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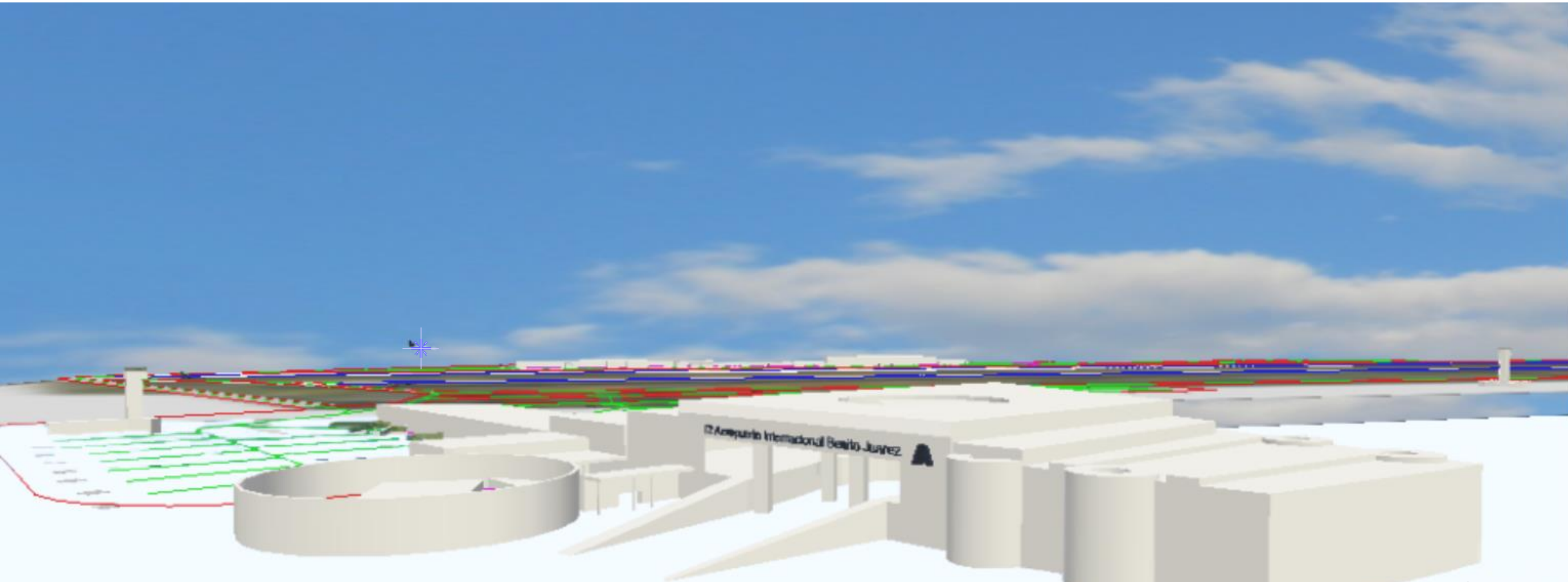
INSTITUTO MEXICANO DEL TRANSPORTE

International Transport Forum

Alternative solutions to airport saturation: simulation models applied to congested airports.



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ABSTRACT

The objective of this paper is to explore several different ways of coping with the imbalance between the available airport capacity and the traffic demand through application of simulation modelling to explore potential solutions.

A. Investment in new infrastructure

B. Demand management

C. Spreading demand peaks

D. Operational and technological innovations → **Computer modeling and simulation**

INTRODUCTION

The problem:

