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Competitiveness and Pricing Policy Assessment for Resilience Surface Access System at Airports

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***Abstract*—**Considering a worldwide tendency, air transports are growing very fast and many changes have taken place in planning, management and decision making process. Given the complexity of airport operation, the best use of existing capacity is the key driver of efficiency and productivity. This paper deals with the evaluation framework for the ground access at airports, by using a set of mode choice indicators providing key messages towards airport's ground access performance. The application presents results for a sample of 12 European airports, illustrating recommendations to define policy and improve service for the air transport access chain.

***Keywords*—**Air transport chain, airport ground access, airport access performance, airport policy.

I. Introduction

IN the early days of the of civil aviation, the ground access to air transport system presented no substantial issue to travelers and authorities. Most of the airports were located on the end or the periphery of the city it served and no activities were located at airport territory [1]. Therefore, ground access to airports was simple and there was no need for sophisticated plans and operation to access airport. From that time, the picture has totally changed and the access to airports constitutes one of the key operational success factors, directly, linked to reliable and resilience of air transport system [2], [3].

Because of the rapid urbanization, the high growth of car ownership and the increase of generalized cost for air travelers, the airport ground access may deliver to air traveler's huge delay and high cost to reach airport facilities. In addition, the growing interest on increasing the non-aeronautical revenues supports decisions for new activities in airport land-side area resulting in more traffic to/from airport. Also, the strong tendency on airport land-side area commercialization by locating trade, services and industrial activities results essential benefits in terms of financials but also traffic and congestion [4].

In the modern society, transport industry spends considerable amounts of resources and capitals to improve accessibility and meet the needs of different market segments. Considering a worldwide tendency, air transports are growing at a rate that saturates the airports capacity, resulting in mounting congestion and delay on air and on ground. Planners and managers argue that airport ground access performance impacts upon the whole air transport chain, therefore, the concept of integration between the air and ground transport services is very crucial towards assessment of the air transport attractiveness and sustainability [2].

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Airport connection and distribution systems are highly complex, especially, for airports serving over 5 million passengers, usually, because of the complicated ground access network serving their large catchment area in terms of space and/or population density. Typically, the ground access networks are characterized as 'many to many', where passengers and cargo from many different points go to many district destinations and the opposite. However, into the scale of strategic planning, the ground access system could be simplified as 'many to one', where the key challenge for the passengers is to define the optimum or the most valuable transport option. The airport layout, the terminal location and the mobility characteristics of ground flows into airport territory increase the complexity to manage and control traffic, while the mitigation measures and the adaptation policies towards aviation industry sustainability oversize the complication in planning and traffic control in terms of transport system flexibility and availability [5].

The key objective of this paper deals with the analysis framework to review operation capability and pricing for ground access to airport. Based on transportation planning principles and transport system operational capabilities for the different transport options offered to/from airports, a set of high level indicators is introduced to assess policies and competitiveness of the offered transport services to meet the demand needs and local targets. Conventional wisdom is to provide key messages to planners, decision makers and stakeholders on airports' ground access efficiency, as well as, to review the effectiveness of the applied transport policy.

II. Key Definitions on Airport Access

Getting to the airport can be a challenge. For the point of view of air travelers, this part of the trip is the most annoying and stressful part of the whole journey, especially, at peak hours where congestion and delays take place. Sometimes, the airport traffic patterns is totally different with the traffic patterns of the access system connecting airport to city, making traveler's and visitors to be confusing about the journey time, cost and the most suitable transport option, [4]. In addition, for the airport employee society, the daily trip to/from airport can be expensive in terms of time or money. All above is supporting the opinion that ground access to airport is a very important factor of the airport attractiveness [5].

Satisfactory design of the access system entails integrated care for the traveler's needs from the origin point to the final destination, including terminal processing. However, the differentiations in traffic patterns in airside and landsite area of the airport, the urban mobility characteristics of the city that the airport is serving and the available alternative transport options could be transforming the ground access transport option to and from the airport as an objective function subject to many constrains i.e. travel time, comfort conditions and level of service.

