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ANALYSIS OF THE DEVELOPMENT OF AVIATION INFRASTRUCTURE ON THE EXAMPLE A COUNTRY FROM NORTH AMERICA

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Abstract: In the era of globalisation and permanent travel of people between faraway regions of the world, air transport is one of the most important means of transport. Today it is also one of the most secure transport modest possibilities. This idea stands at the beginning of the article subject. The aim of this work is to present the aviation infrastructure of Mexico and to analyse how it has changed over the years.

In this contribution, on the example of Mexico country, a statistical analysis of characteristic parameters determining the development of aviation infrastructure was performed. A statistical analysis of selected aspects may enable to reveal the situation related to air transport in North America and the predictions might visualise expectations in the following years. The factors that determine the development of infrastructure in this country are also presented. The most important elements of the aviation infrastructure, such as airports, are described. They were divided in terms of the number of passengers served and the amount of transported cargo.

Keywords: Statistical Analysis, Air Transport, Air Infrastructure

1. INTRODUCTION

In literature, infrastructure is defined as basic equipment, public buildings and service institutions that are necessary for the functioning of the economy and society [1]. Infrastructure can be divided into technical-economic and social [2]. Technical-economic infrastructure includes such equipment, facilities, institutions and buildings that provide services in transport, communication, energy, irrigation and land reclamation, while social infrastructure includes institutions, facilities and equipment operating in the sectors of law, security, education, education and health care [3].

Aviation operations are an important factor in modern globalised economies, which demand flexibility, mobility, efficiency, and dependability. A lot of inter-national transporta-

tion experts compare and contrast how different nations have managed their airports and air traffic control systems and how well they are meeting the needs of their people [4]. To meet these challenges, the infrastructure of air transport should be permanently developed. This includes the growth of a number of airports, airfields, airports and helicopter airfield. By the term "aviation infrastructure" is meant not only a stationary network but also a mobile infrastructure that includes aircraft and helicopters. In order to understand how it should evolve to cope with the increase in passenger numbers, it is important to build forecast models.

The main goal of this contribution is the presentation of the aviation infrastructure in Mexico. The factors that determine the development of infrastructure in this country are also presented. The most important elements of the aviation infrastructure, such as airports, are described. They were divided in terms of the number of passengers served and the amount of transported cargo. There is also presented a detailed statistical analysis of the aircrafts as an element of air transport in Mexico.

2. ANALYSIS OF AVIATION INFRASTRUCTURE

2.1. DATA SAMPLE

The data used in this analysis has been taken from Secretariat of Communications and Transportation web page [5]. All figures presented in this contribution have been created and calculated by authors. The analysis has been performed for two data periods: from 1991 to 2017 (12 years) and from 2006 to 2017. A longer data string was used to find the analytical form of the function. Due to missing data, the rest of the drawings are only used to include the latest data.

2.2. NUMBER OF PASSENGERS SERVED

Following Calderón and Chong [6] and Sahoo et al. [7], the indicators used to represent infrastructure quantity-related measures for the transport sector were, among others, freight air transport, air transport passengers carried [8].

In Fig 1 is presented the number of passengers served at Mexican airports. The increase of the number of passengers is one of the main factors, which determinate the growth of aviation infrastructure.

Referring to Fig 1 an increase over 80% in the number of passengers served at Mexican airports was observed. It was therefore concluded that the aviation infrastructure in Mexico is developing year by year. Not only was noticed the increase by 90% in the number of domestic passengers but also the number of international passengers growth by almost 69%. The lowest number of passengers was observed in 2009 and the highest in 2017. The year 2014 was the first one when the total number of passengers exceeded the 100 million threshold.