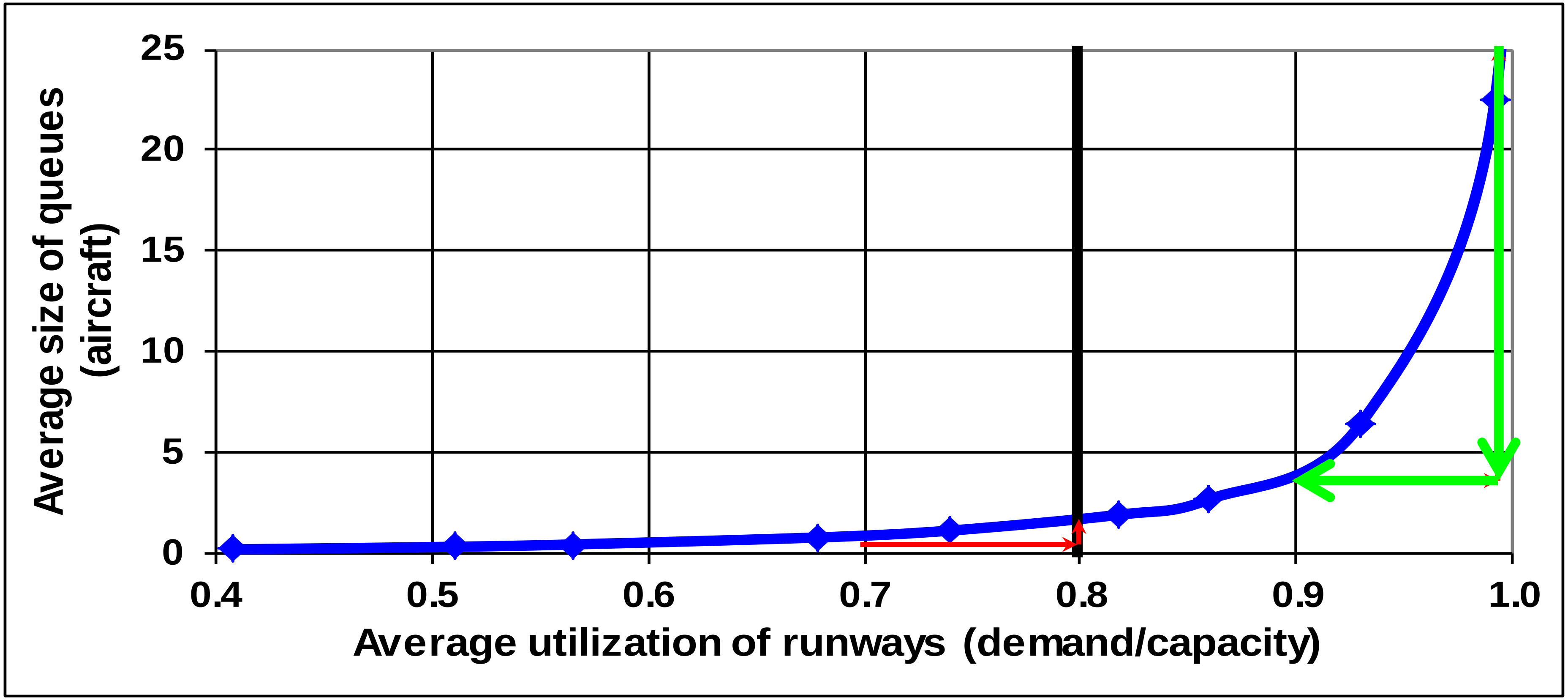
✈ The greatest problem of the aviation industry in Latin America is the lack of an adequate infrastructure, mainly in countries as Brazil, Mexico, Argentina and Colombia (IATA, 2014).

✈ The consumers in Europe are paying €2.1 billion a year in additional air fares, due to capacity constraints at airports (ACI, 2017).

✈ In the US, the three major New York area airports and Philadelphia International Airport will continue to experience major system constraints even after all currently planned capacity improvements are implemented (Mica, 2015).

✈ Aviation passengers in the United States bear nearly $17 billion in additional costs every year due to flight delays (Mica, 2015).

INTRODUCTION



Source: Original figure.

Average sizes of queues on Mexico City International Airport runways as a function of the average utilization of them.

INTRODUCTION

The solution to the problem of airport congestion should therefore focus on finding ways to reduce the demand/capacity ratio.

$$\frac{\textbf{Demand}}{\textbf{Capacity}}$$

INTRODUCTION

The solution to the problem of airport congestion have been divided into four options

