ASSESSING THE IMPACT OF A CONSTRAINED AIRPORT ON THE CAPACITY OF AN AIRPORT NETWORK WITH SIMULATION TECHNIQUES

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Abstract *– The current article deals with the problem of assessing the practical capacity of an airport network. This problem is approached using simulation techniques taking into account not only the variables that currently limit the capacity but also other ones that affect the capacity such as the stochastic behaviour of the system, the current traffic mix, environmental limitations and the interrelationships among the airports that compose the system. The article put focus on the North Holland region which is a good example of a system that struggles for allocating the growing traffic in the coming years.*

Key words – Simulation, airport network, capacity

I. INTRODUCTION

Nowadays the main airports throughout the world are suffering because their capacity are getting close to saturation due to the air traffic which is still increasing besides the economic and oil prices. These levels of high saturation can be perceived as more and more aircrafts put in holding trajectories, lack of gates when they have landed and increasing delays in airside or terminal sections in the airport. Several options appear for alleviating the congestion problem in the airports of the main capitals of the world. The traditional approach is just increasing the facilities which means the investment of important quantities of money. When the physical, economic or political restrictions impede the expansion of the facilities different approaches have to be considered by the airport managers. This efforts range from optimizing current facilities using simulation and optimization techniques [4][5]to the development of novel ways to manage the incoming and outgoing traffic through the development of systems of airports [3].

In order to increase the transport capacity within a region, it is necessary to consider holistic visions that evaluate not only the efficient management of current resources of individual airports, but also an integrated view of ATM systems for the different airports that participate in the system.

MULTI-AIRPORT SYSTEMS

A multi-airport system is the set of significant airports that serve commercial transport in a metropolitan region, without regard to ownership or political control of the individual airports [2]. The main characteristics of these kind of systems are:

- They focus on commercial aviation.
- They focus in a metropolitan region rather than a city.
- They are market-oriented thus they leave aside the ownership of the airports.
- Normally there is one main airport with secondary ones that relieve traffic from it.

The case of London, New York, San Francisco are just some of examples of regions that use airport systems for managing the air traffic. Other European capitals such as Amsterdam is struggling nowadays for changing the management model from a single airport to a system of airports in order to accommodate hub-related and non-hub related growth of aviation in the Netherlands [7].

SCHIPHOL AND THE DUTCH REGION

The case of Schiphol Airport is of special interest because it not only serves a region which comprehends some of the most important urban and technological centres in the Netherlands but also because is one of the main Hubs in Europe, mainly operated by AF/KLM. The KLM hub provides the Netherlands with crucial connectivity for the Dutch economy to many destinations worldwide [7].

Schiphol currently performs 423,000 operations which corresponds to an 83% of saturation considering the declared capacity of 510,000 ATM. Table 1 presents the information concerning the number of passengers transported and the number of operations performed in 2012 by Schiphol. If we put focus on this information it is important to notice that Schiphol is getting to a level of saturation where a small disruption would cause a chain effect in the whole system which would be translated in delays and queues not only in the terminal airspace sector but also in the airfield (taxiways,runways, head runways etc.).

***Table 1**– Key figures Schiphol Airport 2012 (source Schiphol traffic data)*

Airport Name	Schiphol Airport
ATM	510,000
Current ATM	423,407
Saturation Level	83%
Millions of Passengers (2012)	50,976
Originating Passengers	30,101
Transfer Passengers	20,875
Operating Hours	24
Airside Infrastructure	5 RWY - Deicing - RFFS Cat 10 - cargo facilities

These delays would impact in the whole system at different levels, not only at the quality of service provided but also at the economy in the actors that participate in the system (airlines, airports, passengers, business in the region, etc.)

On the other hand the growth rate in terms of passengers transported is expected to continue during the coming years. Figure 1 illustrates this situation, it can be seen that the only perceived reductions in the number of passengers were during S11 and during the economic crisis of 2008 [6].

