MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY

Air Transportation Management Department

PERMISSION TO DEFEND GRANTED

Head of the Department

_____________________D. O. Shevchuk

“______”______________________2021

BACHELOR THESIS
(EXPLANATORY NOTES)

Theme: Comparative Characteristics of the Development of the Airline Fleet

Done by: Hrytsiuk Bohdan

Supervisor: Victoria Akmaldinova, Senior Lecturer

Standards Inspector: Yuliia V. Shevchenko, PhD in Economics, Associate Professor

Kyiv 2021

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Кафедра організації авіаційних перевезень

ДОПУСТИТИ ДО ЗАХИСТУ

Завідувач кафедри

___________________Шевчук Д.О.

«______»_________________2021 р.

ДИПЛОМНА РОБОТА
(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ «БАКАЛАВР»

Тема: Порівняльна характеристика розвитку флоту авіакомпаній

Виконавець: Грицюк Богдан Миколайович

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NATIONAL AVIATION UNIVERSITY

Faculty of Transport Management and Logistics

Air Transportation Management Department

Major (specialty): 275 “Air Transportation Technology”

APPROVED BY

HEAD OF THE DEPARTMENT

___________D. O. SHEVCHUK

“______”_____________2021

TASK

OF COMPLETION THE BACHELOR THESIS

HRYTSIUK BOHDAN

1. Theme of the bachelor thesis entitled «Comparative characteristics of the development of the airline fleet on the example of UAI and Virgin atlantic » was approved by a decree of the Rector order № 668/st. from 27.04.2021.
2. Term performance of thesis: from 04.05.2021 to 16.06.2021.
3. Initial data required for writing the bachelor thesis: statistical data and analytical materials from Internet resources
4. Content of the explanatory notes: Analysis of the development of the international market of aviation services, Aircraft Fleet Trends, Covid-19 Effect on aviation market and fleet trends, Analysis of UIA's activities, Analysis of Virgin Atlantic activities, Theoretical and methodological bases of efficiency of use of airline fleet, Development of project proposals to increase and compare the efficiency of UIA and Virgin Atlantic aircraft fleet use, using Direct Operating Cost (DOC).
5. List of mandatory graphic matters: Market Values by region, Global fleet forecast by aircraft class, The fleet of UIA and Virgin Atlantic.

6. PLANNING CALENDAR

№	Assignment	Deadline for completion	Mark on completion
1.	Collection and processing of statistical data	04.05.2021	done
2.	Writing of the theoretical part	14.05.2021	done
3.	Writing of the analytical part	25.05.2021	done
4.	Writing of the design part	31.05.2021	done
5.	Writing of the introduction and summary	04.06.2021	done
6.	Execution of the explanatory note, graphic matters and the presentation	10.06.2021	done

7. Given date of the task: April 27, 2021.

Supervisor of the bachelor thesis: Victoria Akmaldinova

Task was accepted for completion: HRYTSIUK BOHDAN

EXPLANATORY NOTE

Explanatory note to the bachelor thesis « Comparative Characteristics of the Development of the Airline Fleet»: 101 pages, 16 figures, tables 9, 53 references.

KEYWORDS: AIRLINE, AIRCRAFT PARK, COSTS, FLEET FORECAST

***Object of the bachelor thesis* --** the airline fleet.

***Subject of the bachelor thesis* is --** methods to increase the efficiency of the airline's fleet.

***Main task of the bachelor thesis* is --** Compare fleets and their efficiency on the example of modern widebody aircraft in used of UIA and Virgin Atlantic on the given routes. Develop proposals on how to increase the efficiency of fleet based on the use of Direct Operating Cost (DOS). Find the optimal solutions for the operation of the aircraft on the specified routes

***Methods of analysis include* --** statistical, technical and economic analysis, mathematical modeling.

***The relevance of the thesis* --** The present work simulates the evaluation and selection of an aircraft for a proposed airlines for operate across an assumed routes that includes both medium-haul and long-haul destinations. This simulation is conducted through a series of phases and subsequent meticulous levels of analysis. At the end of these work some recommendations are given for selecting the suitable aircraft for a specified routes. The output of the study predicts the aircraft efficiency. Considering the destination ranges and such other important criteria as the respective payloads, a Boeing 777-200ER; Boeing 787-9; 767-300ER; A350-1000; A330-300 aircrafts were chosen for the study as the most widely use new and efficiency wide-body aircraft in the fleet of each airline. A Project Manager or a Fleet Planner can utilize the output information to determine which aircraft would deliver the most benefit or results during operation in time for the money spent in the case of the fleet planner.

ABREVIATIONS

FAA- Federal Aviation Administration

UNWTO - World Tourism Organization

GMF – Global Market Forecast

GDP – Gross domestic product

IMF - International Monetary Fund

HSLT - high-speed land transport

GAMA - General Aviation Manufacturers Association

MRO - maintenance, repair, and operating supply

FTK -- is one metric tonne of revenue load, carried one kilometre

NHS -- United Kingdom National Health Service

PPE – personal protect equipment

PDC -- planned direct cost

Eqs –Equation

EU – European Union

ICAO – International Civil Aviation Organization

IATA – International Air Transport Association

UIA- Ukraine International Airlines

Yield --Airline passenger yield is generally expressed as the number of cents (or equivalent) earned for each passenger mile or kilometer flown.

CONTENTS

INTRODUCTION

Air Transportation Management Department				*NAU.21.06.98 001EN*				
Done by:	Hrytsiuk B.M.			*INTRODUCTION*	Letter		Sheet.	Sheets
Supervisor	Akmaldinova V.Ye.					D	8	3
Standards Inspector	Yuliia V. Shevchenko				***FTML 275 ОП- 403Ба***			
Head of the Department	Shevchuk D. O							

Fleet efficiency, like business efficiency, focuses on generating the most output from the least amount of resources. This entails increasing output while keeping expenses down. Productivity, fuel consumption, emissions, routes, and expenses are all factors that go into determining fleet efficiency.

One of the most difficult aspects of the airline industry's decision-making process is fleet planning. An excessively large fleet size would result in an airline incurring unnecessary costs, as expanding capital assets make for a significant amount of the airline's operating expenditures. An undersized fleet, on the other hand, would result in a large number of passengers fleeing to other market competitors. Furthermore, with the airline industry's profit margins around the world under constant pressure from long-term exposure to a high-cost and low-fare environment, an irrational fleet composition will inevitably impair the airline's operations. As a result, airlines may need to create a more practical fleet planning method at a strategic level in order to meet passenger demand with reduced costs and more manageable risks.

The goal of airline fleet planning is to identify the structure and composition of the fleet for a given operational environment, which includes network characteristics, flight schedules, and mean fare levels. Macro-fleet planning is one of the most widely utilized methods around the world, in which network-based passenger demand within a future area is utilized to predict the number of different types of aircraft required for a given candidate aircraft type set.

We will use the Direct Operating Cost (DOC) to determine the most suitable. Aircraft for specific routes and reduce its operating cost compare 5 wide-body aircraft of different models. The analysis of aircraft's direct operating costs (DOC) is a crucial step in attaining financially viable aviation operations. However, data on the DOC's value for various aircraft types and flight conditions is scarce. Using the technique of the Association of European Airlines, we conduct a thorough investigation of the DOC of certain wide-body passenger aircraft now in use by UIA and Virgin Atlantic (AEA). Individual parts of the DOC, such as finance expenses, maintenance expenses, and flight costs, are assessed. Several realistic flight scenarios are analyzed, each with its own set of variables such as route distance and fuel price. The most cost-effective aircraft type is found and evaluated for each flight scenario in the context of operations from two different international airports. The data gathered in this study could be beneficial to airline companies.

Solving the challenge of aircraft fleet management by lowering operating expenses as an economic lever for profit development will boost the airline's efficiency and help it reach a specific level of profitability, allowing it to survive in a terrible economic crisis. The answer to the challenge of increasing the fleet's efficiency in the execution of regular medium- and long-haul passenger traffic is critical in this regard.

1. ANALYTICAL PART

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Done by:	Hrytsiuk B.M.			*ANALYTICAL PART*	Letter			Sheet.	Sheets
Supervisor	Akmaldinova V.Ye.						D	11	43
Standards Inspector	Yuliia V. Shevchenko				***FTML 275 ОП- 403Ба***				
Head of the Department	Shevchuk D. O								

1.1 Analysis of the development of the international market of aviation services

The importance of international air freight transportation in today's world economy to assure the smooth operation of international trade, as well as the supply of modern production and distribution networks is huge.

Airline industry is a fast-paced segment of global transportation. Not only does aircraft equipment evolve, but so do corporate strategies, techniques, and models. From interline agreements on collaborative operation of lines to the formation of alliances, airline cooperation is rising. Meanwhile, the advent of new information technologies has resulted in the establishment of new modes and areas of airline cooperation and engagement.

Multifactor models, which take into consideration the primary characteristics that impact the demand for new passenger and cargo aircraft, were used to analyze the prospective trends and potential for the development of the world market for aviation services. The most fundamental and universal factors that influence the volume of air traffic are the region's GDP indicators and the cost of aviation fuel. In emerging countries, economic expansion has a favorable impact on the development of air transportation services. As a result, Asian countries have a bright future in terms of the structure of the aviation business and the expansion of air traffic in the next years [1].

Europe and Asia, North America and Asia, Europe and Latin America, and North America and Latin America are the most developed modes of transportation today. Domestic transportation is also in high demand in Asia and Latin America. The amount of increase owing to changes in GDP is greatly reduced in nations with developed economies, where air transport has reached the highest rates in absolute terms. Aviation fuel expenditures make up around a third of all direct operational costs involved with aircraft operation.

Network airlines transport the majority of the world's aviation traffic. The share of mixed business models of airlines has increased in recent years, despite increased market competition. Many large network carriers are introducing budget transportation features, the level of competition is increasing, and regional routes are becoming more competitive.

The current economic and geopolitical conditions of the global air transportation market define the medium-term patterns in its development. The deregulation of the global air transportation business is one of the major developments. Not only in Europe and the United States, but also in Asia, the liberalization movement accelerated in the 2000s. As a result, the number of airlines in the market has grown, as has competition between them, resulting in cheaper air fares and more passenger and cargo traffic. According to projections, global passenger turnover might increase 2.5 times between 2018 and 2030 [2].

The global air network's structure, as well as the growing percentage of budget airlines, provide a consistent need for narrow-body aircraft. It has become the most popular market category in recent years.

In the passenger market, more over 50.0 percent of aircraft are under 10 years old. A substantial number of regional aircraft with a capacity of up to 60 seats are also present in the world park. However, airplanes of this size do not operate in very profitable areas, have a relatively high cost of space, and compete directly with other modes of transportation in a number of countries throughout the world. The demand for airplanes of this size is cyclical, and it is heavily influenced by environmental factors. This market segment is typically affected by changes in the cost of aviation fuel or a decrease in demand for air transportation [3].