A. Investment in new infrastructure

B. Demand management

C. Spreading demand peaks

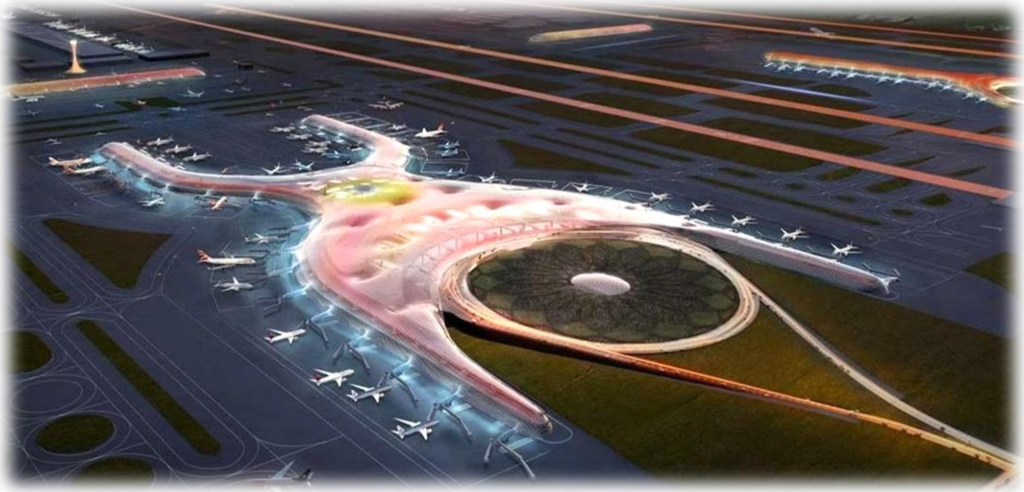
D. Operational and technological innovations

Source: Hamzawi, 1992.

INTRODUCTION

A. Investment in new infrastructure

- **Build new airports**
- **Expand existing airport facilities**



INTRODUCTION

B. Demand management

- Remote processing
- Relocation of certain air traffic operations
- Shift short-haul air traffic to other transportation modes

INTRODUCTION

C. Spreading demand peaks

Peak-period pricing

Slot auctioning

Economic measures

Traffic quotas and slot allocation

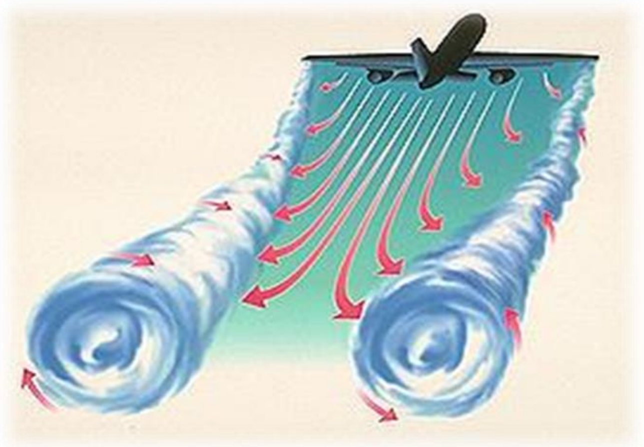
Traffic flow control

Administrative measures

INTRODUCTION

D. Operational and technological innovations

- **Operational practices**
- **Technological innovations**



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SIMULATION MODELS

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Simulation is the representation of a process or system through time

Simulation models commonly take the form of a set of assumptions about the operation of a system. These models are used as a tool of analysis, or as a design tool.

APPLICATION OF SIMULATION MODELS TO CONGESTED AIRPORTS, THE CASE OF AICM.

