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Analytic Hierarchy Process assessment for potential multi-airport systems – The case of Cape Town

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A B S T R A C T

This paper discusses the application of an Analytic Hierarchy Process (AHP) analysis for the assessment of a potential multi-airport development. The case study presented evaluates the potential introduction of a second airport in the City of Cape Town, which is currently served solely by Cape Town International Airport. With socioeconomic development, spatial planning, transportation improvement, environmental preservation and financial viability proposed as the main objectives of airport development, a survey of key stakeholders addressed the relative weighting of these criteria in the AHP. The multi-criteria decision-making assessment, as well as analyst judgement, concluded that the City of Cape Town should continue to utilise a single-airport system until passenger volumes per annum increase beyond the 27 Million Air Passengers per annum level.

1. Introduction

The global economy is currently based on economic growth, and many studies have indicated that economic growth or decline leads to a growth or decline in air passenger travel (Graham, 2000; Brons et al., 2002; Njegovan, 2006). Over the past 40 years the air transport of passengers and cargo (measured by tonne kilometres flown) has expanded tenfold, well in excess of the three to fourfold expansion in the world economy (Pearce, 2012).

Changes in the demand for air travel require the assessment of airport facilities, capacity and the management of expected growth. Authors, such as Wei (2008) have examined a utility-based methodology to quantify passengers' benefit resulting from airlines' adaptation and improvement of service after airport expansion. Sellner and Nagl (2010) used an econometric endogenous growth model to estimate the impact of air accessibility on GDP and investment growth for Vienna International Airport, and Gelhausen et al. (2013) explored the impact of airport capacity constraints on the future development of air traffic. Besides the fact that economic growth effects air travel demand, airports influence the economy and economic growth. Sellner and Nagl (2010) estimated the catalytic economic effects of air passenger traffic using a seemingly unrelated regression approach on a panel of European countries. The effects include the direct effects of air accessibility, as well as the indirect effects from increased investments.

During the last decade, studies have defined airport activities as not limited to merely infrastructure characteristics or economic activities, but rather that they are also able to play a crucial role in increasing territorial competitiveness (Senn and Zucchetti, 2001; Siciliano and Zucchetti, 2006; Percoco, 2010). Therefore, airports can generate economic and social value on two different fronts: as a business activity, and as infrastructure for the development of the regional economy (Fasone et al., 2012).

Cape Town, South Africa, has shown an impressive growth in passenger traffic over the past decade, almost doubling in volume between 1999 and 2009 (ACSA, 2012). The need to assess the impacts associated with this development has, therefore, come to the fore. Presently, Cape Town's commercial air travel demand is served solely by Cape Town International Airport (CTIA). Currently handling a passenger throughput of 8.5 Million Annual Passengers (MAP), CTIA is the second busiest airport in South Africa in terms of passenger traffic (ACSA, 2012). Johannesburg, South Africa, is currently served by O.R. Tambo International Airport (ORTIA), which handles 19 MAP (ACSA, 2012), as well as Lanseria International Airport (HLA), which handles over 1 MAP (South Africa Travel Online, 2012); this is the only recognised Multi-Airport System (MAS) in Africa, where the commercial traffic in the region is served by more than one airport (Bonnefoy and Hansman, 2007). The global cases of significant MAS are shown in Fig. 1, which clearly shows how it is a phenomenon of increasing importance.

In the majority of developed countries, airport ownership, governance and institutional controls have undergone considerable

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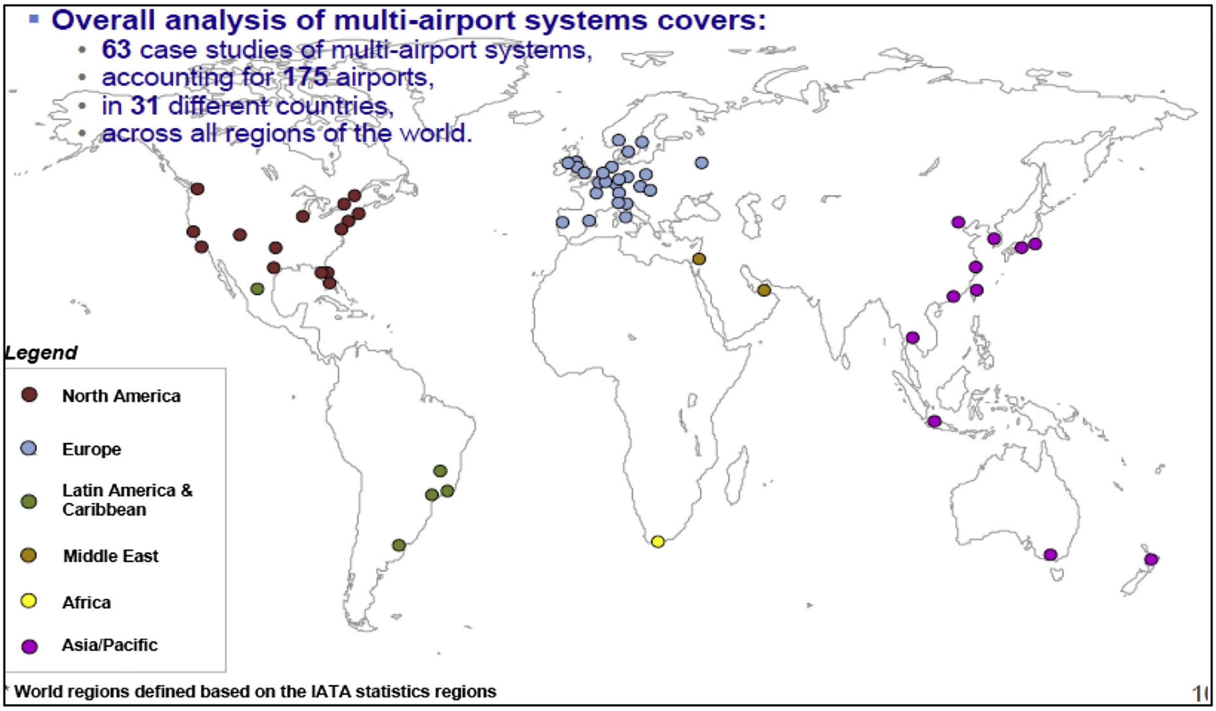