It is noteworthy that the expectations for the airport ground access performance may vary significantly for the different stakeholders involved in planning and operation of ground access systems. Airport operator focuses on revenues generated in landside area; therefore, car-parking demand and accessibility to commercial areas are the key drivers in their strategy. Airlines and travel agents focus on low fares and integrated services that meet the passenger expectations, promoting quick and safe access from the point of origin to final destination. Aviation authorities focus on sustainable development of aviation business, promoting safety, security and technology innovation towards efficient use of existing capacity. Regional authorities and governmental bodies focus on continuing growth of connectivity and its effects in regional economic development. Those different priorities and motivations may lead to dysfunctional decisions and inefficient policies on airport ground access system impact essential the air transport business. However, it is widely mentioned that successful surface access policy at airport is promoting the use of Public Transports (PT) under the concept of sustainable airport business and airport carbon neutrality. The main objective for airport operators should be to increase the market share for PT to about 50% and encourage authorities to invest on PT reliability of operation to meet this target, [2]. However, while parking revenues are essential for airport business, actions and regulations for promoting the use of PT are strongly supported by local government and international institutions

III. Assessment Methodology

Individually, the prime concern for passenger is getting to the airport on time. This means that passengers tend to be most concerned about the reliability of a transport system in terms of travel time. To deal with unreliable access, passenger routinely allows substantial extra time for their trip to airport [6].

Collectively, passengers also choose to use a quick access transport option to travel form/to airport avoiding delays, vehicle changes and unexpected events or unpredicted situations. The filling of a quick access for a given region could be achieved only if the users can recognize that the selected transport option move faster than alternative transport options. Higher access speed levels demonstrate a buffer to ensure that the trip time to/from airport is the appropriate for the user abilities and needs.

Fare can be a significant consideration and it is also a very important concern for passengers, along with time reliability and quick accessibility. Business travelers may be prepared to pay reasonable amounts to get them comfortable to airport, while economy travelers may not. In other words, whereas some passengers are willing to pay for premium service to access airport, many passengers and the most of employees cannot accept this kind of service. In most of the cases, PT are cheaper than private cars and taxi services and the average cost per trip per passenger is much lower.

The benefits for the use of PT are essential in terms of environment protection. The new technology in rail and bus vehicles provide low emission and low energy consumption operation. Also, the PT could offer services, sometimes, much faster than the private car or a taxi, especially during the traffic peak hours where the road network may face congestion. Reliability and fare policy for PT is the key driver to achieve high market shares offering cost effective transportation options to majority of the air transport travelers.

Taking all above into consideration, the assessment of the airport ground access system should review the different transport services outputs. Purposefully considering the airport ground access system as System of System (SoS) within the regional transport system domain, then the access system at airport could be reviewed as an independent control part of the transportation system [7]. In this content, the assessment exercise deals with the review of the key decision parameters which are:

(a) to compare the most suitable transport options serving the most attractive destinations or landmarks; and
(b) to compare this performance between airports.

This functionality provides a quite flexible measure to review operational performance for the alternative transport options from/to airport. The provision of comparisons between airports provides essential benefits to review the difference in offered level of services and evaluate mobility policies related to regional goals.

Employing airport ground access as a SoS problem, the analyses include a series of indicators to compare the performance of alternative access transport services in both directions:

(a) the most efficient PT service vs premium services; and
(c) range results for a group of airport in the same market.

The selected sample of airports includes a group of 12 European airports served capital cities. Conventional wisdom is to review the performance of alternative ground transport options between airports in different regions or states. The analysis results based on calculation for the access system from/to the airport terminal to/from the city center that constitute the higher demanded area and the most recognizable landmark of a city.