Environmental considerations have a significant impact on the development of narrow-body aircraft with a capacity of 61-120 passengers. Airlines using this size aircraft are frequently compelled to compete with high-speed land transportation (HSLT). In Europe and China, for example, the network of HSLT destinations is rapidly expanding.

Current trends, combined with the potential for increased passenger traffic and the predicted write-off of aircraft with a capacity of 61-120 seats, allow us to forecast 4605 units of demand for aircraft of this size from 2018 to 2030. The global aviation market They account for around 50.0 percent of the global aircraft fleet and 47.0 percent of global traffic. Modern aircrafts under the age of 10-15 years make up the majority of narrow-body planes of this size [4].

Commercial aviation has undergone an amazing renewal process during the previous decade, with operating expenses decreased, unprofitable routes abolished, and older, less fuel-efficient, and emission-efficient aircraft grounded.

Furthermore, we have all watched the disintegration and fragmentation of the services given to customers, which has contributed to the increase in airline operating revenues.

As a result, ticket prices have been lowered, democratizing access to commercial aviation for a wider audience and, as a result, maximizing airline profits.

By 2030, demand for narrow-body aircraft with a capacity of more than 120 seats is expected to total 24,385 units, with 11.0 percent of those aircraft having a capacity of 121-140 seats and 89.0 percent having a capacity of more than 140 seats [5]. Wide-body aircraft have generally been used on lucrative routes with significant passenger traffic, such as the transatlantic, Asian, and Middle Eastern routes. Despite the fact that wide-body aircraft have a better profitability than narrow-body aircraft, their economic efficiency and optimization for the performance of their duty is increasing.

We'll look at the rise of commercial aviation from 2020 to 2039, looking at things like the demand for aviation employees, the increase in new aircraft deliveries, and the construction of new routes in various geographic regions, among other things.

The realistic growth of regional jet aviation will show 2240 deliveries of the new aircraft till 2038.

The realistic growth of narrow-body aircraft 32 420 deliveries of the new aircraft till 2038.

The realistic growth of wide-body aircraft 8340 deliveries of the new aircraft till 2038.

The realistic growth of cargo aircraft 1040 deliveries of the new aircraft till 2038. [6]

The health crisis caused by the COVID-19 pandemic is unparalleled, and it has shattered economic and productivity expectations across the globe. Nonetheless, some light has been cast on the near and medium-term uncertainty.

The coronavirus pandemic's patchy economic recovery continues to provide a challenge to airline capacity planning, given the unpredictability of demand. Carriers may be erring on the other side of the equation, putting too many planes back into service before reliable demand materializes, after pulling nearly 70% of the worldwide fleet out of service between January and early April.

Without a question, COVID-19 has destroyed the passenger-carrying sector around the world. Here are a few numbers to consider: Global airline losses in 2020 were $118 billion; overall demand for international airline services was down 66 percent in 2020 compared to 2019; and at the height of the downturn, nearly half of planes were parked due to a lack of demand. [40]

According to IMF reports [7] released in June, the economy is likely to resume its pace of growth from 2021 onwards. (See Fig. 1.1.)

Europe and the Middle East were the two most impacted regions with similar declines of 5% compared to the projected baseline.

After being hit first, Asia-Pacific embarked on recovery earlier and faster than other regions—mostly driven by China’s sizable domestic market— and closed the year 2020 with a decline of 61.3% compared to the projected baseline (59.8% decline compared to 2019 level). Asia-Pacific, however, recorded the highest traffic loss of all regions with a loss of 2.15 billion passengers in 2020 compared to the projected baseline.

Latin America-Caribbean was the least impacted of all regions posting a decline of 61.1% compared to the projected baseline (-59.8% compared to 2019 level).

Following the “Great Lockdown” of April 2020, international passenger traffic was virtually non-existent in the second half of 2020. International passenger volume ended the year below 1 billion passengers, a decrease of more than 75% compared to 2019 volume.

Latest World Economic Outlook Growth Projections

(real GDP, annual percent change)	2019	PROJECTIONS 2020	PROJECTIONS 2021
World Output	**2.9**	**-4.9**	**5.4**
Advanced Economies	**1.7**	**-8.0**	**4.8**
United States	2.3	-8.0	4.5
Euro Area	1.3	-10.2	6.0
Germany	0.6	-7.8	5.4
France	1.5	-12.5	7.3
Italy	0.3	-12.8	6.3
Spain	2.0	-12.8	6.3
Japan	0.7	-5.8	2.4
United Kingdom	1.4	-10.2	6.3
Canada	1.7	-8.4	4.9
Other Advanced Economies	1.7	-4.8	4.2
Emerging Markets and Developing Economies	**3.7**	**-3.0**	**5.9**
Emerging and Developing Asia	5.5	-0.8	7.4
China	6.1	1.0	8.2
India	4.2	-4.5	6.0
ASEAN-5	4.9	-2.0	6.2
Emerging and Developing Europe	2.1	-5.8	4.3
Russia	1.3	-6.6	4.1
Latin America and the Caribbean	0.1	-9.4	3.7
Brazil	1.1	-9.1	3.6
Mexico	-0.3	-10.5	3.3
Middle East and Central Asia	1.0	-4.7	3.3
Saudi Arabia	0.3	-6.8	3.1
Sub-Saharan Africa	3.1	-3.2	3.4
Nigeria	2.2	-5.4	2.6
South Africa	0.2	-8.0	3.5
Low-Income Developing Countries	5.2	-1.0	5.2

Source: IMF, *World Economic Outlook Update*, June 2020

Note: For India, data and forecasts are presented on a fiscal year basis, with FY2020/2021 starting in April 2020. India's growth is -4.9 percent in 2020 based on the calendar year.

INTERNATIONAL MONETARY FUND IMF.org

Fig. 1.1 Latest world economic outlook growth projections (GDP)

As shown in the graph above, an average positive fluctuation in real GDP of 5.4 percentage points is projected this year.

As a result, in the medium term, the commercial aviation growth estimates shown below will become applicable. (See Fig. 1.2.)

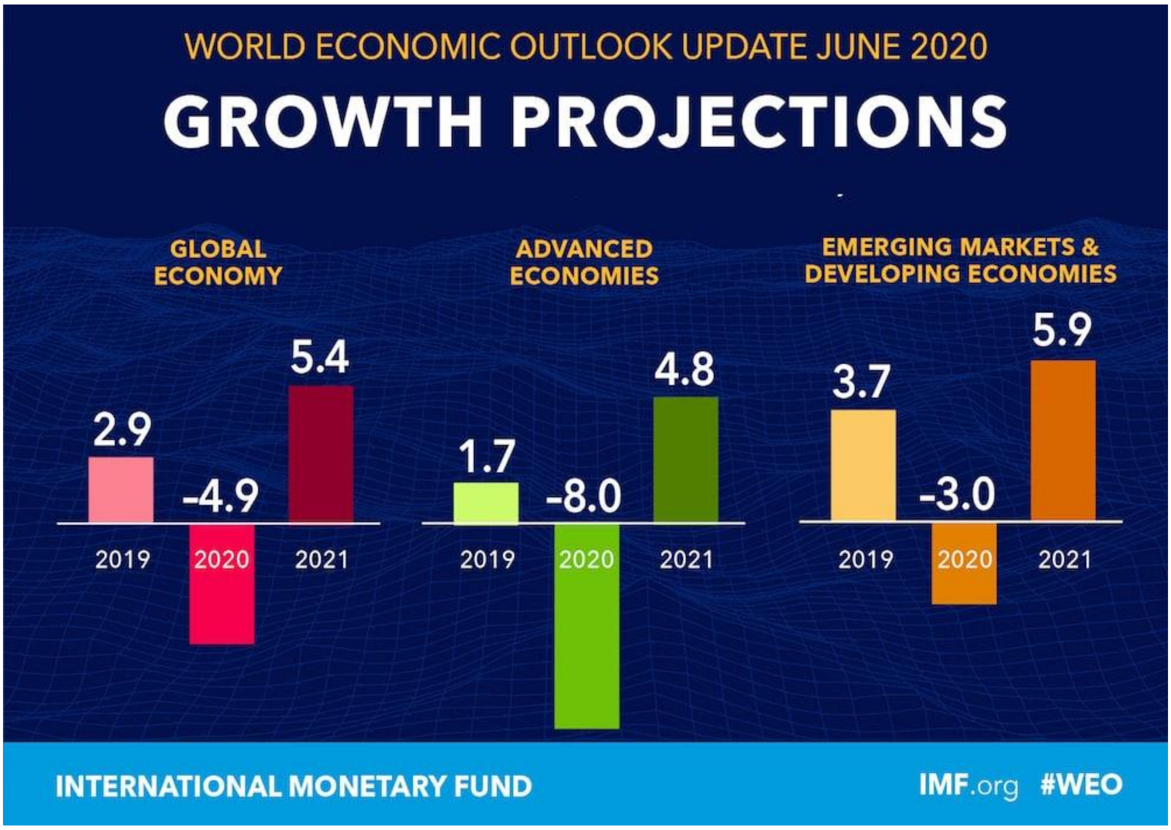

Fig. 1.2 World Economic outlook update June 2020

Despite the fact that commercial aviation has historically been defined by cyclical booms and busts, it is undeniable that we are dealing with one of the most concentrated businesses today.

With three major mergers in the last five years, commercial aviation has seen unprecedented consolidation. In addition, 2019 marked the global airline industry's eleventh consecutive year of profitability. This aim represents a new high in the industry.

Commercial aviation is predicted to become a capital-intensive business in the future, providing significant economic returns and long-term profitability.

Due to the fact that commercial aviation is a worldwide business with ongoing strong growth, some markets are growing at a faster rate than others.

As a result, we will assess the estimates for the future of commercial aviation at a worldwide level, segmenting the main regions and breaking down particular data for each area, based on the annual reports of Boeing and Airbus issued in 2020.

But first, let's look at the various factors that have contributed to the increase in commercial flights and, as a result, the exponential rise of commercial aviation.

The most important reason for the commercial aviation revolution can be found on the Asian continent. While commercial aviation has been steadily improving in the United States and Europe for years, it has seen a significant increase in Asia during the last decade. The expansion of Asian and international commercial aviation has been aided by the economic awakening of previously underdeveloped countries.

Similarly, the increase of the middle class in Asia has coincided with the expansion of the aviation sector's economic boom. As a result, in addition to increased spending power, persons from the largely middle class have seen a major rejuvenation. By 2030, the Asia-Pacific region is predicted to contain two-thirds of the world's middle class.

The need for aviation employees to meet the global expansion of commercial aviation is impending, as we have seen in recent years.

Furthermore, as air travel has become the most efficient mode of passenger and cargo transportation, the numbers are steadily increasing.