Fig. 1. Global positioning of major multi-airport systems. Source: Bonnefoy and Hansman, 2007.

change (Gillen, 2011). Forsyth et al. (2011) have reported on airport mergers and alliances, with the former Pantares Alliance between Schiphol and Frankfurt formed in 2001 being one of the early examples of an airport alliance. Marques (2011) researched the efficiency of Portuguese airports and found that airports work better alone than together.

CTIA is currently well equipped to handle its passenger demand (8.5 MAP as indicated), as its capacity has been identified as 15 MAP (NACO and SSI, 2007). However, the predicted demand is well beyond the current capacity (Mott MacDonald, 2012). The responsible planning authority (the City of Cape Town) has, therefore, decided that a position should be taken on the following question: "for the benefit of the region as a whole, at what point should CTIA no longer act as the sole airport in the City of Cape Town?" Answering this question could possibly lead to the development of a MAS. This paper summarises the findings of an assessment study into the optimal configuration of the airport system in the City of Cape Town. The use of an Analytic Hierarchy Process (AHP) assessment tool commonly applied in Multi Criteria Decision Making (MCDM) systems was deemed to be best. The findings provide an indication for future planning of the CTIA, and the method used can be adopted elsewhere.

2. Multi Criteria Decision Making applying an Analytic Hierarchy Process

Within the context of this study, an evaluation approach, able to deal with multiple criteria, was required. MCDM is defined as an approach "used to evaluate advantages and disadvantages of alternatives on the basis of multiple criteria, especially when there are different options with multiple, potentially conflicting dimensions, which cannot be evaluated by the measurement of a simple, single dimension" (Postorino and Pratico, 2012). There has been an extensive application of MCDM in the evaluation of transport problems (i.e. Aldian and Taylor, 2005). For instance, Park (2003) applied an MCDM to analyse the competitive strengths of Asian airports. Janic and Reggiani (2002) applied an MCDM to the selection of a new airport for a hypothetical EU airline.

One of the most used MCDM methods is Analytic Hierarchy Process (AHP), which is proposed as a suitable method to explore the ranking of airports in a MAS context (Postorino and Pratico, 2012). Developed by Saaty (1977), AHP is a mathematical model derived to analyse complex decisions by integrating different units of measurements into a single scale. AHP is widely used by researchers (Janic and Reggiani, 2002) and extensively applied to a variety of decision-making problems because of its ability to deal with conflicting, multi-dimensional, incommensurable and uncertain effects of decisions unequivocally (Yoo and Choi, 2006). Practitioners use AHP for its specificity, as it offers freedom to a decision-maker to express a preference for particular criteria using a given scale. Furthermore, it does not require explicit quantification of criteria. For this reason, AHP is seen as an appropriate decision support tool used to solve complex problems by formulating and analysing decisions (Berrittella et al., 2009).

AHP decomposes the problem into the objective/goal, the criteria and sub-criteria, and the decision-alternatives, in terms of hierarchical order (Berrittella et al., 2009), analysing the factors affecting the problem (Castelli and Pellegrini, 2011). The structure of the AHP method is depicted in Fig. 2.

The AHP method utilises data gathered through a survey. The significance of one element over another is estimated using pairwise comparisons of the elements in the hierarchy, based on the respondent's judgement. The following are the recommended steps in a typical AHP (Yoo and Choi, 2006):

- *Step 1:* define the decision problem and goal.
- *Step 2:* structure the hierarchy of the problem and potential solutions, from goal to alternatives, as per Fig. 2.
- *Step 3:* construct $n \times n$ matrices of pairwise comparison for each element by using the relative scale of importance.

Saaty's scale of relative importance is used to compare the relative importance of two alternatives. These judgements are then