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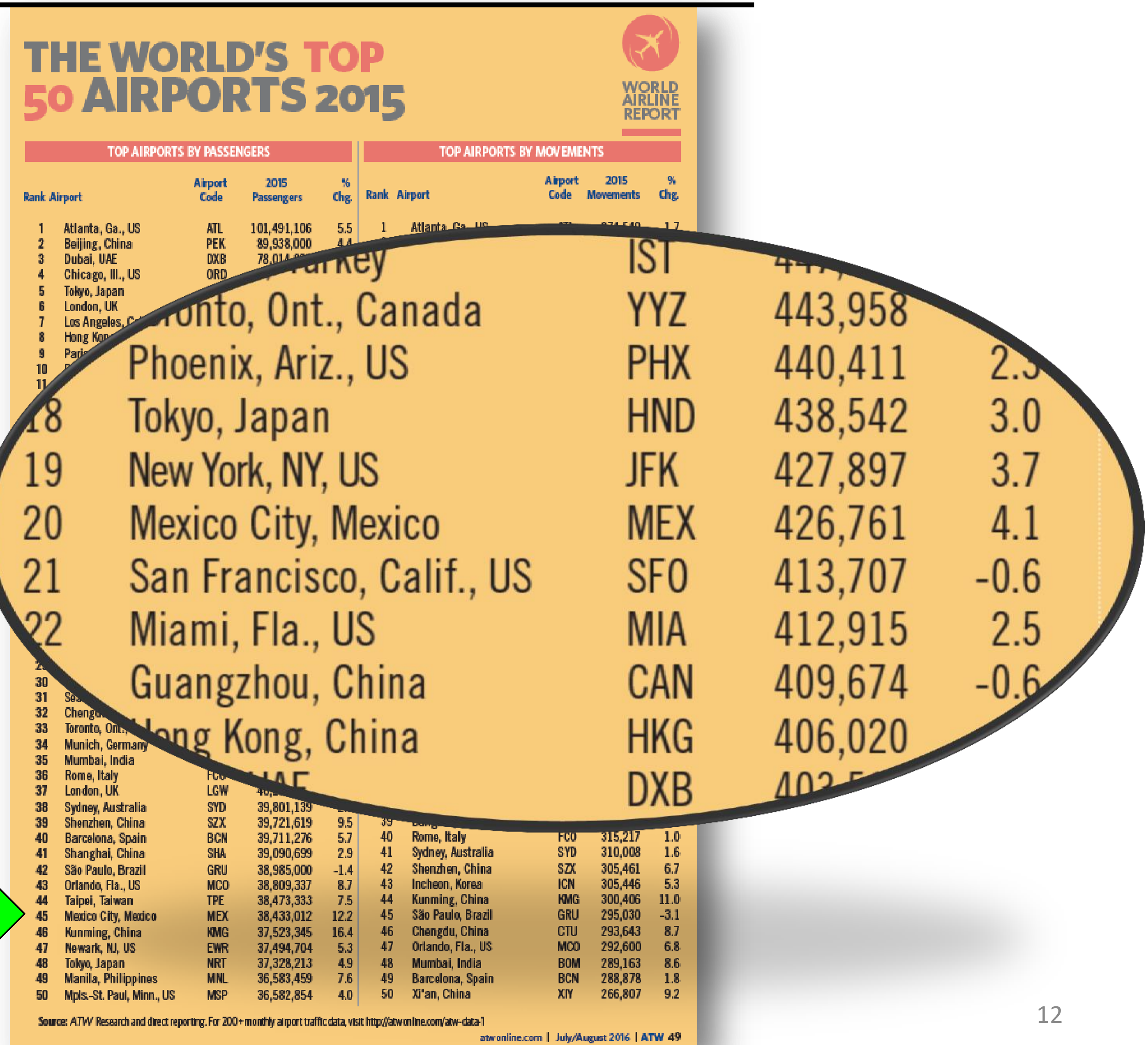