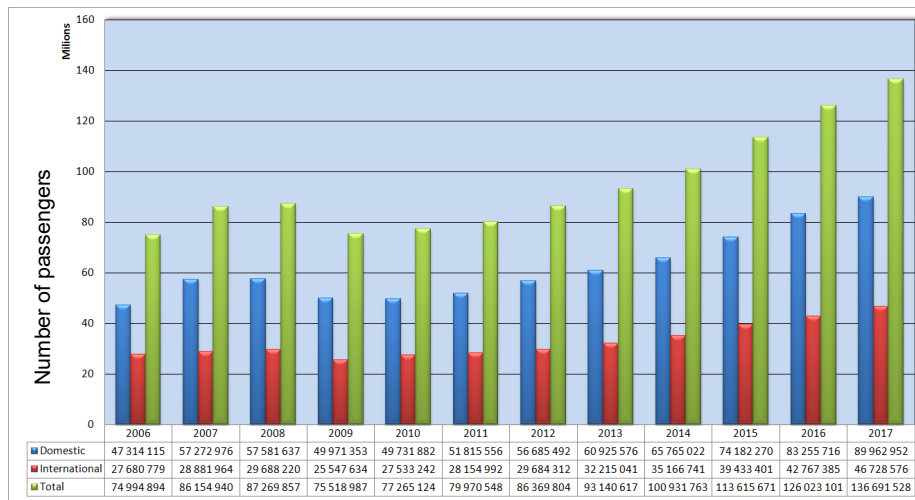


Fig. 1. Number of passengers served at Mexican airports

2.3. QUANTITY OF CARGO TRANSPORTED

Another important factor in the expansion of aviation infrastructure is cargo transport [9].

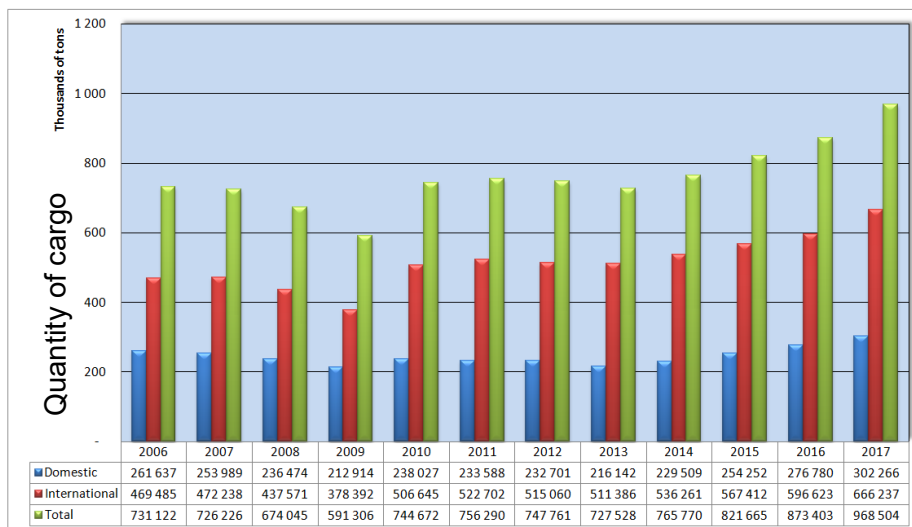


Fig. 2. Quantity of cargo carried at Mexican airports

As can be seen in Fig 2, a decrease in the quantity of transported cargo can be observed in 2008–2009. First by 8%, and in the following year by 12%. International freight transport accounts for 67% in the analysed period. In 2010 it exceeded the barrier of 500 thousand tons.

According to experts [10, 11] general accompanies globalization, obviously leads to more demands for international air services, and changes in the air transport regulatory environment has added to this effect, but trade also increases demands for domestic

transport, including air services, and especially so within larger countries. The economic structures required to produce the additional exports, and to distribute additional imports, also needs supplementation by further layers of domestic economic structures to satisfy the new internal demands that come from a more prosperous economy.

The increase in passenger numbers and quantity of cargo requires that the airlines increase the number of flights or aircraft capacity. As the first factor, the number of flights performed at 64 airports was examined (Fig 3).