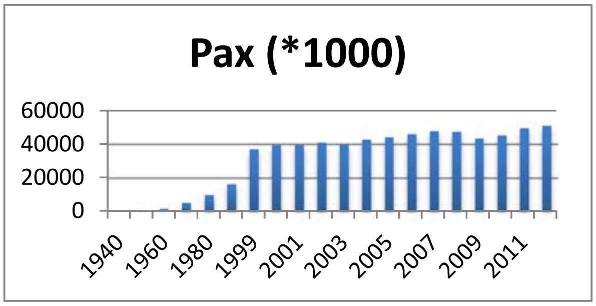

***Figure 1**- Growth rate of passengers in Schiphol*

In the case of cargo operations the behaviour is quite similar. As it can be appreciated in Figure 2 the amount of tons has been stable during this and the previous decades but due to the developments and the type of products transported to and from the region Schiphol is servicing it would be considered that the value of these cargo has increased.

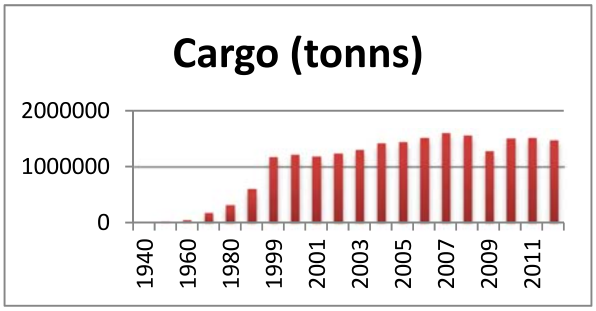

***Figure 2**- Cargo Growth*

The case of air trafic movements (ATM) which sometimes is the one that illustrates in the best way the level of saturation of an airport shows that the current ATM operations (423k) are growing towards the declared capacity of 510,000 ATM. In the coming years the saturation and the consequences of it already are and will remain a big issue in the Dutch agenda.

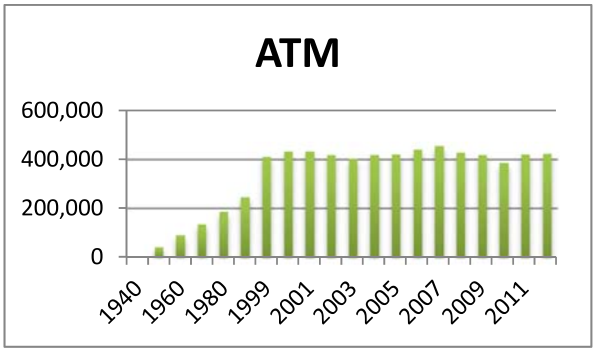

Figure 3- ATM growth in Schiphol

For all these reasons the national government is interested in developing a system of airports that serve for the purpose of the region [7]. The airports involved in the forthcoming project are Schiphol (as the main one), Rotterdam (already saturated with business, VFR and charter traffic), Eindhoven which currently has only some low-cost-carriers and Lelystad which currently is not serving any commercial ones.

Figure 4 illustrates the level of saturation in the different airports in the region of The Netherlands. In the case of Lelystad it illustrates its current capacity which is calculated for the general aviation.