According to Airbus' GMF 2019 study (Global Market Forecast), demand for commercial aviation specialists, split by region, will reach the following levels over the next two decades. (Fig. 1.3)

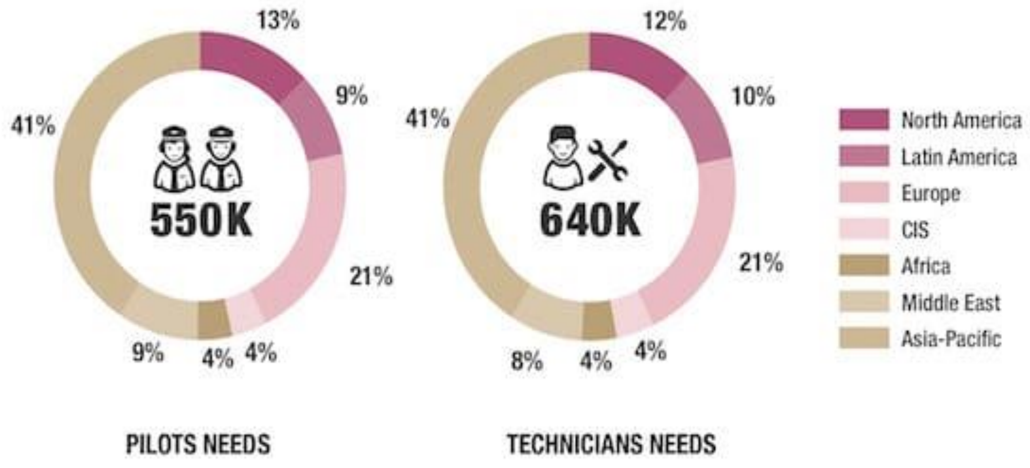

Fig. 1.3 The demand for commercial aviation professionals

The demand was also quantified in the Airbus GMF 2019 study (Global Market Forecast). The need for commercial aviation professionals in North America will exceed 72,000 pilots and 77,000 technicians during the next two decades. 48,000 pilots and 64,000 technicians will be on display throughout Latin America. 50,000 pilots and 52,000 technicians will be on display in the Middle East; 21,000 pilots and 25,000 technicians in Africa; 22,000 pilots and 27,000 technicians in the CIS; 223,000 pilots and 260,000 technicians in Asia-Pacific; 114,000 pilots and 135,000 technicians in Europe. There will be a total of 550,000 pilots and 640,00 technicians required.

The number of passengers in commercial aircraft has doubled in the last 15 years. In 2018, 4.3 billion individuals traveled on one of the 1,300 airlines that are currently in operation. In addition, almost 24,000 commercial aircraft went to the skies around the world in a single year, completing over 38 million trips.

Tourism accounts for 10% of worldwide GDP, according to the UNWTO [8] and with 57 percent of cross-border tourists flying, it is one of the world's key sources of revenue today.

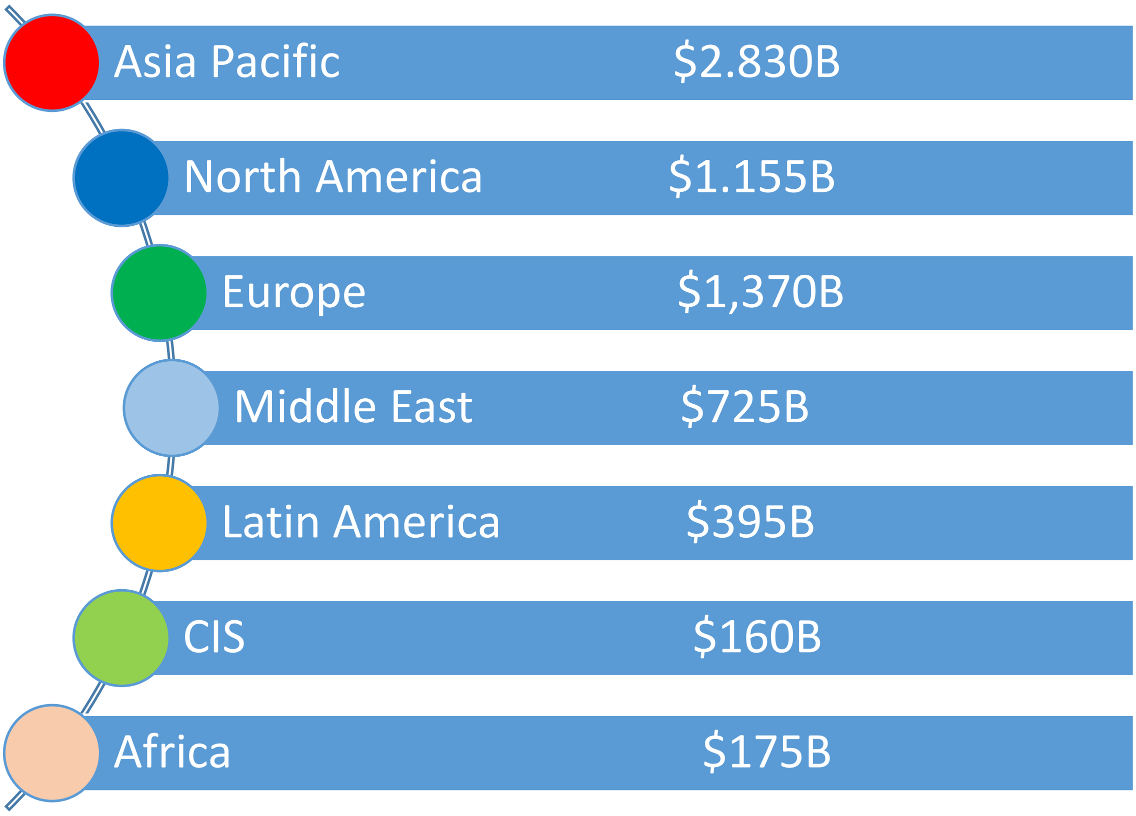

Fig. 1.4 Market Values by region forecasting of growing till 2038 [9]

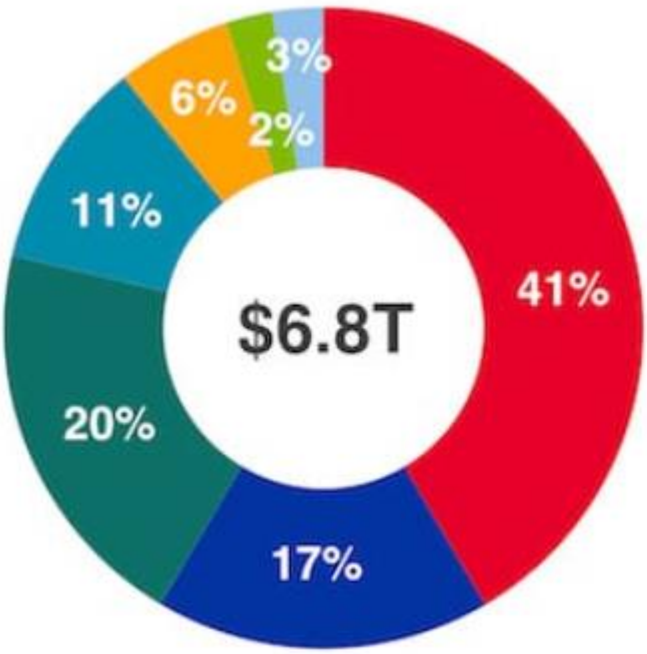

Fig. 1.5 Market Values by region (total) [9]

I would like to compare the same figures based on 2017 year.

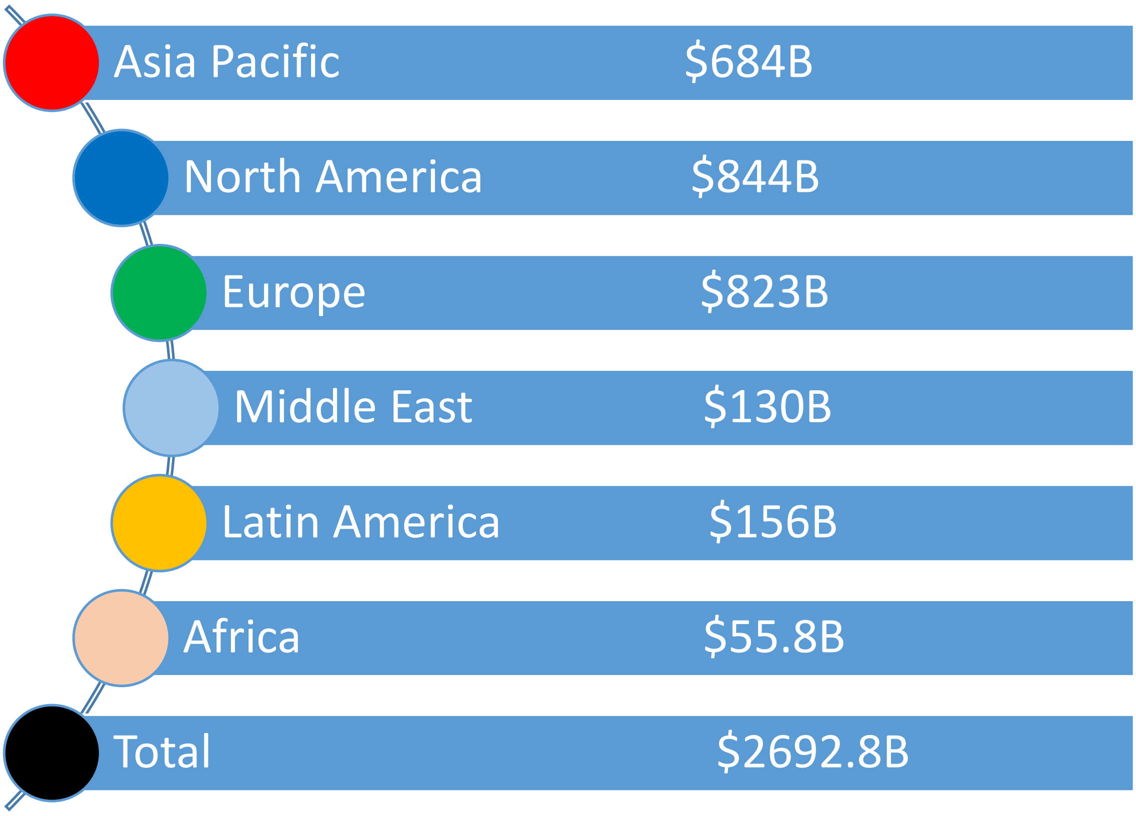

Fig. 1.6 Market Values by region 2017 [10]

The aviation market is continuing to increase, as seen in Figures 1.4, 1.5, and 1.6. In 2038, the entire market value will rise to $6.8 billion, up from $2.7 billion in 2017. Asia Pacific will be the most influential market. This region has the potential to increase the stats by more than fourfold. In the long run, the Asia-Pacific area is likely to experience tremendous expansion in aviation. This region will account for more than half of all additional passengers predicted globally over the next 20 years. Given that aviation is a driver of economic expansion, this is great news for Africa. To fully reap the benefits of this aviation expansion, however, massive investment in infrastructure and technology, as well as the implementation of wise laws by state governments, will be required. The most stunning result, however, will be the Middle East market, which will boost market values by 5.5 times.

New routes, the trend is toward sustainability, with many new short-haul commercial aviation routes being opened on internal Chinese routes and connecting routes between Europe and Africa.