IV. Hypotheses and Assumptions

The criteria adopted for this analysis are grouped in two main categories: Transportation characteristics and fare policy. Each category includes 2 criteria as [8]:

- Transport characteristics
  - Travel time
  - Access speed

- Fare policy
  - o Using parking services
  - o Using taxi services

Key challenge in ground access assessment is to compare the travel time for the faster route served by road access (car) with the faster transport option offered by Public Transports. The distinguished time window for PT and car transport options is presented in Fig. 1, providing key definitions for the travel time calculations.

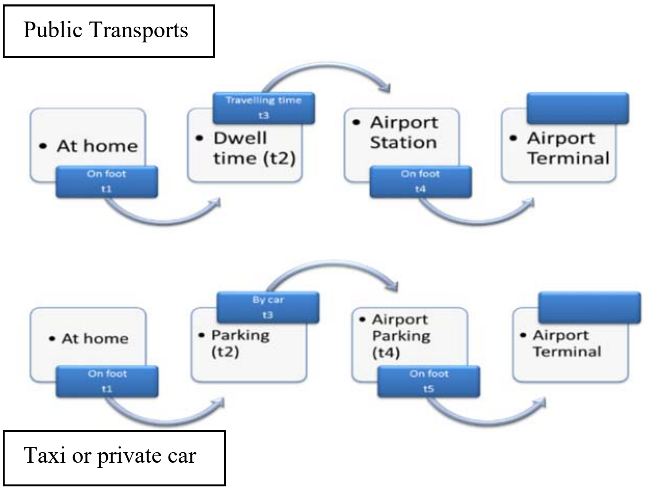

Fig. 1 Transport chain for Public Transports and car services to access airport [8]

The adopted criteria adopted in this analysis include the development of key performance indicators for the operation and the fare policy formulas between alternative transport options. The calculation formula of each indicator is given as [8]:

$$Tp = \frac{minimum\ time\ (minutes)\ of\ public\ transport}{peak\ hour\ travel\ time\ (minutes)\ by\ car}$$

$$Vp = \frac{commercial\ speed\ of\ public\ transport}{average\ speed\ for\ car}$$

$$Fp = \frac{One\ single\ ticket\ of\ the\ fastest\ mean\ of\ public\ transport}{Cost\ of\ gas + fares + average\ cost\ of\ parking\ for\ 1-5\ days}$$

$$Ft = \frac{One\ single\ ticket\ of\ the\ fastest\ mean\ of\ public\ transport}{Fares\ of\ taxi}$$

The key hypothesis in calculations for the above indicators adopted in this analysis could be summarized as:

- Only direct routes at rush hour (peak hour) are taken into account. This time period has been chosen because it represents the worst travel conditions for the pair of origin-destination (city center and airport);
- Distance is measured in kilometers (km) and fares in Euros (€). The calculations take into account the European central bank exchange rates for countries out of Eurozone, e.g. UK and Norway;
- The calculations take into account only the best route in terms of travel time (minutes); and in cases for more than more options present the same travel time, then the direct route -without vehicle change- is taken into consideration;
- Transport fares are calculated for 1 adult (single ticket) with no discounts. Other ticket fares, such those for a large time (e.g. one day/week/month ticket) or specific group of users, are not taken into account;
- Dwell time is calculated only for PT. It is defined as the time that passenger is not use a transport mode. This include the walking time need a passenger to reach the station/stop, the waiting time for the next operation and the waiting time to transmit from a transport mode to another. The dwell time for road access by cars (e.g. time waiting in traffic signals, cross sections etc.) is not considered.
- Walking time to/from the PT station from/to airport terminals (t4=0) is not calculated, because usually the PT station located into, under or close to terminal and this path is part of the terminal process.
- For the car and taxi transport options, the t1=0 and t2=0. It is assumed that no delays and dwell time are taken place to park in the car-parking area and the same for pick-up a taxi in area of arrivals.
- To calculate the car using cost, the average fuel price is taken 1.45 euros per litre. Also, the fuel consumption in urban environment is received 7 liters per 100 kms, representing a usual car consumption rate for a medium class car.
- The number of wagons per train is taken 6 and the capacity per wagon is taken 150 passengers.

