenging and contemporary areas of airport capacity, safety and security, as well as environment. These Workshops were mostly focused on these airport research-related areas, while simultaneously placing particular emphasis on the interdependencies, implications, and trade-offs that are evident on the interface points between capacity, safety / security and environment. This section will highlight the feedback and some conclusions drawn by these Workshops and will address the cross-implications and trade-offs from the perspective of environment. In particular, a number of interesting observations and conclusions based on the Workshop presentations and discussions are summarised below:

- The overall capacity of the European ATM system is to a significant extent determined by the capacity of its airports and en-route sectors. Environmental issues have the potential to constrain the operation and growth of airports and therefore the overall operational capacity of the system.

  Recent studies have demonstrated that airports across Europe are already subject to growth constraints including some resulting from environmental impacts and that these are likely to become critical in the future. For example, 65% of the European airports are restrained in growth by the environment consequences of their existing operations, with over 90% anticipating constraints within the next 20 years. And there is evidence for environmental constraints at individual airports beginning to affect the network and its overall capacity.

  The principal issues with the potential to constrain current operations or future growth are the disturbance caused by aircraft noise and local air quality. Other issues which could also constrain growth in the future include, third party risk, ground transport access and climate change.

- As a result of the large effort carried out by the different stakeholders involved, aviation community has achieved in the last years an important reduction of both noise impact and emissions. For instance, it is foreseen a reduction of 4 dB for new innovative aircraft designs and the fuel consumption at the moment is quite close to the consumption of cars (3 l/100 pax km).

  However, reduction potential is still important. In fact, it has been estimated that the total aircraft noise, taking into account all noise sources, could be reduced around 5-7 dB in relation to the technology of the 90´s. Regarding air pollution, the different measures considered, which depend on the phase of flight, will also enable further reductions.

- The differences in objectives and requirements for the parts involved, especially airports and airlines, and the necessity to spend the resources in the most cost-effective way, require a collaborative behaviour to solve environmental problems. In particular, since most of the faced problems are common, it is essential to share and compile information about what is being done at other airports.
- In respect of key environmental impacts, a variety of different modelling systems are in use in different parts of Europe, although efforts are currently underway to achieve European standardisation in respect of noise and emissions modelling.

  In fact, there are plenty of Environment Performance Indicators (EPI) to measure the impact of airports of the net. However, although hundreds of EPIs have been published; almost none adopted the same set-up. In this way, there are a large number of published EPIs for airlines and airports, although there is little consensus on a common suite for benchmarking and subsequent use across Europe.

  On the other hand, in contrast to the variety of EPIs in use by airlines and airports, there are few published ATM-related EPIs.
- Noise impact reduction seems to be inconsistent with emission reduction (i.e. noise abatement procedures usually result in an increase of engine time). Therefore, a trade-off between noise and emissions has to be adopted by aircraft manufacturers, but only after having received inputs from all the stakeholders involved.
- The attitude of people towards aviation noise and emissions depends on their perception of air transport and how useful they find it. Although in many cases aviation emissions are only a small percentage of total harmful emissions (a 0.5 % in the USA), and airport pollution values are similar to city centre ones, people usually react more actively to aviation annoyance. Environmental issues are not only technological issues, but also a question of public opinion, which can be changed. For example, people living next to high traffic roads are less annoyed than people living next to airports with the same level of noise.

  In relation to this, the inclusion of other noise sources within the global approach and the global map initiative will facilitate the comparison and evaluation of the real state of noise in Europe.
- Environmental issues should not be reduced to noise and emissions, since the level of annoyance of inhabitants is also determined by things such as sleep disturbance, speech interference, general annoyance, parking problems,…All factors have to be considered, especially local factors.
- Although emissions have a global effect on environment, local air quality in the vicinity of airport and noise impact are at the moment a main concern due to their potential implication to health, and have to be considered at a local level. As a result of this, it is quite unlikely that a fixed general normative can be directly implemented at a particular area without a previous process of adaptation to local conditions. For the same reason, not all solutions are applicable at every airport.
- Local air quality around airports depends not only on aircraft or airlines. Airport ground vehicles have a considerable share of air pollution, as well as the traffic generated by the people arriving or departing to/from the airport. In this sense, intermodality could play a key role in order to reduce emissions.
- Since levels acceptable at the moment will not be accepted after 10 years, stakeholders have to solve not only current problems but also future ones and nowadays there is no long term policy or plan available defining the evolution of requirements. For example, 65 db is

today considered as an acceptable level of noise but the public perception is not likely to accept it in the future.