Analysis includes both commercial and general aviation flights as well as helicopter flights in the analysis. The data were divided into domestic and international flights. It has been noted that the number of flights carried out during this period has increased by almost 12%. The chart also shows that international flights account for only about 20% of all flights. Over the last 10 years, this range has been between 19.1% and 19.1% a 24.1%. Between 2008 and 2009, the decline in the number of flights was caused by the economic crisis. Since then, an increasing trend has been observed.

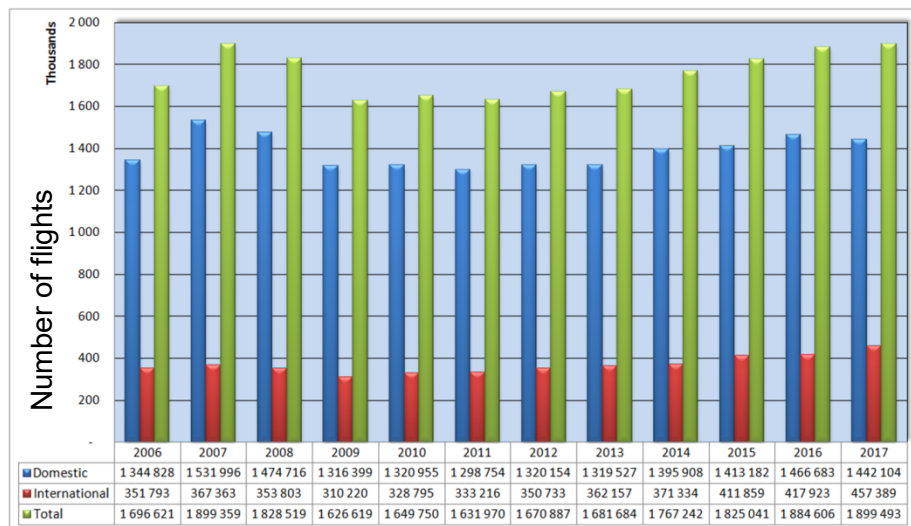


Fig. 3. Number of flights served at Mexican airports

2.4. NUMBER OF AERODROMES

The growth of the number of passengers and carried cargo should result in the increase of the number of aerodromes. The number of aerodromes in Mexico between 1991 and 2017 is shown in Fig 4.

The initial number of them, within a few years, has decreased twice. Most of them were closed during the economic crisis in 1994-1995 [12]. Later on, the fluctuations are much smaller and the number of airports is beginning to increase. In the Fig 4, the trend line polynomial, fourth degree, is fitted. It shows the initial decline and the subsequent increase in the number of aerodromes. Fig 3 includes also the equation of the trend line and the value of the R^2 coefficient. It means that 85% of the development tendency of airports is includ-

ed in this line. The forecast for the next 5 years has also been made. The forecast shows that the total number of airports will not change significantly.