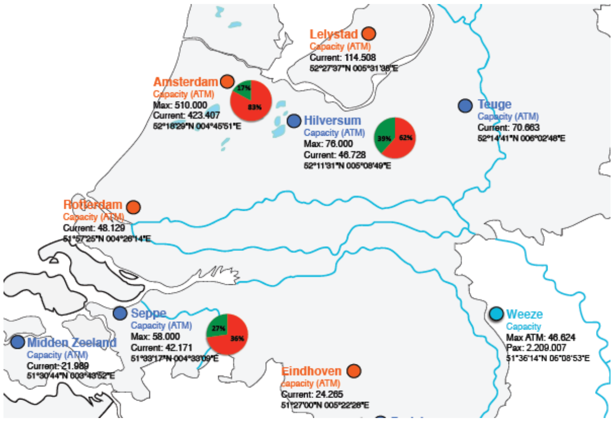

Figure 4- *The map of North Holland Region*

As it has been previously mentioned, Schiphol has a level of saturation of 83%; this level of saturation reflects the problem Europe is facing nowadays as it has been stated by EUROCONTROL [8]. The Dutch politicians have estimated that with proper investment in Lelystad and Eindhoven the level of operations of Schiphol (implementing the airport system) could be increased to 580,000 ATM. The previous scenario might be achieved through the management of the traffic between Schiphol as the main airport serving and the use of 3 secondary ones, in this case the question that arises is which type of traffic should be diverted to which airport?. A secondary question is what the impact of the new airport system is on the use of the airport capacity of the other secondary and tertiary airports in the Netherlands (inclusive the border region with Germany and Belgium). It is important to assess whether or not current GA-traffic at Lelystad and Eindhoven can be diverted to other regional airports (a knock on effect of the new airport system).

Montreal, San Francisco among others are examples of failed efforts for developing this airport systems [3]. Therefore planning experts have identified that in order to develop a self-sustained airport system it is necessary to have at least a minimum of 14 million of originating passengers which in the case of Schiphol this number has been reached long time ago. Based on the information presented it seems that an airport system for the Netherlands looks attractive and is an option which should be evaluated from different scopes and using diverse techniques.

II. Requirements for a Simulation model

In this section the methodology and requirements for assessing the performance and the assumptions for developing the airport system will be presented.

The evaluation of the airport network for the Netherlands will be performed through the development of a set of scenarios which will take into account the different characteristics of the airports that are involved in the system, namely Schiphol, Eindhoven and Lelystad. As a second step the knock on effects on the other airports in the region will be evaluated. The second step will take into account the impact on general aviation and special services for Dutch regions that are served by regional airports.

Simulation Methodology

Simulation is very-well known technique which has been used traditionally to evaluate systems performance through a series of experiments with the developed model. Figure 5 presents the traditional methodology for the simulation approach [1].

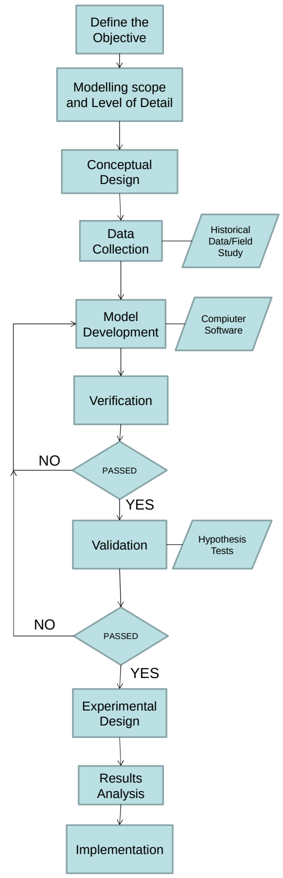

Figure 5- *Simulation Methodology*

This general flowchart presents the different steps that must be followed in order to analyse, validate and get a deeper understanding of the system under study. There are some key steps which must be performed properly in order to have useful and valid conclusions for the system.

The first step (objective definition) is very important because it will lead the remaining ones. Once the objective of the study is set up then it is relatively easy to define the required level of abstraction for the developed model. The level of abstraction will depend on the pursued level of insight about the system under study. Sometimes simulation models based on analytical or empirical rules are sufficient for the objective pursued while in other occasions a very high-level of detail is needed for understanding the dynamics involved in the system.

The conceptual design is a step where the modeller should have the first approach for the model and during that step the initial requirements for the data collection are defined.

Data collection should be performed according to the previous step, this phase is also very important because depending the quality of the data will be the outcome of the developed model.

The following step (model developing) is normally performed using of-the-shelf tools or developed by the modeller through a general-purpose language such as C++,VB,Java, Etc.

After the model has been developed a cycle for verification is performed, in this phase it is evaluated that the developed model behaves in accordance with the conceptual model. At this step the model cannot be considered that it represents properly the system under study therefore it makes no sense to experiment with it until the next step is performed.