In this sense, certain disappointment regarding the attitude of people was detected during the 3rd Workshop, since stakeholders consider that population will always ask for further reductions, without taking into account the effort being carried out by the industry and the real values in comparison to other noise or emission sources.

- The FAA is developing the Airport Noise Compatibility Planning Programme, a voluntary programme that asks for creating a current map and a forecast map, both for the airport and surrounding area, with the noise contours of LdN 65, 70, 75 and assess the number of people affected by the noise contours. This initiative will facilitate the selection of the best combination of measures to address the individual airport noise situation and to provide the general public with the right information on the right time.

  Moreover, EU member states have received the mandate to prepare noise maps by June 30th, 2007 and to draw action plans regarding environmental issues by July 2008. This initiative is considered by the industry of the highest relevance in order to establish the real state of noise in Europe and to what extent people is affected in the vicinity of airports by noise.

- It is commonly agreed that the adoption of new charges cannot lead to a decrease in the competitiveness or lead to a disturbance in competition between large and small airlines or push Europe to a bad competitive position with regard to the USA.

  In addition, since for some energy sources there is no other alternative at the moment, charging for them will only imply that the operator will simply pay for the extra tax and subsequently will raise the price of tickets. Therefore, taxes would result in higher price for tickets and no real reduction in emissions would be achieved.

- Initiatives linking the environmental performance with slot allocation are being implemented at certain airports in Europe (i.e. Salzburg). However, airlines consider that slot is deeply connected to capacity and impacts greatly into airline competition and therefore it should never be correlated to environment, since some companies could be quite disadvantaged.

- Land-use planning and differentiation of charges are a matter for member states in EU, since these measures are outside the EC competence. Therefore EC can only support studies regarding these initiatives, although some stakeholders consider that Commission could play a more active role.

- Although industry and ICAO consider emissions trading as the lowest economic cost solution to satisfy the requirements on emissions, this measure does not provide a real reduction on emissions (it consists of paying for polluting somewhere else) and the effects on third world parties seem to be negative.

- The reduction at source is very effective for noise reduction, but aviation community has to look at all the elements of ICAO's balanced approach and market driven measures in order to optimise the environmental efficiency.

- Aviation produces important macroeconomic benefits and therefore a balanced between collective and individual benefit is desirable. That is the reason why it is considered that a part of the revenue from air transport could be used to compensate people living around airports financing mitigation actions. Direct payments to the affected people are not foreseen at the moment.

- There is not a clear opinion regarding the effect of closing airports at nights on intercontinental traffic. It seems that night regime will not exclude them, but will make them more difficult.
- Environmental capacity limits are already in place at many airports, but at the moment there is no common approach or definition.

3.6.3. Research Voids & Gaps

During the elaboration of 1.6 Position Paper, and in particular during presentations and open forum of Workshop III ("Green European Airport: A Balanced Approach"), several voids & gaps on research initiatives, as well as conflicting opinions from some of the participants were detected.

The main identified constraints and the most important pending issues are described in the following paragraphs, proposing additional research activities whenever they are considered necessary:

- The variety of different modelling systems in use in different parts of Europe could frustrate the development of a forecast and analysis system for use across the European region. In order to adopt a common approach across Europe to model future capacity within the air traffic system, there is a need to develop and adopt a common suite of indicators for all key environmental impacts.
- Although a number of ATM forecasting and analysis systems are being developed taking account of the infrastructure capacity at different airports across Europe together with operational constraints or restrictions, these models only consider "declared capacity", which contains some environmental components, but environmental capacity issues are not yet fully represented.
- The existing noise models are very poor in modelling approach and aircraft configuration is not taken into account. In fact, current ENHANCE/INM is not detailed enough to model approach. FAA is developing a new version of INM that will be integrated into ENHANCE. EEC is taking part on the ANCAP working group to improve the models with better configuration data. In summary, the existing models needs to be improved.
- There is no specific aircraft tracer in air pollution, which complicates the evaluation, and assessment of the real impact of aircraft emissions on pollution. In the same way, there are currently no EPIs related to the most important environmental issue to affect airport capacity, the disturbance caused by aircraft noise. Existing indicators only relate to noise exposure and do not indicate the level of annoyance or opposition to further growth found in communities surrounding airports.
- A sustainability indicator providing a method to couple environment, economy and social interests is needed. However, this indicator seems to be difficult to define, difficult to measure and probably expensive.
- In order to measure the impact of one airport on the net, it is detected the necessity to set up a Collaborative Environmental Management at Airports. This requires putting in place a performance management to commonly agree on targets, metrics and monitor the level of success.