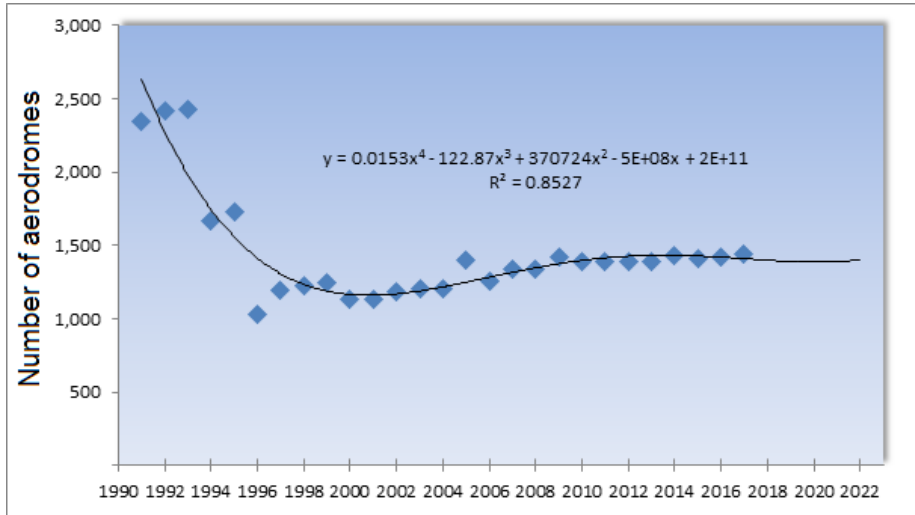


Fig. 4. Number of aerodromes in Mexico between 1991 and 2017

In order to understand the changes in the mobile infrastructure in Mexico, a fleet of major carriers was analysed. Referring to fig 5, it was observed that the number of aircraft increased while the age of the aircraft decreased.

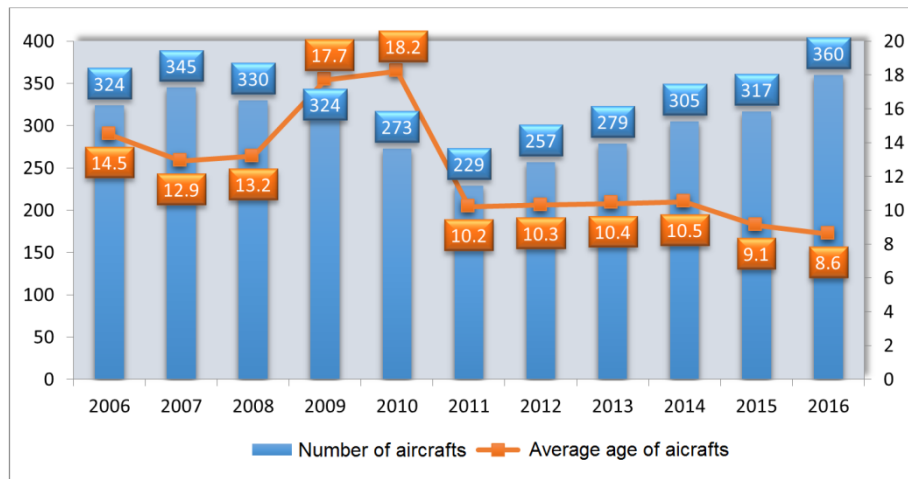


Fig. 5. Number of aircrafts and their average age

The number of aircraft from 2007 to 2011 had a regressive tendency. In the following years, a gradual increase in the fleet was observed. Since 2011 the number of aircraft has increased by 57%, while the average age of aircraft has decreased. In 2010, the Mexicana airline went bankrupt, which is a result of a decrease in the average age of the fleet by as many as 8 years. The most of aircrafts in this company was older the 30 years. The difference between the youngest and the oldest models is 29.5 years (Table 1). The most recent aircraft is the Airbus A321 with an average age of just 1.3 years. Further models with a

higher average are the ATR 72 and the Boeing 787. At the very end there is the Airbus A300 with an average age of 30.8 years.

Tab. 1

The aircraft model, the number of aircrafts and the average age of the plane

	Number of aircrafts	Average of age [years]
Airbus A320	130	5.8
Boeing 737	69	11.9
Embraer 190	48	8.5
Airbus A321	21	1.3
Boeing 787	17	2.7
Sukhoi SU 100	16	3.7
Embraer 145	15	18.9
Embraer 170	13	13.2
ATR 72	7	1.9
ATR 42	7	12.3
Airbus A319	5	11
Airbus A300	5	30.8
Embraer 120	1	20

2.5. NUMBER OF AIRPORTS

The number of passengers and the number of machines to be handled require the use of stationary infrastructure in the form of airports. International airports are the most important for passenger transport [13]. The largest of them serve from a few to several dozen million passengers a year. In 2017, Mexico had 64 such airports. The change in the number of airports as a function of time is shown in figure 6.