V. Analysis Results

The research sample includes 12 European airports serving capital cities. The analysis is providing essential results easy to compare with other regions in Asia, USA and Middle East. Based on data collected from tip planner applications and reports presented on official airports and authorities website, the results are given in Table I.

TABLE I
RESULTS FOR THE OPERATIONAL AND FARE INDICATORS OF AIRPORT GROUND ACCESS, [9 AND AUTHOR ANALYSIS]

		Performance KPIs			
Airport	Country	Tp	Vp	Fp	Ft
Athens	Greece	1.62	0.60	0.27	0.26
Heathrow	Un. Kingdom	0.33	3.02	0.70	0.75
Zurich	Switzerland	1.81	0.55	0.12	0.11
Oslo	Norway	0.58	1.71	0.61	0.26
Schiphol	Netherlands	0.72	1.39	0.10	0.07
Paris -CdG	France	1.00	1.00	0.32	0.19
Brussels	Belgium	1.00	0.56	0.09	0.06
Vienna	Austria	1.47	0.68	0.24	0.22
Lisbon	Portugal	1.23	0.81	0.07	0.09
Madrid	Spain	0.82	1.21	0.25	0.20
Luxembourg	Luxembourg	0.54	1.85	0.07	0.06
Rome	Italy	0.72	1.38	0.56	0.56
AVERAGE		0.88	1.39	0.28	0.23

Analyzing the research results, the variations for the key performance indicators (KPIs) to compare transportation performance and fares between Public Transports (PT) and Premium Services (PC) are provided in Figs. 2 and 3.

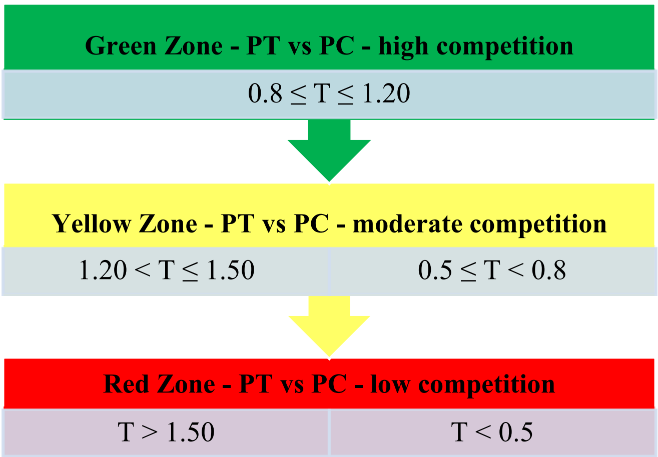

Fig. 2 Competitiveness levels for the used indicators to assess ground access at airport, [9 and author analysis]

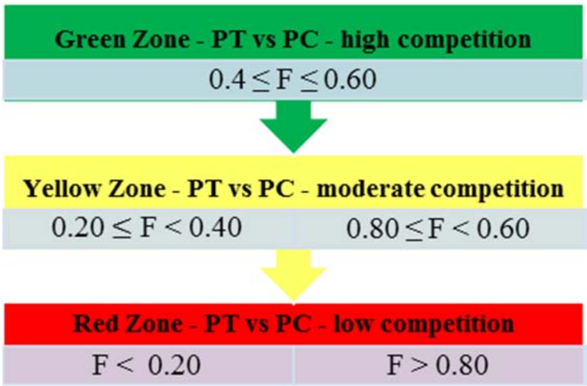

Fig. 3 Pricing variance levels for the used indicators to assess ground access at airport, [9 and author analysis]