Validation is the process of verifying that the developed model represent reality with sufficient level of reliability. There are several quantitative and analytical tests that can be performed in order to determine the level of confidence that can be put in the model [1]. The remaining steps are straight forward; in the experimental design, the different configurations are evaluated and some simulation runs are performed in order to obtain information for the research question.

Once the analysis of the experiments is performed, some conclusions can be taken based on the information provided by the work with the model. At this phase all the previous steps come together in order to propose some improvements to the system under study, if all the steps have been properly performed then the conclusions make sense ad the decision maker can take some actions over the original system based on the study performed with the model.

METHODOLOGY FOR THE SIMULATION OF AN AIRPORT SYSTEM

The following subsection proposes a methodology for the assessment of the future performance of an airport system using simulation techniques.

Traditional simulation techniques have been developed for the analysis of dynamic systems where there is a reasonable number of elements that interleave in a clear way. On the other hand it is typical to perform a bottom-up approach or top-down for the development of the model. Depending on the kind of approach the limits of the model must be established. The modelling and simulation of an airport system present a lot of characteristics and dependencies that make the development of a proper model a particular challenge to be faced. The following table presents some of the most important ones that must be taken into account for the development of a simulation model.

Table 2*-Requirements for a simulation model*

REQUIRED DATA	DESCRIPTION
Schiphol Current and Future Operation Capacity	Mill. Passengers, Ops./hour. This information will be used for validation purposes.
Environmental Restrictions	These and other restrictions will impose the limit for the future operations of the network.
Ultimate Capacity	The simulation models will be used to assess the practical capacity of Schiphol and foreseen the one for the future network.
Current Level of Service, Delay thresholds	The current level of service (level usage) and delay information is a key issue in order to determine the practical capacity of the network and the future capacity of each one of the airports that participate in the system. To be extended in second step with regional airports.
Causes of Delay	In order to propose new configurations and managerial schemas it is necessary to identify the causes of the delay which is the one that determines the practical capacity of the individual airport and it will be in the future system.
Runway Configuration	In the case of the main Airport, it will be useful to understand the current configuration and the different options that could serve for a future re-configuration of commercial transport.
Aircraft Mix (commercial Flights)	This variable is also a very important one due to the restrictions imposed depending od the type of aircraft using the runway.
ATM policy in the Netherlands	This restriction might affect the actual and future capacity of the system.
Breakdown of IFR or VFR operations	This information will be useful for validation purposes and it will determine the distributions of operations throughout the year.

ASSUMPTIONS AND LIMITATIONS

The simulation model will be performed making use of a two-layer approach. Layer A will be a top one which will take into account identified dependencies and high-level relationships resulting from the interaction of the simulation models at a lower-level. Layer B will be composed of different models, mainly the different models of the three airports that compose the system. Figure 6 illustrates the hierarchal representation of the simulation model. The next step will be to define the layers for the regional airports that are involved because of the knock on effects due to the forming of the Airport System.

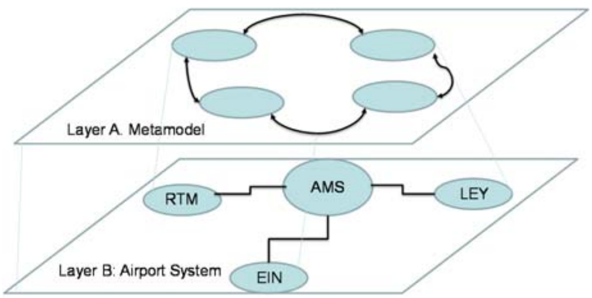

Figure 6 – *Two-layered approach for the simulation of an Airport System*

III. CONCLUSIONS

The simulation of an airport system is a challenging process that has not been addressed performing an approach that uses simulation models at different abstraction levels. In this article the initial approach for a simulation model of these characteristics is presented. This model will be developed for the evaluation of a problem of general concern in the Dutch region that involves the main airport in Holland and three secondary airports, two currently in operation of low-cost carriers and another one which currently is used for general aviation. Simulation approach is considered a suitable one for these kinds of problems. Furthermore the model will enable decision makers evaluate beforehand the problems and practical capacity of the future network.

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