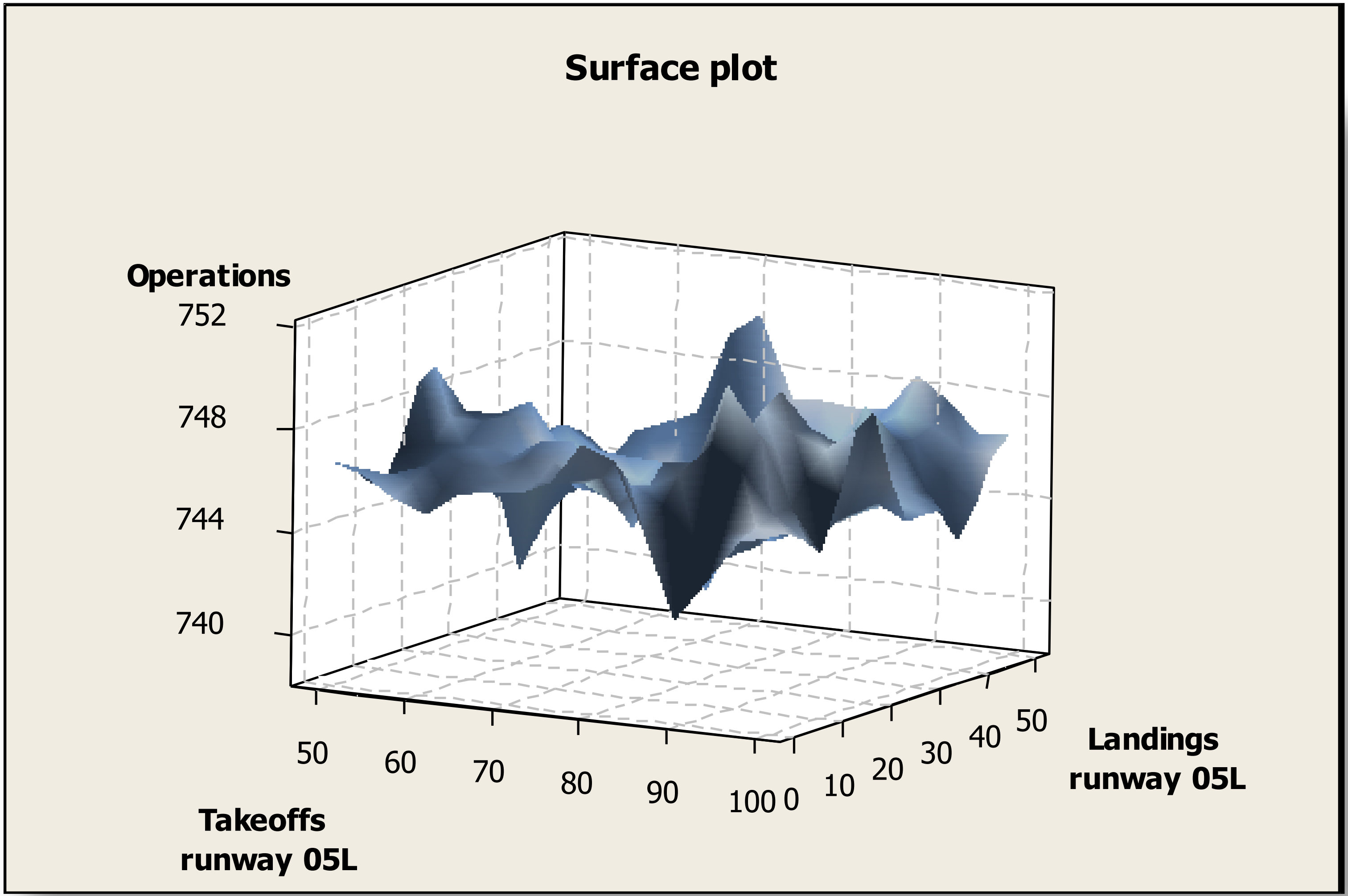
APPLICATION OF SIMULATION MODELS TO CONGESTED AIRPORTS, THE CASE OF AICM.