VI. Key Findings and Discussion of Outputs

Tp expresses the relationship between the time required using the fastest mean of PT and the time required by PC to go to the airport. According to Fig. 2, if Tp is equal to 1.0 then the PT and PC offer the same travel time to users, in other words, the operation between PT and PC is totally competitive. If Tp is less than 1.20 and greater than 1.00 or between 1.00 and 0.8, it means that for the passenger point of view, the travel time is about the same, in other words, none of transport option can influence passenger's decision because of travel time. About the yellow zone, there are two possible options, the first one is 1.20<Tp<1.50 where PC represent a better option and the second one is 0.5<Tp<0.8 where PT are faster than car. The yellow zone represents better efficiency in terms of travel time, but the time saving is not too substantial to influence passenger decision. In the red zone, Tp can be greater than 1.50 or less than 0.5, the travel time advantages of transport choice are wide and there is no competition between the transport modes for this criterion. It could be concluded that, if someone wants to travel fast from the center of the city to the airport, the best choice is travelling by car in cities like Athens and Zurich. On the other hand, the passenger could be unconcerned travelling by PT or PC in terms of travel time (Tp=1.00) in Paris and Brussels. For Heathrow the fastest option is PT (Heathrow Express) providing much lower travel time compared to others.

Vp expresses the speed between the fastest mean of PT and PC represents how fast is the transportation option. Therefore, in Heathrow/UK (3.02), Madrid/Spain (1.21) and Charles de Gaulle/France (1.00), the access speed by PT is higher than PC, therefore, PT are very attractive for the users travel from/ to city central area. Exactly the opposite observed for the airports of Brussels/Belgium, Athens/Greece and Zurich/ Switzerland, where the existing transport system to/from airport promotes mode choice for private cars and taxies.

Fp expresses the ratio of cost effectiveness of the PT vs PC in the case that the passenger goes to the airport by their own car taking into consideration the average airport parking fee for one up to five days. There are also three different zones as in operational performance indicators, representing the high, moderated and low competitive fare policy, given in Fig. 3. In green zone there is strong competition between PT and PC, as Rome/Italy represents. In yellow zone, the advantages for PT are not significant (PC vs PT) as the transportation fares for PT and direct travel cost for PC, are very close, like observed in Oslo/Norway and Heathrow/UK. In the red zone, there are significant advantages for PT or PC, depending on value area, such as in Luxemburg where the PC fare is totally inconvenient compared to PT.

Ft expresses the cost between a taxi and the PT in order to examine which of them is more affordable to travel with. So, if Ft = 5 then taxi is 5 times expensive than the fastest mean of public transport for a single traveler. In other words, a group of 5 travelers is the same to use taxi or PT, such as happens in Luxemburg, Zurich and Lisbon.

VII. Concluding Remarks

In the modern society, connectivity is the basis for economic competitiveness, regional development and social cohesion. Considering a worldwide tendency, air transport is continuing to grow, resulting higher traffic, congestion and delay in airport territory and ground access system to/from airport. Given the complexity of airport operation and management, the best use of existing capacity is the key driver of efficiency and productivity not just for airports but also for aviation industry.

The paper deals with the analysis framework to assess policies for ground access to airport. Based on a SoS approach, the key assessment criteria are defined and the modelling outlook is presented. The application includes a sample of 12 European airports providing essential results to decision makers, planners and managers towards airport's accessibility, as well as, illustrates recommendations to improve accessibility and quality of service to access air transports. The analysis framework and the results can support decisions even for investments even for policies in ground access system measuring the benefits to air transports and national economies.

The paper provides key messages on ground access performance for a group of 12 European airports. The analysis approach provides a flexible and easy to handle evaluation framework to review and compare ground access performance at airports. The analysis key findings highlight key messages to planners, managers and decision makers towards the resilience of ground access system to/from airport. The key findings could be essential to compare with airports not included in the analysis sample, as well as, to support decisions towards air transport system performance. Finally, the introduction of additional access system performance indicators could be an essential subject for further research.

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