- Further collaboration between the different stakeholders in order to define objectives and optimise efforts is missed. Although aircraft manufactures are more and more collaborative, industrial secrecy is still very important and they are reluctant to disseminate noise and performance data, which are essential for noise and emissions models. In addition, the parts involved, airports in special, are not profiting from the experience gained with the measures taken at other airports. A tool to exchange and disseminate information should be developed.
- It is necessary to balance the benefits of air transport for the society (jobs, mobility,..) with the potential burden on environment, so that public opinion accepts aviation as a profitable and environmental friendly mode of transport.
- In order to achieve a global solution to the different trade-offs (noise vs. emissions, environment vs. safety, environment vs. capacity) regulators have to establish criteria and priorities, not only in the short term, but also in the long one. In addition, this global solution requires a common database and currently there is no common database.
- Political representatives have to define acceptable levels for noise and emissions on the long term, since stakeholders need to know foreseen limits and the evolution of standards and regulations in order to plan their strategy and the R&D tendencies. A plan for the longer term both in USA or Europe is missed. In addition, methodologies and tools are required in order to facilitate the selection of foreseen acceptable levels.
- Although European Commission can take initiatives on technical measures, on procedures or at airport level, an overall strategy is missing and stakeholders are requiring it to plan their strategies.
- The introduction of market based measures requires further analysis in order to evaluate its real effects and consequences. In particular, it is necessary to find a method, agreed with the scientist support, to calculate charges.
- Studies are necessary to establish how emission trading would affect the development of third world parties and the foreseen sustainability of those measures.
- Although initiatives aiming at reducing the emissions caused by airport ground vehicles are being implemented at several airports, a general and comprehensive study is missed.
- It is necessary to develop studies describing how to optimise the investment in mitigation measures in order to maximise potential future growth and industry's social and economic benefits, especially now the market is going through severe problems. In particular, detailed Cost Benefit Analyses are required in order to assess the cost of environmental measures and the foreseen benefits.
- Studies should be carried out in order to establish the effect of night restrictions on intercontinental traffic and capacity.
- There is a lack of studies related to the environmental impact of hubbing vs. point-to-point.

3.6.4. Recommendations

The group of experts within THENA recommend the following action lines for research and development in the environment topic for airports.

- The current models related to noise around the airports should be improved considering aircraft configuration and enhanced aircraft performance data, in order to produce more accurate and varied results. In the same way, the existing and future models should be

unified to share the same information. Furthermore, environmental indicators have to be clearly defined at international level considering the output from the tools/models and other issues such as aircraft contribution to air pollution, annoyance, sustainability and so on.

- The improvement of communication between neighbours, politicians and stakeholders is of the highest importance to optimise efforts and to develop plans for the long term. In this sense, networks of experts created to foster collaboration and disseminate information should be promoted. Communities tend to be more tolerant as they get more information of air navigation benefits. A strong communication programme seems to be needed. It is necessary to balance the collective benefits obtained from air transport and the annoyance created to people living around airports.
- An economic approach has to be developed. CBAs are necessary to present to the society the costs of improvements and the foreseen benefits from an environmental point of view. Investment has to be optimised to maximise efficiency.
- Current R&D projects are producing results to improve capacity and safety and reduce noise and emissions, and the moment is arriving to define a clear position regarding the different trade-offs concerning these issues. With regard to environment, regulators, industry and society have to establish clear criteria for the noise vs. emission trade-off.

4. CONCLUSIONS

As a final remark, it can be inferred that the success of audience, from our point of view, in the workshops organised for such a thematic network as THENA is the better proof of the power of initiatives like that. THENA has provided a specific R&D Network on airport activities including safety performance and security improvements, capacity and cost benefit analysis, validation processes, etc dedicated to airports. If a network like THENA could be continued, it would be a key factor for developing a single framework where airport experts, users and operators could work on a common basis.