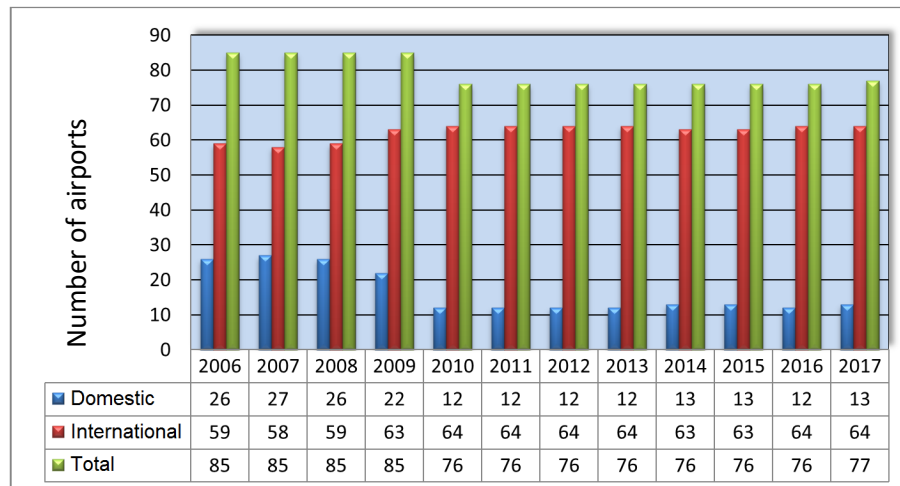


Fig. 6. Number of airports at Mexico

Referring to fig 6, over the past 11 years, there has been a significant decline in the number of domestic airports and a simultaneous increase in the number of international airports. Since 2010, the total number of airports has been stable for 6 years. The change took place only in 2017.

2.6. NUMBER OF HELIPADS

As the last element, the number of helicopter landing fields has investigated. Results are presented in Fig. 7. In the analysis are taken under the consideration heliports located on the territory of the country, heliports of rescue services and heliports on maritime platforms.

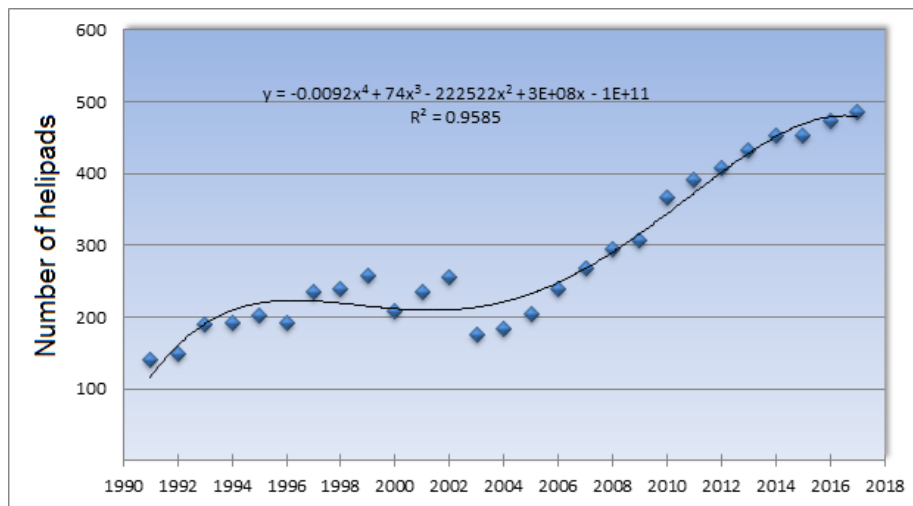


Fig. 7. Number of helipads in Mexico

Until 2002, rescue heliports were not subject to operating charges. Therefore, in 2002, the Ministry of Finance decided to introduce this fee. For this reason, out of 58 rescue heliports, only 8 decided to continue their activities. This decline is very visible in Fig 4. Since 2002, the number has gradually increased, reaching 485 heliports in 2017. The polynomial trend line showing the changes in the analysed years is also presented in the chart. The equation and the value of the R^2 [14] coefficient were shown.