Airbus anticipates global average annual growth of 4.3 percent over the next 20 years, with growth being strongest in the early years and weakest in the latter. The Asia-Pacific and the Middle East will have the greatest impact on this pace.

Another apparent consequence of commercial aviation's inevitable rise is the predicted increase in the number of aircraft in operation over the next two decades.

If there were over 21,000 Airbus commercial aircraft in operation and 34811 total commercial aircraft in operation at the start of 2019, By 2038, this number is predicted to double, to over 45,000 Airbus planes and 43110 Boeing planes. [9] According to Airbus, over 38,000 new planes will be delivered over the next 20 years, some of which will replace older jets and help to modernize the global fleet.

1.2 Aircraft Fleet Trends

The aircraft fleet used spans from small single-engine planes operated by general aviation pilots to huge wide-body planes used for long-distance domestic and international commercial travel. Wide-body aircraft have ample space for two passenger aisles with seven to 10 seats each across the plane. National and international trends are influencing how airlines, businesses, and private pilots buy and use planes. I'd like to share some information about aircraft fleet trends.

Every year, the FAA assesses how the economy affects aviation by anticipating changes in the aircraft fleet, which includes everything from huge commercial jets to single-seat general aviation planes and drones. The 20-year estimates also consider the number of hours pilots fly, the number of passengers who fly commercially, and the need for cargo flights. The results are reported in the FAA Aerospace Forecasts once a year.

The total active general aviation fleet was in decline between 2008 and 2013.[12]. Beginning in 2014, deliveries of general aviation aircraft fleet began to gradually increase. In 2017, the FAA forecasts stated the active general aviation fleet would increase by an average annual rate of 0.1 percent over the 21-year forecast period. There are three categories of aircraft included in the general aviation fleet: piston powered aircraft, turbine powered aircraft, and light sport aircraft. Piston aircraft have piston powered engines connected to propellers on aircraft which allow the aircraft to move through the air and on the ground. Piston-powered planes operate at a lower altitude than turbine-powered planes. A piston-powered aircraft may carry one to six passengers and travels over short distances (300–400 miles).

General aviation pilots and aircraft owners most commonly employ piston-powered airplanes. The sharpest drop in sales for this type of aircraft occurred during the 2008 recession, and the market has yet to rebound to the levels seen in the early 2000s. The fall in the piston fleet is expected due to a decrease in the number of leisure pilots, rising aircraft ownership costs, and an aging aircraft fleet that is outpacing new aircraft production. Despite lower sales, the overall number of piston-engine airplanes constructed climbed by 3.8 percent between 2016 and 2017. [12] Cirrus (located in Minnesota), Textron Aviation (Cessna Aircraft), TECNAM Aircraft, Diamond Aircraft, and Piper Aircraft, Inc. were the top five piston-engine manufacturers in 2017.

Turbine-powered aircraft, including helicopters, are predicted to grow at a 1.9 percent annual rate, with the turbojet fleet growing at a 2.3 percent annual rate. According to the 2017 Year End Report from the General Aviation Manufacturers Association (GAMA), new business jet shipments grew 1.3 percent over the previous year. [13] Charter firms are commonly used in corporate air travel. Part 135, a set of federal flight laws that apply to charter businesses, governs their operations. Companies have chosen to hire charter companies to help with their transportation needs rather than owning their own aircraft, or they have entered the market of using general aviation aircraft, and the number of Part 135 hours flown has steadily increased – approximately 16 percent from 2006 to 2015 as they chose to hire charter companies to help with their transportation needs instead of owning their own aircraft. This leads to the rise in business jet shipments.

The light sport aircraft category was established in 2005. Flying this sort of plane is less expensive, and pilots aren't required to pass an FAA medical check. A driver's license can be used as proof of medical competency by the pilot. This type of aircraft is expected to grow at a rate of 4.1 percent per year on average. Between 2015 and 2037, the light sport fleet will nearly double in size. According to GAMA, there were around 170 light aircraft in the country when the light sport category was introduced. However, when light sport aircraft were required to register in 2007, the number of aircraft climbed dramatically to 6,066. GAMA does not anticipate the average annual growth rate of light sport aircraft, however there were 6,942 aircraft documented in 2016. [12]

As demand for commercial passenger travel and air cargo is expected to rise, the commercial fleet is expected to grow at an average annual pace of 0.8 percent each year. [12] Older, less fuel-efficient planes are likely to be phased out of the fleet and replaced with more fuel-efficient planes. As the narrow body (single aisle) and wide body (double aisle) jet fleets grow, the mainline carrier fleet (airline firms that provide service with aircraft containing 90 or more passenger seats) is likely to rise. Wide-body aircraft are predicted to see significant fleet increase of 67 percent. [12] The need for new aircraft is fueled by network expansion, which necessitates the use of narrow-body aircraft such as the Boeing 737 or Airbus 321. Carriers are looking for aircraft that are more fuel efficient, which leads to rising aircraft demand. [14]

Short- to medium-range aircraft, such as the Embraer E-170 or Bombardier CRJ200, are commonly used by regional airlines. Flights on regional airlines function as feeder routes for mainline carriers. Lower operating expenses than their wide-body equivalents commonly flown by major airlines are due to fewer flight crew requirements and increased fuel efficiency. This allows regional and commuter airlines to connect to big national hubs while serving smaller, low-traffic airports. Regional carriers' aircraft fleets are likely to shrink as less fuel-efficient 50-seat jets are replaced by larger 70-90-seat jets. The shift to larger jets with more seats may enhance airline profitability, but it also put more pressure on smaller communities to fill those planes.

Boeing Company and Airbus SE control the majority of the worldwide commercial aircraft market. United Carriers Holdings Inc., one of the world's largest airlines, placed a large order with Airbus SE in December 2019. United Airlines has ordered the first A321neo long-range airplanes from Airbus. The agreement is estimated to be worth more than $7 billion.

1.3 Covid-19 Effect on aviation market and fleet trends

After five years of profitability and development, the aviation sector is now approaching a decade of uncertainty and, for the first two to three years at least, significant financial constraints. According to the International Air Transport Association, the sector lost over $115 billion in 2020 as COVID-19 expanded over the world, and dozens of airlines filed into bankruptcy or ceased operations. It's unlikely that 2021 will be substantially different. Except in China, where domestic travel had returned to pre-pandemic levels by November 2020, global airlines will continue to waste millions of dollars every day for the rest of the year, if not all of it. This year, tens of billions of dollars in losses are projected, though the industry will be affected less than half as hard as it was in the first year of COVID-19.

This indicates that cash preservation will continue to be a primary goal for airlines, which is bad news for aircraft manufacturers and MRO service providers. COVID-related constraints on airline cash flow and lower demand for air travel in 2020 prompted global carriers to store tens of thousands of planes, retire twice as many as usual, convert others to carry cargo, and cancel or postpone some new jet deliveries.

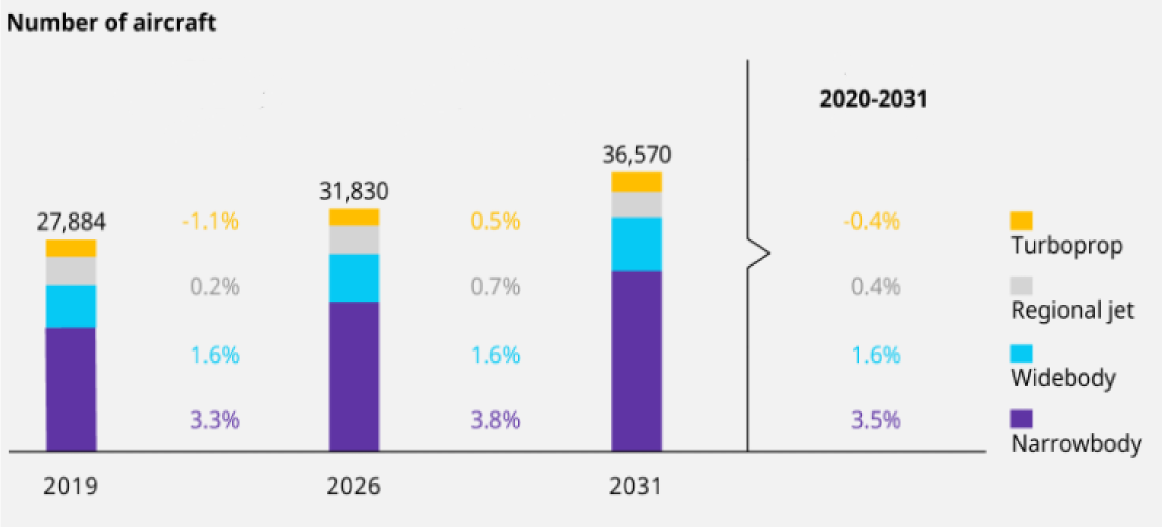

Fig. 1.7 Global fleet forecast by aircraft class, 2020-2031 [15]

The worldwide fleet had just about 13,000 airplanes in service at its nadir, less than half the amount operating before the pandemic was declared in January 2020. The 2021 fleet now numbers more than 23,700 planes. We estimate that the fleet will number more than 36,500 by 2031. However, it is still a far way from pre-COVID forecasts, which projected the global fleet at 28,800 in 2021 and more than 39,000 in 2030. Please see Fig. 1.7 for more information.

After the fleet eventually recovers to its pre-COVID January 2020 level in the second half of 2022, the 10-year forecast period begins slowly, with growth gaining up momentum in the second half of 2022. Nonetheless, by the end of the decade, none of the three categories — airlines, aerospace, and MRO — are likely to catch up to pre-COVID estimates.

Given the inventory backlog of new planes that have been built but not delivered or sold, more aircraft will be delivered to airlines in the coming years than aerospace manufacturers will construct. In typical years, production and deliveries are closely linked, but this year's discrepancy reflects competing pressures on airframe makers to balance the realities of lower market demand with the demands of key suppliers to maintain adequate output.

Other aerospace revenue streams could be in peril as well. Because of increasing competition from a boom in availability of used components and green-time engines extracted from retired aircraft, early plane retirement may limit aerospace sales of new parts. Working through the overabundance of utilized usable material could take up to three years.

A smaller fleet translates to less work for MRO businesses. Demand for 2020 and 2021 is estimated to be 33%, or $60 billion, lower than pre-COVID predictions. MRO demand is predicted to decline by $95 billion throughout the predicted period. [15]

Due to the lower projections for MRO, the sector is expected to increase at a three percent compound annual rate between 2019 and 2031. For private equity investors, the mix of near-term lower demand and long-term growth prospects has produced an appealing climate, and interest in MRO is high.

Narrowbody aircraft are likewise becoming more popular. For years, the narrowbody's proportion of the total fleet has risen as the class's improved range and appealing seat mile efficiency have made it the preferred aircraft of low-cost carriers. As more airlines adjust their fleets to the demand reality of COVID-19, this tendency is projected to continue.