1) Effect on the aircraft movements performed when the takeoffs and landings are redistributed in the two runways of the AICM

In this case, the effect of shifting the proportions of takeoffs and landings performed at the two runways of AICM is analyzed. To do this, different proportions were established by each runway, and then using a simulation model the total number of operations performed for each case was estimated.

When this model was developed (2003) the real proportions of takeoffs and landings on runways were: 82.3% takeoffs and 9.8% landings on runway 05 left, and 17.7% takeoffs and 90.2% landings on runway 05 right.

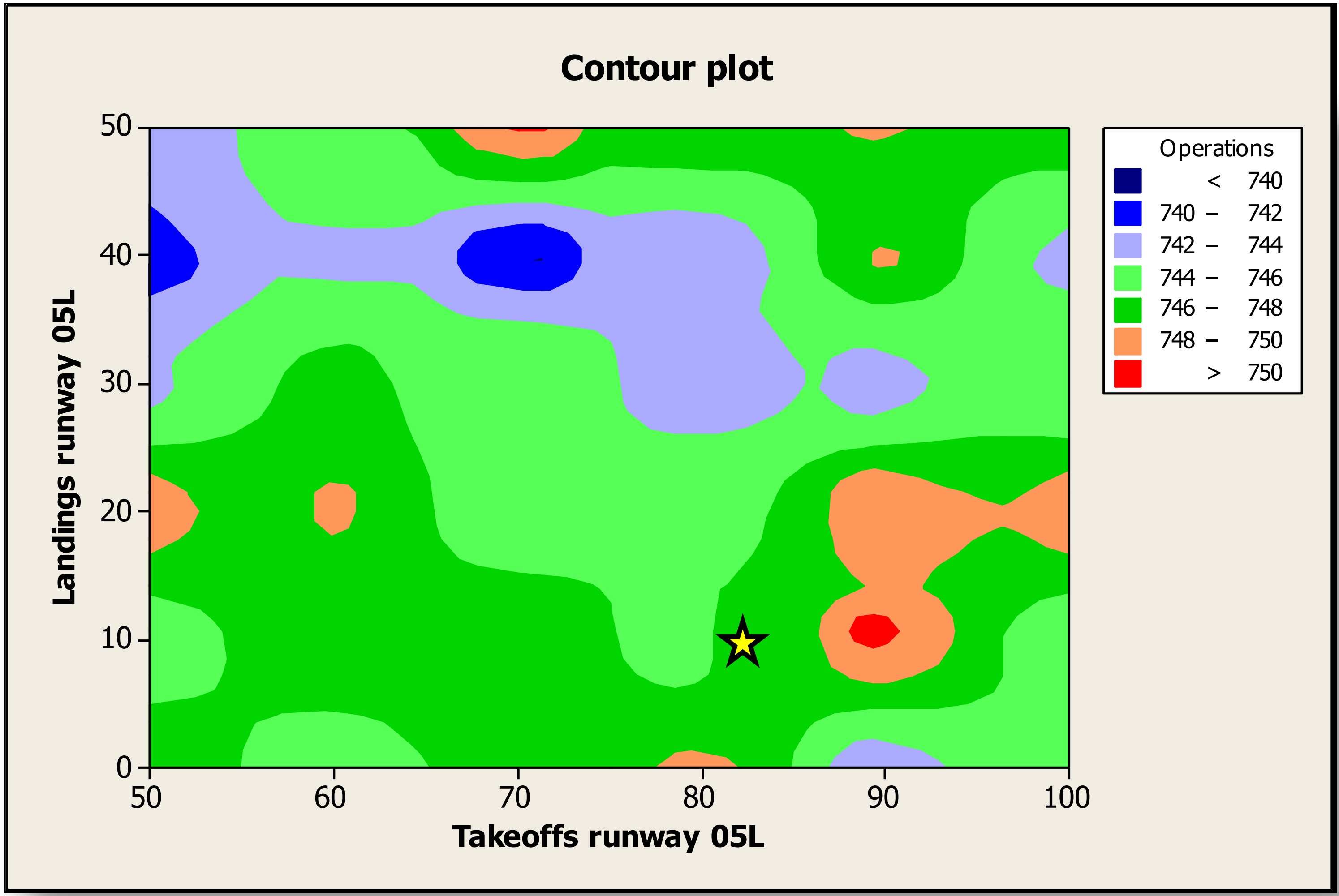
1) Effect on the aircraft movements performed when the takeoffs and landings are redistributed in the two runways of the AICM



Source: Original figure.

Operations processed according to the proportion of landings and takeoffs on the runways, for a daily operation between 07:00 and 24:00 hours.

1) Effect on the aircraft movements performed when the takeoffs and landings are redistributed in the two runways of the AICM



Source: Original figure.

Operations processed according to the proportion of landings and takeoffs on the runways, for a daily operation between 07:00 and 24:00 hours.

2) Effect of intensive use of aircraft with greater capacity

It was considered that a specific type of aircraft is replaced by another of greater capacity than the first. In this way, it is assumed that the new aircraft moves the same number of passengers but requires fewer ATMs.

For the considered demand conditions (January 2011), there was no operations of ATR 42 aircraft between 00:00 and 06:00 hours, however, for the interval between 06:00 and 24:00 hours, 40 landings and 39 takeoffs of aircraft ATR 42 were performed, which would be equivalent to 25 landings and 24 takeoffs of ATR 72 aircraft.

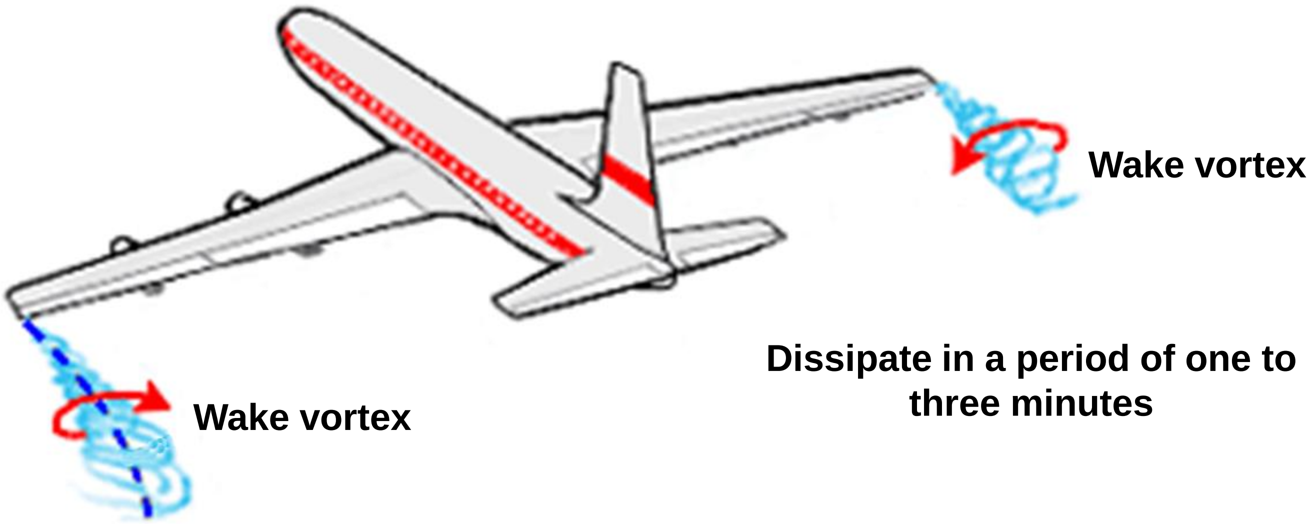
2) Effect of intensive use of aircraft with greater capacity