2.7. CASE STUDY – THE LARGEST AIRPORT IN MEXICO

Mexico's most important airport is the Benita Juárez International Airport, the busiest one not only in Mexico but also in Latin America. In 2017, it was ranked 36th in the ranking of the largest airports in the world, with the number of serviced customs amounting to 44,732,418 [15]. The airport serves 26 domestic and international passenger airlines and 12 cargo airlines. It is not only the busiest for passengers in Mexico (33% of passenger traffic), but also dominates the freight category (55% of freight traffic). Statistics of the largest airport in Mexico in terms of the number of passengers, the number of flights performed and the number of cargo transported are given in Fig. 8–10.

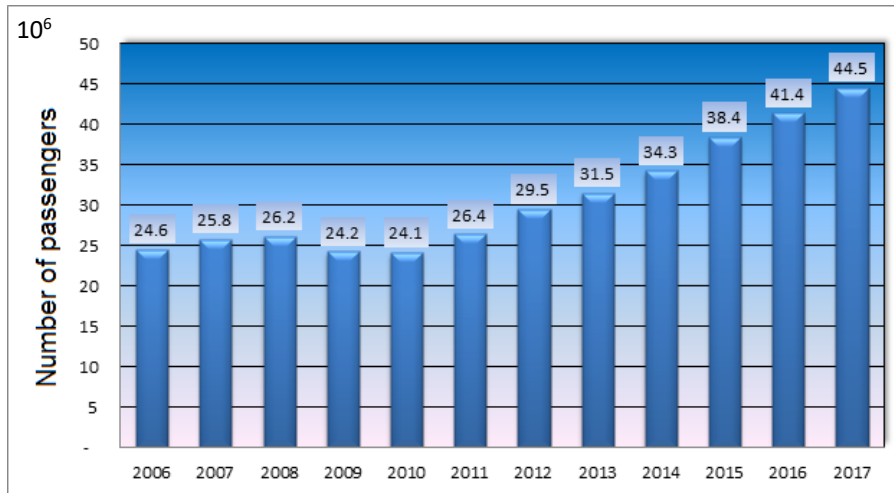


Fig. 8. Number of passengers served at the airport Benito Juárez

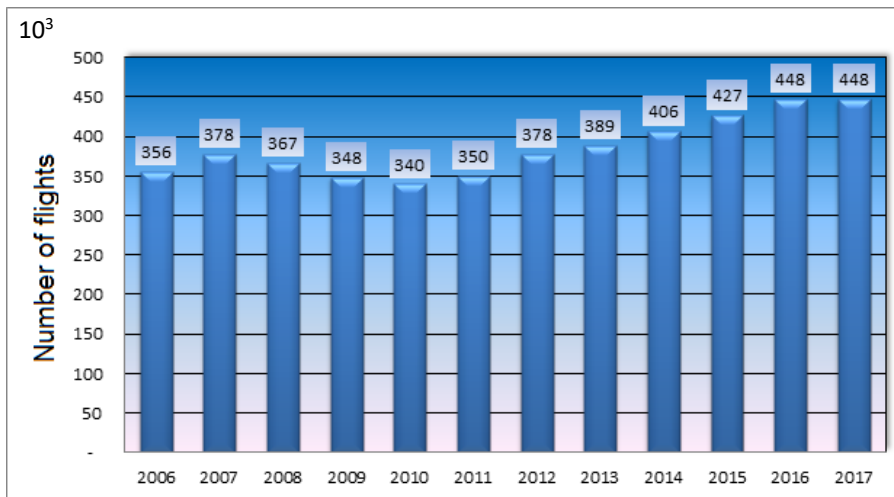


Fig. 9. Number of flights performed at the airport Benito Juárez

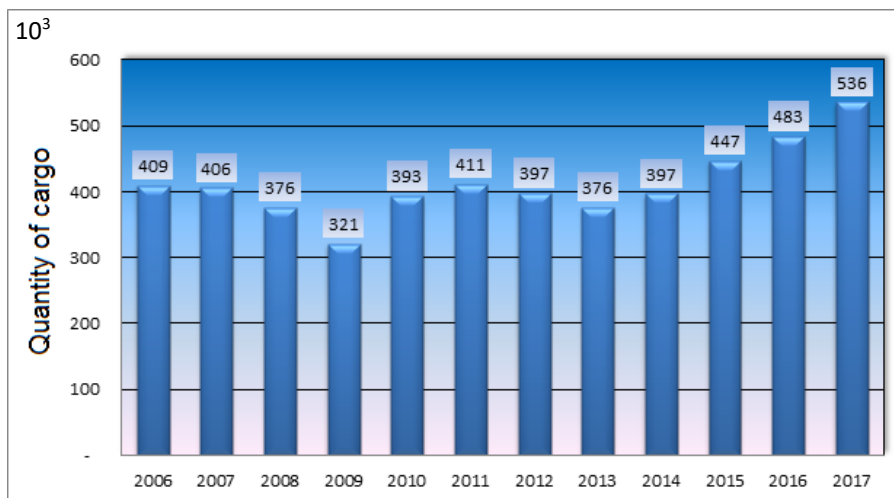


Fig. 10. Quantity of cargo carried at airport Benito Juárez

The airport is currently at the limit of its current capacity [10] and is likely to be replaced in the future by the New International Airport of Mexico (Nuevo Aeropuerto Internacional de la Ciudad de México, NAICM).

3. CONCLUSIONS

Summarising, the aviation infrastructure of Mexico has developed over a given period of time. However, this progress was not continuous. The evidence of the impact of the economic slowdown [16] was noticed in 2008-2009, which significantly delayed the expansion of the Mexican infrastructure. Having population around 125 million, the country needs to develop every type of transport infrastructure to ensure that citizens can travel domestically and internationally. In this country, where there are so many natural barriers, air transport plays an important role in internal transport. It allows long distances to be covered in a short time and is one of the safest means of transport. It is no longer a problem to cross mountain ranges, canyons or precipices. Due to its climate, historical, natural and cultural richness, Mexico is a country that attracts foreign passengers, not only from America, but also from all over the world.