While narrowbody production expectations for 2021 are 40% lower than in 2018, we expect the aircraft class to rebound to within 10% of our initial pre-COVID expectations in the forecast period's final years. One bright point has been A321LR sales, which have remained high despite the pandemic. The aircraft has the range to serve routes that were formerly served by Boeing 757s or widebody aircraft, as well as giving carriers more scheduling freedom.

The Federal Aviation Administration and the European Union Aviation Safety Agency have both decided to recertify the Boeing 737 MAX for commercial service, which will boost narrowbody deliveries in 2021. Since the recertification, more than 20 737s have returned to carrier fleets, but there are still 400 to 450 MAX aircraft in Boeing's inventory that have yet to be delivered or sold. In addition, the nearly 400 737s that airlines have had in storage since the plane's grounding in March 2019 will be added to the fleet of narrowbodies.

Widebody aircraft production, on the other hand, has suffered a major drop as a result of COVID-19's influence on long-haul travel demand. Unless long-haul routes recover faster than predicted, we can expect widebody output to fall by as much as 40% below pre-COVID levels over the predicted period.

International travel, which accounts for the majority of long-haul travel, virtually disappeared in the early days of COVID-19 and continues to be severely impacted, which has ramifications for widebodies. Over the last year, countries throughout the world have tightened cross-border travel regulations in an attempt to keep the epidemic at bay or at least limit it. Border closures and abrupt quarantine restrictions of 14 days have discouraged cross-border travel, with people fearing being stuck or unable to return home. The drop in business travel, which is the most profitable sector for airlines, has contributed to the drop in international long-haul travel. This is particularly true on long-haul flights, where CEOs frequently choose premium seating.

Videoconferencing and teleconferencing have become popular alternatives for corporations looking to save travel costs, especially for intracompany travels. COVID-19 has also prompted numerous business conferences and trade exhibits to go virtual or to be canceled altogether, removing yet another rationale for executive travel. While much of this travel will resume as more people receive COVID-19 vaccinations, it is unlikely to entirely recover in the near future.

Meanwhile, several of the latest models in the regional jet class are experiencing multiyear delays due to development issues and stipulations in US pilot contracts that limit their deployment. Since that many regional jets will exceed typical retirement age or cumulative utilization levels over the projected period, we can expect many of them to fly above historical limits to meet demand for smaller commercial aircraft.

It's no undisputable fact that COVID-19 has presented modern commercial aviation with a long list of issues. It will most certainly take many years for the fleet to adapt to the new realities, and even then, the industry will not reclaim all of the ground lost due to the epidemic in the following ten years. Please see Fig. 1.8 for more information.

Region	Africa	Middle East	Asia Pacific	China	India	Latin America	North America	Eastern Europe	Western Europe	World
2021 Fleet										
Narrowbody	380	425	1,816	2,999	524	785	3,742	874	2,654	14,199
Widebody	149	579	1,051	459	43	139	1,085	152	789	4,446
Regional jet	143	48	203	134	2	181	1,654	243	330	2,938
Turboprop	258	25	591	0	81	203	514	102	358	2,132
TOTAL	**930**	**1,077**	**3,661**	**3,592**	**650**	**1,308**	**6,995**	**1,371**	**4,131**	**23,715**

Fig. 1.8 Overview of worldwide fleet 2021 [10]

We can refresh our memory and go up to see the total worldwide fleet by Covid-19. There were around 34811 commercial aircrafts. In one and half year the fleet was decrease for a 32%. It is the effect of Covid-19.

The $26 billion in airline profits in 2019 will be forgotten for a long time. According to IATA, global losses are likely to top $115 billion in 2020. Concerns about travel and restrictions enacted by various governments to contain COVID-19 have destroyed air travel demand, particularly in the international market. Since April, international revenue passenger kilometers have fallen by at least 85% year over year in every month. Please see Fig. 1.9 for more information. Global airline industry financial performance, 2012-2021F

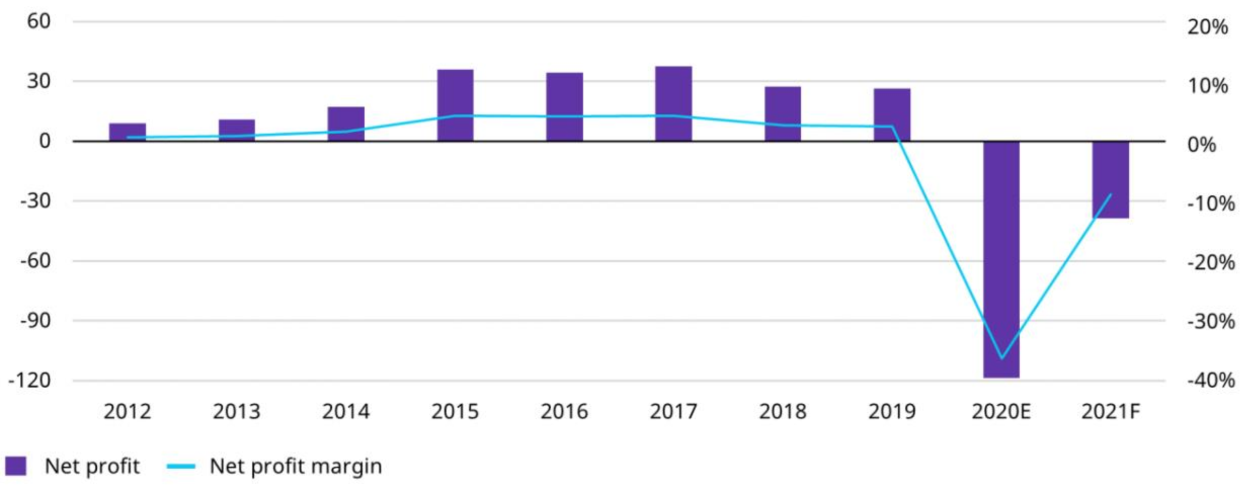

Fig. 1.9 Global airline industry financial performance, 2012-2021F US$ in billions [10]

Note: The net profit totals have been rounded to the nearest whole number; E stands for estimate, F for forecast Source: IATA.

Governments around the world have donated more than $170 billion in relief funds and other financial support for airlines to help limit losses and stabilize the business. With global demand hovering at half of what it was in 2019, more assistance is still required.

IATA has defined a number of ways that governments can help stimulate demand in the short term, including temporary suspension of government charges, taxes, and fees for both carriers and passengers; subsidies for domestic routes, especially to rural areas, as demand recovers; advance ticket purchases by governments or public vouchers that can be used for future trips; and pausing government charges, taxes, and fees for both carriers and passengers.

As worldwide demand fell in March, airlines cut capacity by canceling flights, temporarily parking some planes, and retiring others permanently. Despite this, passenger load factors, which indicate the percentage of available seats that are sold, declined 17 percentage points, as revenue passenger kilometers decreased 66% and available seat kilometers plummeted 58%. Due to a combination of lower demand and precautionary steps by airlines, such as the blocking of middle seats to promote social distancing, planes frequently flew less than half full on certain routes. Please take a look at the Fig. 1.10 passenger traffic 2017-2021F and Fig. 1.11 cargo traffic 2017-2021F.

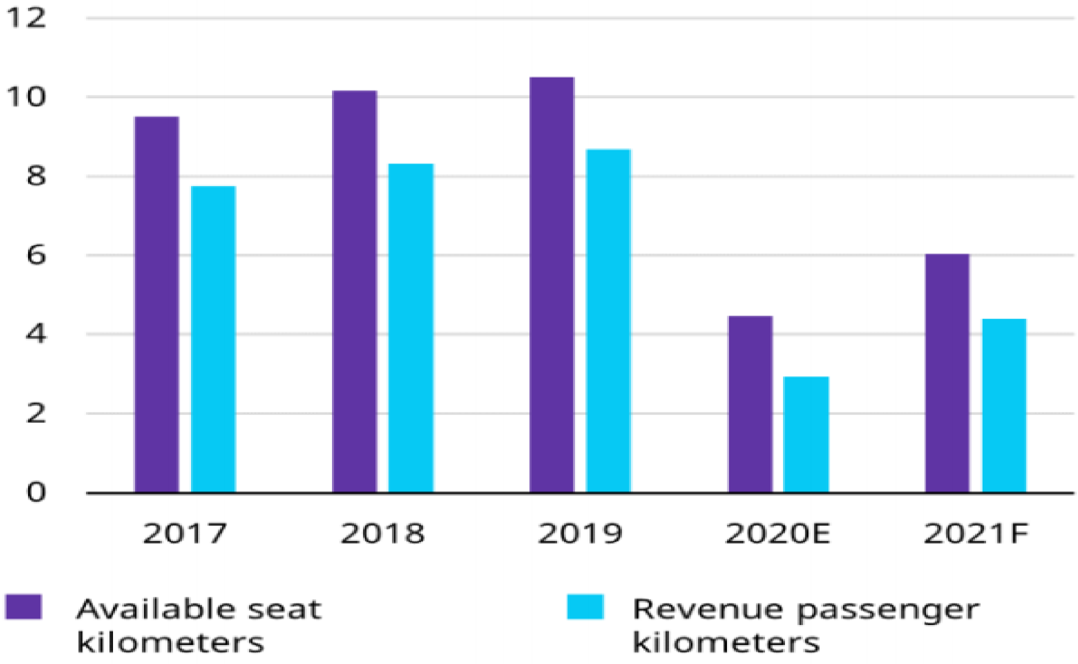

Fig. 1.10 Passenger traffic 2017-2021F

Note: E stands for estimate, F for forecast; Source: IATA [10]

Tonne kilometers in millions

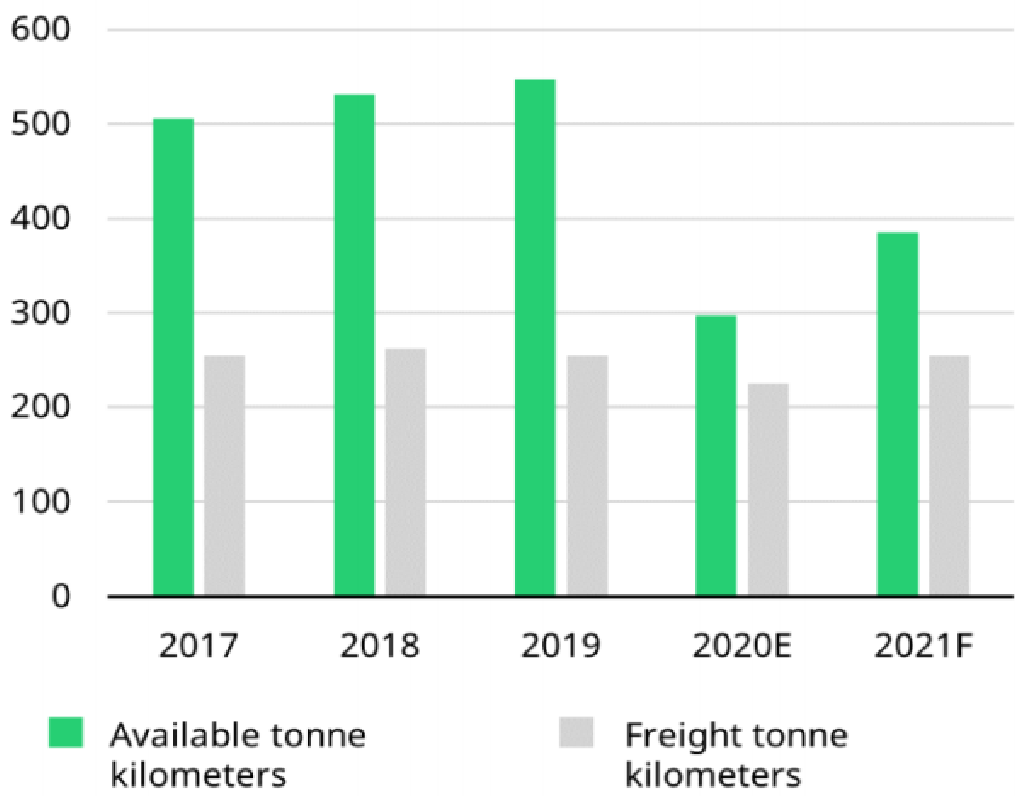

Fig. 1.11 Cargo traffic 2017-2021F

Note: tonne is the equivalent of a metric ton. : E stands for estimate, F for forecast; Source: IATA [10]