Quality of service on AICM runways with ATR 42 or ATR 72 aircraft, for the interval between 06:00 and 24:00 hours.

	Total operations	Queue size (aircraft)		Waiting time (minutes)	
		Maximum	Average	Maximum	Average
ATR 42 operation	788.90	10.80	1.32	11.86	1.82
	Total operations	Queue size (aircraft)		Waiting time (minutes)	
		Maximum	Average	Maximum	Average
ATR 72 operation	758.20	8.80	1.07	11.08	1.54
Comparative reduction	30.70	2.00	0.25	0.78	0.28
	3.89%	18.52%	18.99%	6.57%	15.48%

Source: Original figure.

3) Effect of new technology to increase the capacity of airports with close-spaced parallel runways



ICAO has established mandatory minimum separations based on the category of vortexes generated.

Knowledge of wake vortex behavior can increase capacity for airports with close-spaced parallel runways (Burnham et al., 2001). After several decades of research on vortex behavior, wake transport over short times is well understood. In order to increase the capacity of runways with the use of this knowledge, new criteria have been suggested to reduce the current operational limits at airports.

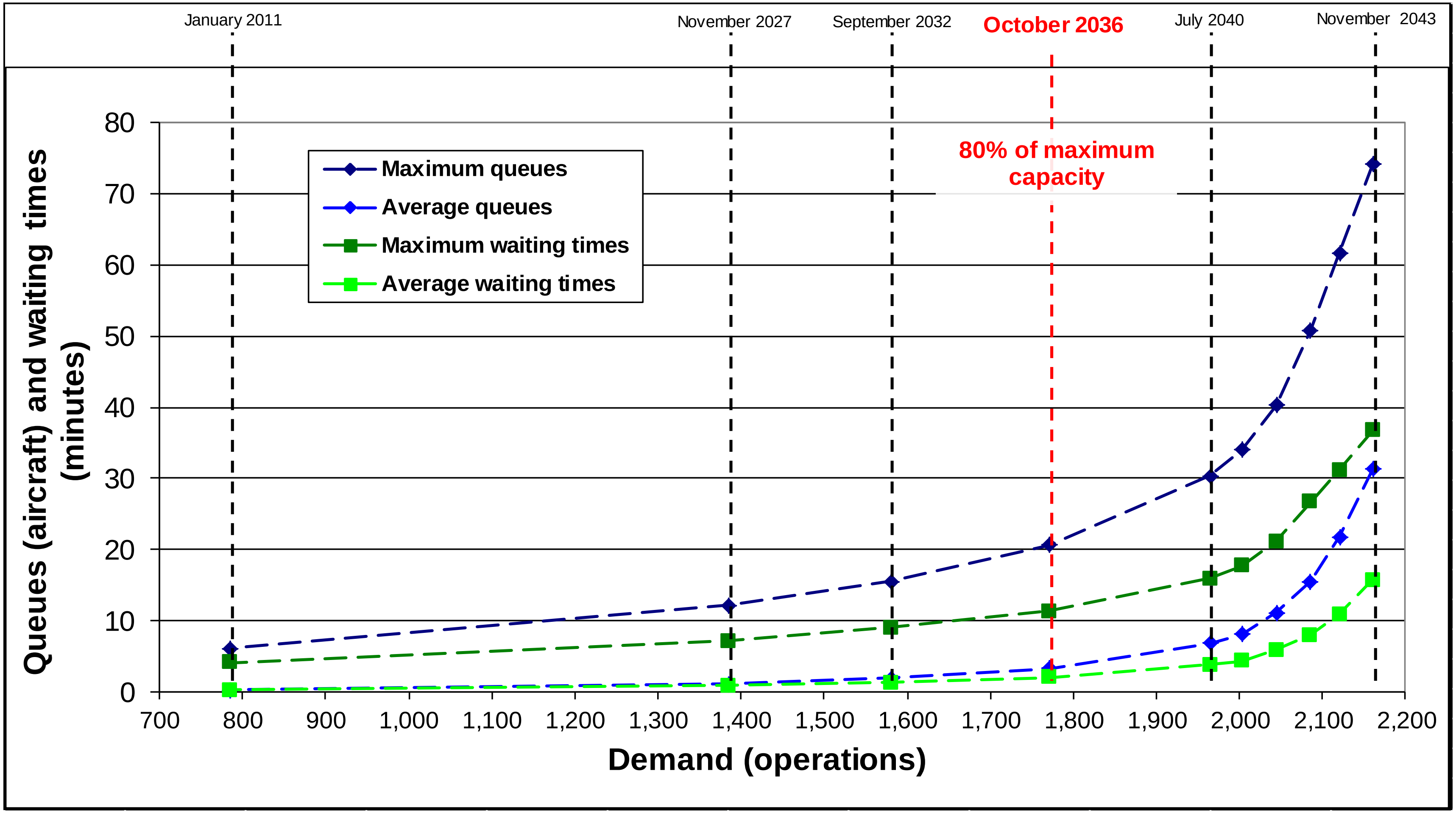
3) Effect of new technology to increase the capacity of airports with close-spaced parallel runways