The most visible effects of the improvement were observed on the basis of the increase in passenger numbers. Every year, for more than 10 years, the results have been higher and higher. Over the last few years, this number has increased by several million a year. Cargo transport has also been growing steadily since 2013. In the near future, the limit of 1 million tons of transported goods will be exceeded.

The number of aerodromes and airports fluctuates in a small range, although the number of operations is increasing year on year. The growth of Mexico's leading air carriers also indicates an increase in air infrastructure.

The above analysis is not exhaustive, because it covers only a part of the subject. For this reason, the work may be an inspiration for further research and analysis in this direction.

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ANALIZA ROZWOJU INFRASTRUKTURY LOTNICZEJ NA PRZYKŁADZIE KRAJU Z AMERYKI PÓŁNOCNEJ

Streszczenie: W dobie globalizacji i stałych podróży ludzi między odległymi regionami świata transport lotniczy jest jednym z najważniejszych środków transportu. Dziś jest to również jedna z najbezpieczniejszych możliwości transportu. Celem tej pracy jest przedstawienie infrastruktury lotniczej Meksyku i jej analiza jak zmieniła się na przestrzeni lat. W artykule tym na przykładzie kraju meksykańskiego, przeprowadzono analizę statystyczną charakterystycznych parametrów determinujących rozwój infrastruktury lotniczej. Analiza statystyczna wybranych aspektów może umożliwić ujawnienie sytuacji związanej z transportem lotniczym w Ameryce Północnej, a prognozy mogą przedstawiać oczekiwania w kolejnych latach. Przedstawiono również czynniki determinujące rozwój infrastruktury w tym kraju. Opisano najważniejsze elementy infrastruktury lotniczej, takie jak lotniska. Zostały one podzielone pod względem liczby obsługiwanych pasażerów i ilości przewożonego ładunku.

Słowa kluczowe: analiza statystyczna, transport lotniczy, infrastruktura transport lotniczego