From a cargo perspective, demand as measured by cargo tonne kilometers declined 11 percent, while capacity as measured by available tonne kilometers fell 24 percent. The drastic reduction in passenger travel in 2020, specifically involving widebodies on long-haul routes that usually offer belly-cargo space, seriously cut into available cargo capacity. [15]

Passenger and cargo demand have historically risen in tandem with economic growth. However, in 2019, this pattern was broken as FTKs fell but passenger travel increased. This was due in part to rising trade tensions, particularly between the United States and China.

The drop is partly a result of an increase in e-commerce deliveries and a decrease in traditional cargo. E-commerce deliveries are naturally lighter and less dense, but their volume necessitates much more space. Even as the sector saw a decline in FTKs, this evolving cargo profile, together with other variables, contributed fuel a 5% increase in the global cargo fleet in 2019. Consider the following scenario in the United States: Both UPS and FedEx observed sustained growth in their fleets and surges in their cargo volumes in 2020, a year when passenger airlines were decreasing capacity wherever feasible. Because to COVID-19, the need to maintain social distance and stay at home, and changes in consumer behavior, e-commerce growth is projected to continue this year and next.

With an operating fleet of just fewer than 24,000 aircraft, 2021 is predicted to be the recovery year for possibly the most difficult financial and operational chapter in aviation history. That's the same as the fleet size at the start of 2015, and it's more than 15% lower than the pre-COVID figure on January 1, 2020.

More than 4,000 planes, with a disproportionately large number of widebodies, are in storage awaiting recall or early retirement. While most narrowbodies, regional jets, and turboprops in storage are scheduled to return to service by the middle of 2022, much of the widebody fleet will never leave storage.

As domestic and leisure travel slowly recovered over the summer, airlines began to return aircraft to service at a quicker rate than traffic. COVID-19 recurrence at the end of the summer, however, slowed the recovery. As the winter months neared, it became evident that the crisis was intensifying and that it would persist until at least the end of 2020, if not longer. As a result, the industry slowed the rate at which planes were returned to service.

2020 has been the most difficult year for aerospace manufacturers and suppliers, with production down 55% from 2019 and deliveries at a standstill for several months. After two catastrophic crashes in March of that year, the Boeing 737 MAX was abruptly grounded.

In absolute terms, the global commercial fleet now has twice as many airplanes over the age of 25 as it did in 2010. Even in the wake of a large number of retirements in 2020, when the average retirement age was 21.3, this is true. Even in a post-COVID scenario, many of the surviving aircraft over 25 years old have a strong revenue case, which is why they will not be phased out until direct replacements are available later in the projected period. Those older planes account for more than 9% of the current fleet, compared to only 5% in 2010. Almost half of these older aircraft are operated by airlines. As they are phased out of the fleet, retirements, starting in 2023, will increase six percent annually, averaging 300 per year through the end of the decade.[15]

1.4 Analysis of UIA's activities

Ukraine International was created in 1992 by the Ukrainian State Association of Civil Aviation and GPA (later AerCap B.V.), the world's largest aircraft lessor, as an international carrier of independent Ukraine.

The airline has attracted top-tier strategic and financial investors during the last 15 years. The Ukrainian government's stake in the company was transferred to the State Property Fund in 1995. Austrian Airlines and Swissair joined the European Bank for Reconstruction and Development (EBRD) as shareholders in 1996 and 2000, respectively.

The organizational format of a public-private partnership enabled UIA to leverage the strengths of all owners, seize a wide range of business opportunities, and incorporate best maintenance, operation, service, and management practices from its worldwide partners.

UIA was founded with the goal of establishing nonstop flights between Ukraine and Western Europe and effectively implementing a point-to-point carrier strategy.

By its 18th anniversary in 2009, UIA has established itself as one of Ukraine's major aviation industry participants, accounting for 20% of the market. However, additional development necessitated a change of the UIA business plan. The latter was precipitated by international investors' exit from the stock, which was spurred by a shift in their market strategy in Ukraine and the expiration of the EBRD investment conventional participation period, which occurred in 2010.

UIA's commercial flexibility was secured by privatization, which allowed the company to begin its transformation from a point-to-point to a network carrier in the face of a difficult operating environment and fierce price-based competition.

Following the business failure of its primary competitor in 2013, UIA proved to be the only carrier capable of preventing the market infrastructure from collapsing. The transfer process turned out to be a lot more dynamic than we had anticipated. Over the course of a year, UIA had to double its fleet and strengthen its personnel. The latter allowed the airline to resume service to most of the routes it had "acquired" from the competitor.

The UIA's operations were boosted by involuntary expansion, which prioritized the development of Ukraine's transportation potential. Through its hub, Kyiv Boryspil International Airport, UIA grew its operations to generate and direct transit passenger traffic from the north to the south and from the west to the east.

Aboard December 9, 2013, UIA flew its maiden long-haul trip on a Boeing 767-300ER between Kiev and Bangkok. On April 25, 2014, the second Kyiv-New York route was established. As a result, direct air traffic between Ukraine and the United States has been restored.

In 2014, UIA had to deal with a severe political and economic crisis, a depreciation of the national currency, and a sharp drop in effective demand. UIA had to take significant contingency measures to optimize its workforce, fleet, and route network for the first time ever.

UIA maintained and developed a route network to provide a hub model from 2014 to 2017, despite the fact that it was uncompetitive due to overflight of Russian Federation territory. A presidential decree approved the hub development model, which was designed in collaboration with Boryspil Airport. [16]

From its base at Boryspil Airport, UIA connects Ukraine to over 80 locations in Europe, Asia, and the Middle East, as well as New York City and Toronto, and also runs internal flights. Ukraine International Airlines (UIA) had to make certain unavoidable alterations to its summer 2019 flight schedules, including fewer frequency and capacity on several routes. Although UIA is not a cheap airline, many of its international flights are popular with travelers due to their low costs, and they use Boryspil International Airport as a transportation hub.

Ukraine International Airlines has codeshare agreements with the following airlines;

- Air Astana
- Air France
- airBaltic
- EgyptAir
- KLM

Due to ongoing losses, the airline suspended flights to Amman, Riga, Beijing and Minsk in November 2019. From 2020, flights to Bangkok and Krakow were also suspended

Ukraine International Airlines' fleet consists of 21 aircraft in service and 6 are parked. In total UIA has 27 aircrafts. It consist of: 1 wide-body long-haul Boeing 777-200ER aircraft, 2 long-haul Boeing 767-300ER one of them is parked, 17 medium-haul New Generation Boeing 737 and 2 of them are parked for today, 7 medium-haul Embraer-190 and 2 of them are parked. Fig. 1.12 The fleet of UIA [17]

Aircraft Type	Current			Future [2]	Historic	Avg. Age
	In Service	Parked	Total			
+ Antonov An-148/An-158					3	
+ Boeing 737	15	2	17		45	13.1 Years
+ Boeing 767	1	1	2		2	28.8 Years
+ Boeing 777		1	1		2	16.1 Years
+ Embraer ERJ-190	5	2	7			10.3 Years
Total	21	6	27	0	52	13.6 Years

Fig. 1.12 The fleet of UIA [17]

UIA's top management began optimizing the airline's route network towards the end of 2019 in order to cut excess costs and bring the firm to break-even in 2020 with continued stable growth. Unprofitable flights to Almaty, Beijing, and Bangkok, in particular, were discontinued due to unjustifiable travel costs resulting from the requirement to fly over Russian Federation territory. Between 2014 and 2019, the airline lost roughly $ 216 million due to unequal business conditions (overflight over Russian Federation territory on the eastern shoulder of the network, which was carried out only by UIA among the rivals on the route). UIA received an unscheduled revenue of $ 11 million in early 2020 as a result of actions to alter the flying program.

The largest aviation disaster involving Ukrainian aircraft in decades occurred on January 8, 2020. A military missile shot down a UIA jet with the registration number UR-PSR, which was departing from Khomeini Airport on flight PS752 from Tehran to Kyiv. 176 individuals were on board, including 167 passengers and 9 staff members, all of whom died.

To combat the coronavirus infection COVID-19, a complete lockdown was implemented in the spring of 2020. Regular flights in Ukraine and overseas were halted during this time, thus UIA management devised an anti-crisis program to reorganize costs, optimize personnel, and reduce airline costs. This has resulted in an almost threefold reduction in UIA's mandatory monthly running expenditures, as well as the release of around 1,000 personnel.

Since the partial return of scheduled flights in June 2020, the airline's focus will be on flexible and short-term flight network planning, taking into account frequent situational changes in foreign country entry laws throughout 2020.

Statistics UIA from 2016 till 2019 was showing the stable growth trend. We can see passengers, (million passengers) for 2016 (6), for 2017(6,984), for 2018 (8,075) for 2019 (7,963) and for 2020(1,787). Regarding amount of flights,(thousand units) for 2016(48,6), for 2017(56,4) , for 2018 (61,5), 2019(58,6), and 2020(17). The last figures are showing the amount of mail and cargo transferred (thousand tons) by UIA from 2016-2020. It is showing next figures for 2016(15,34), for 2017(20,28), for 2018(21,348), for 2019(19,477) and for 2020 we can see (6,17). [16]

We can make a conclusion that the way of development which was taken by UIA was showing the positive indicators until the Covid-19. The number of transported passengers in 2016 was more than 6 million passengers (with a transit rate of more than 52%). In 2018, UIA carried more than 8 million passengers, which is 15% more than in 2017. The share of transfer passengers on UIA scheduled flights was 53% [16].