To estimate the effects of this knowledge in the AICM, it was assumed that the capacity of its runways is increased to 120 operations per hour, in accordance with the operational implications identified by the research of Vernon and Larry (2008).

It was determined under this new condition when the congestion problems initiate at the AICM and the value of the corresponding amount of operations at runways.

APPLICATION OF SIMULATION MODELS TO CONGESTED AIRPORTS, THE CASE OF AICM.

3) Effect of new technology to increase the capacity of airports with close-spaced parallel runways



Source: Original figure.

Evolution of service deterioration at AICM during the interval between 00:06 and 24:00 hours, for a capacity of 120 operations per hour on runways

APPLICATION OF SIMULATION MODELS TO CONGESTED AIRPORTS, THE CASE OF AICM.

4) Potential benefits of applying a new policy to serve the aircraft at runways in order to reduce the passenger delays

In this case the impact of implementing a new policy to serve the operations at runways is estimated. This policy is different from the applied currently in the world (FCFS, first-come-first-served) and its purpose is to minimise the passenger delays.

The FCFS rule does not take into account that the operating costs and seating capacities of various aircraft are different.

$$PAX_{B\text{-}747} = 9.4\ PAX_{ATR\text{-}42}$$

4) Potential benefits of applying a new policy to serve the aircraft at runways in order to reduce the passenger delays

Initially, 40 simulations were executed with the model, applying the current policy. The new strategy was subsequently evaluated, according to the proposal of Herrera y Moreno (2011) with 40 simulations performed. Afterwards the benefits in terms of waiting time reductions were determined comparing the current policy and the new strategy estimations.

4) Potential benefits of applying a new policy to serve the aircraft at runways in order to reduce the passenger delays

The results showed that if the new strategy is applied, it is possible to reduce the daily waiting time in 10,763.2 passenger-minute.

If the benefits are expressed in annualized terms, the reduction of waiting time is equal to 65,476.3 passenger-hours.

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CONCLUSIONS

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✈ The simulation models could help to establish the proportions of takeoffs and landings in order to maximize the operations in airports with several runways (case 1).

✈ The use of aircraft with greater capacity that replaced to smaller aircraft could originate benefits in the operation of the airport, for instance, reducing the queue sizes and the waiting times (case 2).

✈ The application of a new technology to increase the capacity of the runways, in the best case, to 120 operations/hour would produce significant benefits in the operation of the AICM. Under this condition the saturation issues could be deferred 21 years more (case 3).

CONCLUSIONS

- ✈ **It was estimated that if a new proposal to serve the aircraft during takeoff and landing phases at the AICM runways is applied, it is possible to obtain reductions in the passenger delays (65,476.3 passenger-hours annually (case 4).**

- ✈ **Finally, although the four cases described before were considered in an independent way, they could be considered in an integral case, since they are complementary.**

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