5. ACRONYMS & ABBREVIATIONS

***Term*:**	***Description*.**
ACI	Airport Council International
ADS-B	Automatic Dependent Surveillance, Broadcasts
AMAN	Arrival MANager
AND	Approximate Network Delays
ANTLE	Affordable Near Term Low Emissions
AOPG	Airport Operation Group
ARR	Arrival
ASA	Aircraft Safety Area
A-SMGCS	Advance-Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATM	Air Traffic Management
ATFM	Air Traffic Flow Management
BETA	operational Benefit Evaluation by Testing an A-SMGCS
CAEP	Committee on Aviation Environmental Protection
CAMACA	Commonly Agreed Methodology for Airport airside Capacity Assessment
CAS	Complex Adaptive Systems
CBA	Cost Benefit Analysis
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CFD	Computational Fluid Dynamics
CFMU	Control Flow Management Unit
CLEAN	Component vaLidator for Environmental friendly Aero eNgine
CNS / ATM	Communication, Navigation, Surveillance for Air Traffic Management
COE	Centre of Excellence for Aircraft Noise Mitigation
COM	Communication
CTOT	Calculated Take Off Time
DEP	Departure
DGPS	Diferential Global Positioning System
DMAN	Departure MANager
DSS	Decision Support System
DUCAT	Duct Acoustics
EATMP	European Air Traffic Management Programme
EASA	European Aviation Safety Association
EC	European Commission
ECAC	European Civil Aviation Conference
EDMS	Emissions and Dispersion Modelling System
EEFAE	Efficient and Environmental Friendly Aero Engine
EGNOS	European Geostationary Navigation Overlay System
EOBT	Estimated Off Block Time
EPA	Equipment Parking Area
EPI	Environment Performance Indicators
ESA	Equipment Staging Area
ESARR	Eurocontrol Safety Regulation Requirements
EU	European Union
EUROCONTROL	European Organisation for the Safety or Air Navigation

***Term*:**	***Description*.**
FAA	Federal Aviation Authority
FTS	Fast Time Simulation
GASR	Group of Aerodrome Safety Regulators
GCAS	Ground Collision Avoidance System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEIDI	Harmonisation of European Incident Definition for ATM
HIRO	High Intensity Runway Operations
IATA	International Airlines Transport Association
ICAO	International Civil Aviation Organisation
IFR	Instrumental Flight Rules
IMC	Instrument – Meteorological Condition
INM	Integrated Noise Model
IPCC	Intergovernmental Panel on Climate Change
JAA	Join Aviation Authority
JAR	Joint Aviation Requirements
JEAN	Jet Exhaust Aerodynamics & Noise
KPI	Key Performance Indicator
MACAD	MANTEA Airfield Capacity and Delay modelling tool
MIT	Massachusetts Institute of Technology
NARSIM	NLR ATC Research SIMulation
NASA	National Aeronautics and Space Administration
NLR	Nationaal Lucht- en Ruimtevaart Laboratorium, National Aerospace Laboratory
OPAL	Optimization Platform for Airport operations, including Landside, EC DG-TREN
OPTAS	OPTimisation of Airport System
PRM	Precision Runway Monitoring
R&D	Research & Development
RAIN	Reduction of Airframe and Installation Noise
RANNTAC	Reduction of Aircraft Noise by Nacelle Treatment and Active Control
RESOUND	Reduction of Engine Source nOise through Understanding and Novel Design
RVSM	Reduced Vertical Separation Minima
SAE	Society of Automotive Engineers
SAGE	System for assessing Aviation Global Emissions
SILENCE(R)	Significantly Lower Community Exposure to Aircraft Noise
SLAM	Simple Landside Aggregate Model
SMAAQ	Screening Model for Airport Air Quality
SMGCS	Surface Movement Guidance and Control System
SOURDINE	Study of Optimisation procedures for Decreasing the Impact of Noise around airports
SWIM	System Wide Information Management
TANC	Transport Aircraft Noise Classification
TAPE	Total Airport Performance and Evaluation
TEA	Tool set for Emission Analysis
THENA	Thematic Network on Airports Activities
TMA	Terminal Manoeuvring Area
TURBONOISECFD	Turbomachinery NOISE CFD
UNFCCC	United Nations Framework Convention on Climate Change

***Term*:**	***Description*.**
UK	United Kingdom
US(A)	United States (of America)
VFR	Visual Flight Rules
WG	Working Group

6. LIST OF REFERENCE DOCUMENTS

This list presents the reference used, not only for this synthesis report, but also for the previous documents where the information was extracted.

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