During the corona crisis of 2020, UIA managed to withstand the lack of any support from the state solely through management decisions: redistribution of financial pressure on expenditures, staff reductions, transfer of a significant part of the team to remote work, etc. These are the strategic steps provided UIA with the opportunity to compete in the aviation market despite losses of about $ 60 million caused by the 2020 pandemic crisis.[16]

UIA had the following indicators during the Corona year (2020). UAI performed about 17,000 flights, which is 72% less than in 2019. Was carried during this period 1 million 787 thousand passengers in four times less than in 2019 (about 8 million passengers). Regarding the percentage of transit passengers amounted 43% of total traffic (486 thousand passengers), which is 86% less than last year.[16]

UIA actively transported humanitarian, medical and special cargo during the Covid-19 period. This has given the airline invaluable experience in the organization of anti-crisis cargo, which has the potential to be realized during the transportation of vaccines from Covid-19. Cargo traffic during the spring lockdown 2020 was a priority for UIA.

UIA transported 4 million 824 thousand kilograms of cargo (15 million 073 thousand in 2019) and 1 million 350 thousand kilograms of mail (4 million 404 thousand in 2019).

UIA is the only one airline in the Ukrainian market that primarily develops regular passenger air transportation, thus being part of Ukraine's transport infrastructure.

1.5 Analysis of Virgin Atlantic activities

Virgin Atlantic is a British airline based in the English town of Crawley. The airline was founded in 1984 as British Atlantic Airways, with co-founders Randolph Fields and Alan Hellary originally planning to fly between London and the Falkland Islands. After differences with Sir Richard Branson over the firm's administration, Fields sold his shares in the company shortly after it changed its name to Virgin Atlantic Airways. On June 22, 1984, the first flight from Gatwick Airport to Newark Liberty International Airport took place. Virgin Atlantic Limited, a holding company owned 51 percent by the Virgin Group and 49 percent by Delta Air Lines, is in charge of the airline. Administratively, it is distinct from the other Virgin-branded airlines. Both Virgin Atlantic Airways Limited and Virgin Atlantic International Limited hold Civil Aviation Authority (CAA) Type A Operating Licences (AOC numbers 534 and 2435, respectively), allowing them to carry passengers, cargo, and mail on aircraft with 20 or more seats while operating as Virgin Atlantic Airways.

Virgin Atlantic operates to destinations in North America, the Caribbean, Africa, the Middle East, and Asia from its main base at Heathrow and its subsidiary base in Manchester, using a mixed fleet of Airbus and Boeing wide-body aircraft. Seasonal flights are also available from Glasgow and Belfast. There are three cabins on Virgin Atlantic planes: economy, premium (previously premium economy), and upper class (business).

Randolph Fields, an American-born lawyer, and Alan Hellary, a former chief pilot for British private airline Laker Airways, founded Virgin Atlantic together. Following the demise of Laker Airways in 1982, Field and Hellary decided to form a new firm, dubbed British Atlantic Airways at the time. Fields is said to have developed a plan for an airline that would fly between London and the Falkland Islands in June 1982, just after the Falklands War ended. Fields contacted Hellary, who had already been examining options for establishing a regular commercial service to the Falklands, in need of expertise in the subject. Hellary, on the other hand, was in contact with other out-of-colleagues as a result of Laker Airways' demise, and the two agreed to fine-tune their aspirations.

Virgin Atlantic launched its first regular service between Gatwick and Newark on June 22, 1984, utilizing a leased Boeing 747-200 (registration G-VIRG) dubbed Maiden Voyager that had formerly been operated by Aerolneas Argentinas. Its activities were supplemented from the start by utilizing existing Virgin Group resources, including as tickets sold via Virgin Megastores record stores.

Richard Branson's stated business philosophy is to either succeed or abandon the market within the first year; this attitude includes a one-year limit on everything related with starting up operations.

Virgin Atlantic turned a profit during the first year, thanks to the ability of sister firm Virgin Records to finance the leasing of a used Boeing 747. The company had planned its activities to take advantage of the entire summer, from June to September, which is traditionally the most profitable time of year.

In November 1984, the airline began flying a chartered BAC One-Eleven between Gatwick Airport and Maastricht Aachen Airport in the Netherlands.

In 1986, the airline added another Boeing 747 to its fleet and began flying from Gatwick to Miami on a regular basis. Additional aircraft were swiftly obtained, and new routes from Gatwick were opened in 1988, 1989, 1990, 1991, and 1992, including New York JFK, Tokyo Narita, Los Angeles, Boston, and Orlando. Virgin Atlantic began flying between Luton and Dublin in 1987, using secondhand Vickers Viscount turboprop aircraft, however the service was discontinued about 1990. In 1989, the airline ran a Viscount service between Maastricht and London Luton Airport. Club Air operated two Boeing 727 jet aircraft on behalf of Virgin Atlantic from 1988 to 1990, serving the Luton to Dublin route.

Virgin Atlantic stopped flying to Sydney in 2014. Virgin Atlantic also announced plans to cancel flights to Tokyo, Mumbai, Vancouver, and Cape Town, as well as codeshare transatlantic flights with Delta Air Lines; the firm was also rumoured to be considering canceling its new domestic airline, Little Red, due to severe losses.

Virgin Atlantic also announced in 2014 that Little Red services between London and Manchester would end in March 2015, with Scottish routes ending in September 2015. Passengers used the routes as a point-to-point connection rather than as a stopover for longer-haul Virgin Atlantic flights. The former BMI routes were continued by British Airways, a competitor.

Richard Branson indicated in June 2015 that the aforementioned arrangement with Delta was necessary for Virgin Atlantic to survive after losses of £233 million between 2010 and 2013. [32] In the same month, the airline declared that 500 employees would be eliminated in order to create a more efficient management structure.

In July 2017, Air France-KLM acquired a 31% stake in Virgin Atlantic for £220 million

Virgin Atlantic announced its expansion plans in September of this year. Flybe would have been a key part of these plans, with a plan to rebrand it as

"Virgin Connect" starting in early 2020; however, the plans fell through when Flybe filed for bankruptcy and ceased operations in March 2020.

Branson announced in December 2019 that the sale of a 31 percent stake in the airline to Air France-KLM would be scrapped, and Virgin Group would keep its 51 percent stake.

On 5 May 2020, it was announced that due to the COVID-19 pandemic, the airline would lay off 3000 staff, reduce the fleet size to 35 by the summer of 2022, retire the Boeing 747-400s and would not resume operations from Gatwick following the pandemic.

Virgin Atlantic filed for Chapter 15 Bankruptcy Protection in New York on 4 August 2020 as part of a £1.2 billion private refinancing package.

Virgin Atlantics` fleet consists of 28 aircraft in service and 9 are parked. In total Virgin Atlantics has 37 aircrafts. It consist of: 17 wide-body long-haul Boeing 787 Dreamliner, 7 long-haul Airbus A350 XWB, 13 medium-haul Airbus A330 and 9 of them are parked for today. Fig 1.13 the fleet of Virgin Atlantics.

Aircraft Type	Current			Future 2	Historic	Avg. Age
	In Service	Parked	Total			
+ Airbus A320					6	
+ Airbus A321					1	
+ Airbus A330	4	9	13		1	12.0 Years
+ Airbus A340					29	
+ Airbus A350 XWB	7		7	1		2.0 Years
+ Boeing 747					30	
+ Boeing 767					1	
+ Boeing 787 Dreamliner	17		17			5.2 Years
Total	28	9	37	1	68	7.0 Years

Fig. 1.13 The fleet of Virgin Atlantics [17]

Virgin Atlantic has codeshare agreements with the following airlines:

- Air France
- Air New Zealand
- Delta Air Lines
- KLM
- Singapore Airlines

- Virgin Australia
- WestJet
- Aeroméxico

Virgin Atlantic Ltd annual financial results for the year 2017 – reported a pre-tax loss of £28.4 million before tax and exceptional items. (2016: £23 million profit). Strong passenger load factor of 78.3% (-0.4pts year-on-year) despite significant capacity increases across the Atlantic. 5.3 million passengers flown in 2017, down 0.1 million year-on-year.[18]

Despite a challenging macro-economic environment and operational challenges, Virgin Atlantic Group sustained its focus on delivering an unrivalled customer service, whilst maintaining rigorous cost control. Virgin Atlantic took decisive action in light of the continued weakness of Sterling to increase inbound traffic to the UK – achieving a 20% increase in US-based passengers, and double-digit unit revenue growth on rest-of-world routes.

Virgin Atlantic achieved the highest customer satisfaction scores for transatlantic flights (IATA Airstat 2017) and alongside its transatlantic joint venture partner Delta Air Lines operated the most punctual flying schedule between the US and London Heathrow.

Virgin Holidays reported a profit of £15.5 million before tax and exceptional items and a 1.5% increase in customers year-on-year.

Virgin Atlantic Cargo revenues grew by 9.3% to £199.3million and cargo tonnage increased by 5.8% year-on-year.[18]

Virgin Atlantic Ltd annual financial results for the year 2018 showed next indicators. The company, comprising Virgin Atlantic, Virgin Holidays and cargo, reported a pre-tax loss of £26.1 million before tax and exceptional items - significantly improved from the £49.0m loss in 2017.

Against a challenging economic backdrop, Virgin Atlantic Ltd increased overall revenue by £150m, a 5.8% year on year growth. Passenger numbers have grown by 4.8% to 5.4 million, with results displaying a passenger unit revenue (PRASK) increase of 1.7%[2] - the first year of positive growth since 2014. These results put the company in a strong position to realise its plan to revive growth and return to profitability. [18]

Cargo achieved its strongest revenue performance in the last five years, as revenues grew 13% year on year to £222m. This record result was supported by a 6% annual growth in volume to more than 244,000 tonnes - the airline’s best result since 2010. [18]

The company continued to focus on delivering unrivalled customer service, maintaining its number one IATA customer satisfaction ranking for transatlantic flights and operating its most punctual flying schedule between the US and London Heathrow since 1997.

Performance was impacted by the weakness of GBP versus USD, economic uncertainty and the continued shortage of Trent 1000 engines used on Boeing 787 aircraft.

For the year ended 31 December 2019, Was returned a loss of £29.5m (2018 restated: loss of £9.0m) before tax and exceptional items. 2019 was the year in which was put in place the foundation building blocks of company three-year plan which will both return them to profitability and set on the flight path to being recognized as Britain’s 2nd flag carrier.

Alongside the rest of the industry they have hit the significant headwinds of the Covid-19 pandemic however they believe their relentless focus on delivering long term benefits for customers, people and the planet through sustainable growth will ultimately enable them to succeed aim to be Britain’s most loved travel company. Load factor up 2.4pts to 81% and PRASK (passenger revenue per Available Seat Kilometre (ASK)) up 4.3%; Launched two new destinations in 2019 – Tel Aviv and Mumbai.

Virgin Atlantic Ltd annual financial results for the year 2020. The Group, comprising Virgin Atlantic, Virgin Holidays and Virgin Atlantic Cargo, reported revenue figures of £868 million, down from £2.9 billion in 2019; a pre-tax loss of £659 million before tax and exceptional items, and fair value movements versus a loss of £22 million in 2019. These results reflect the toughest year in the airline’s

36-year history and the immense challenges that the airline industry has faced due to the Covid-19 pandemic.

Despite the incredibly tough backdrop, the company made a significant contribution towards the national effort to protect lives, from transporting vital PPE and medical supplies, to volunteering to support NHS frontline services. Virgin Atlantic Cargo enjoyed a record year, launching 12 new cargo-only routes for the first time in the airline’s history. Throughout the pandemic, the airline continued to deliver unrivalled customer service and was voted Britain’s only Five Star Airline by APEX for the fourth consecutive year in the Official Airline Ratings. In addition, Virgin Atlantic received Diamond Status from APEX for delivering the highest standards of cleanliness and demonstrating a steadfast commitment to ensuring its customers and people can fly safe and fly well.

Virgin Atlantic responded swiftly to the crisis, suspending Shanghai flights on 1 February 2020 and immediately shifting focus to liquidity preservation. Through disciplined focus on operating only cash positive flying, ASKs were reduced by 73% year on year and passenger flying was suspended for 90 days from 21 April. Passenger numbers decreased from 5.8m in 2019 to 1.1m in 2020.

For the first time in the airline’s history, Virgin Atlantic established a cargo-only flight business transporting critical supplies to the UK. This resulted in a record year for cargo performance, with revenue of £319m, up 49% year on year.

Decisive action was taken to resize and reshape Virgin Atlantic; consolidating operations to London Heathrow; simplifying the fleet by retiring Boeing 747-400 and Airbus A340-600 aircraft early. Even in the toughest times, the amazing people of Virgin Atlantic are what sets it apart and they have made tremendous sacrifices. Sadly, the number of people employed had to be reduced by 41% to 5,907* in order for the airline to emerge from the crisis. Combined, these actions contributed more than £300m in cost reduction.

On 4 September 2020, Virgin Atlantic completed the £1.2bn privately funded solvent recapitalisation of the airline. Two further financing transactions closed in Q1 2021, raising an additional £330m, with the proceeds paying down debt and bolstering the airline's cash position. £880m of fleet capital expenditure was deferred, realigning growth and capital investment in line with demand for travel.

From the start of the pandemic, the airline supported the NHS with people volunteering at NHS Nightingale and the London & St John Ambulance services, providing critical support as well as administering the vaccine. Virgin Atlantic Cargo carried over 8.5 million kilos of essential medical supplies including respirators, ventilator parts, face masks, scrubs, testing kits, aprons and eye protection and PPE equipment into the UK, helping to keep NHS frontline workers safe.

Virgin Atlantic has announced plans to reshape and resize its business to ensure that is it fit for the future, in response to the severe impact of the Covid-19 pandemic on the global economy, our nation and the travel and aviation industry. Following the pattern of previous crises including 9/11 and the Global Financial Crisis, capacity across the aviation industry will significantly reduce, with recovery to pre-crisis levels expected to take up to three years. Uncertainty around when flying will resume, coupled with unprecedented market conditions brought on by the pandemic, has severely reduced revenues for the global aviation industry and Virgin Atlantic.

Accordingly, the airline has taken decisive action to reduce costs, preserve cash and to protect as many jobs as possible.

As Virgin Atlantic aims to establish itself as the sustainability leader, it will fly only wide-body, twin-engine aircraft from London Heathrow and Manchester to the most popular destinations. It will be moving its flying programme from London Gatwick to London Heathrow, with the intention of retaining its slot portfolio at London Gatwick, so it can return in line with customer demand.

From today, Virgin Atlantic will no longer use all of its seven 747-400s, with four A330-200 aircraft retiring in early 2022 as planned. By 2022 the simplified, greener fleet will comprise of 36 twin engine aircraft reducing

CO2/RTK emissions by an estimated further 10%, building on the 18% efficiency already achieved between 2007-2019.

So we can make conclusion that Covid-19 shocked Virgin Atlantic as all other world. Financial results of 2020 reflect the immense challenges that aviation industry has faced due to the Covid-19 pandemic. Aviation was one of the first industries to be affected and will be one of the last to fully recover. Since February 2020, they have been guided by the single mission of ensuring Virgin Atlantic’s survival, through a laser focus on reducing our costs, preserving cash and protecting as many jobs as possible.

This statistic illustrates the total profit and losses after tax of Virgin Atlantic Airways Limited and its subsidiary companies from 2013 to 2019. Virgin Atlantic Airways Limited is a British airline.

The highest net profit was recorded in 2016, at 180.9 million British pounds. In 2019, Virgin Atlantic Airways Limited and its subsidiaries recorded a loss of 48.5 million British pounds.

1.6 The Cost Of Flying

The relationship between ticket prices and airline profitability is complicated. Airlines have substantial fixed expenses for running flights, and only a small portion of these are connected to the number of passengers carried. We wll discusse what airlines pay to operate flights and looks at some of these costs. This is a tremendously complicated area with a lot of variation between regions. Consider this a beginning point for learning about the topic rather than a comprehensive price guide.

Before we look at the costs of operating a flight, let's take a look at the fixed costs that airlines confront. These are also reflected into flight costs, although attributing them to each flight is more difficult. Below we will provide you with the major expenses of each airline.

Depreciation and rental costs of aircraft. The cost of the aircraft is, without a doubt, a significant component of airline costs. For jet aircraft, standard accounting procedures (as detailed in this 2017-2018 FAA guide to airline expenditures) [12] estimate a depreciation cost of 4% per year. An aircraft's operating life would be estimated to be 25 years. Of course, an airline may not maintain an aircraft for this long, but the residual value is represented in the aircraft's secondhand value.

In order to take this into account, a list price of 410,2 million dollars for new 777-8 aircraft might be up to 16,4 million dollars per year. In actual fact, prices would probably be less than the cost of the list would normally be much reduced by airlines.

Costs of maintenance. As part of daily operations, aircraft are regularly monitored and maintained. In addition, the heavier A, B, C and D controls are provided.

This can either be regarded fixed or flight-dependent. As with other fixed costs, each flight is responsible for a cost. However, maintenance costs are inevitable to maintain an airworthy fleet.

Costs of insurance. The fleet size is more important than the number of flies to ensure the aircraft are.

Costs for booking and reservation. This is an important region for cheap carriers because many of their costs here are only reduced by selling flights on their own websites. However, airlines typically pay a percentage fee to reservation agencies and websites.

Staff and management costs. Depending on the schedule there may be some flexibility in altering crew salaries but other wage expenses are longer-term.

Let’s take a look at flight operating costs. Now we'll look at the expenses of each flight. These are the costs that airlines incur as a result of their flight schedules. Some costs, of course, directly tied to each flight and would not be incurred if the flight did not fly. Others, such as staff costs, are longer-term and more focused on a schedule.

To demonstrate the cost of flight operation, we will make a complex calculation using the (DOC) method in design part of the work, but now I will provide you with short example of a Boeing 777-300ER flight from London to New York. Some other relevant and interesting cost areas will be highlighted.

Staff and fuel costs are by far the highest expenses, according to Jean-Paul Rodrigue's book "The Geography of Transport Systems."[44] They are responsible for half of all costs (with staff at 32.3 percent and fuel at 17.7 percent).

Cabin crew numbers are strictly regulated, with a minimum number for each aircraft type (this will be at least equal to the number of exit doors, but can be more).

Salaries differ between airlines, of course. According to Glassdoor, the average British Airways pilot income is £87,000, while the average easyJet pilot income is £50,184. Cabin crew can also receive a variety of incomes depending on their contract terms or base location.

Crew bases and rotations, especially on long-haul flights, are another key cost component. To help with this, several airlines have multiple crew bases. This has a monetary impact, but it also offers local crew with superior passenger service and prowess.

Norwegian Airlines is a fantastic example of a company that has adopted this concept. It has a complicated structure that includes subsidiaries in various countries. It does it by taking advantage of cheaper labor costs (among other things) outside of its main base of operations in Norway. Finnair also makes extensive use of international hubs, particularly in Asia.

We'll look at the FAA analysis statistics to get a good notion of how much it costs to operate an aircraft. For all personnel, it calculates the following per-hour (block hour, which is the complete time from gate to gate rather than just airborne time) operating costs:

- Widebody over 300 seats: $2,356;
- Widebody under 300 seats: $1,857;
- Narrowbody over 160 seats: $1,1,52;
- Narrowbody under 160 seats: $1,034;

So, as a guide, our seven-hour 777 flight from London to New York would have a staff of around $16,500.

Airlines spend a lot of money on fuel, which is why they suffer so much during periods of high oil prices. In the 18 months leading up to September 2018, the price of gasoline, for example, had more than doubled. Simple Flying [investigated the cost implications for Emirates at the time. Other airlines were affected as well, but airlines with larger, more fuel-hungry aircraft were hit the hardest.

There are a few options for dealing with this. Many airlines may purchase fuel options ahead of time to lock down pricing. This can make planning and accounting easier in the future and provide some security, but prices will eventually rise as oil prices rise.

More efficient airplanes assist to mitigate the effects of increased prices to some extent. Long-haul flight was the territory of big, four-engine aircraft in the 1970s. In recent years, aircraft efficiency has improved significantly, and twin-engine aircraft, in particular, have become much more capable. With the A380's downfall, the four-engine era may be coming to the end. We should expect to see even smaller (and more efficient) twin-engine aircraft on longer trips in the future. The new Airbus A321XLR, which is already popular with airlines, promises a lot in this area.

Blog “The Points Guy” [46] looked in detail at total fuel costs in late 2019 based on data from Airlines for America. [47] The average cost of fuel for a flight from London to New York is $33,411. However, with normal winds, the return would consume less gasoline and cost $27,270. A transcontinental flight from New York to Los Angeles, for example, would consume $10,757 in fuel.

When comparing fuel usage per seat, the improvement in economy is most obvious. In 2019, the International Council on Clean Transportation (ICCT) [48] published a fascinating study that looked at this for transatlantic operators. It contrasted airplane types as well as highlighted which airlines have the best fuel economy (Norwegian was best, British Airways was worst). The average passenger-kilometers per liter of fuel burned in the industry was 33. With almost 40 passenger-kilometers per liter, the fuel-efficient Airbus A350 and Boeing 787 outperformed the competition.

Airlines must pay a charge to land and use the needed facilities at any airport. Fees differ significantly between airports and take into consideration a variety of factors such as aircraft type and weight, landing duration, and, in certain cases, emissions and noise. Some places divide this into a fixed and variable fee (based on the load-factor).

The Port Authority of New York publishes prices for JFK (and other New York airports). The price will be $6.95 per thousand pounds of maximum gross weight in 2020. A 777-300ER's maximum take-off weight (MTOW) is 775,000 pounds (351,534 kg). This would result in a $5,386 take-off/landing cost.

In addition, airport parking rates vary depending on the size of the aircraft and the amount of time it spends on the ground. These cost $70 plus an extra $25 for every 25,000 pounds of MTOW exceeding 200,000 pounds at JFK. This fee is collected for each eight-hour period. This would cost $645 for our 777-300ER.

The airport publishes tariffs for London Heathrow as a comparison. [49] These are determined by the size of the aircraft as well as the noise category. This would be $7.758 per landing for most heavy widebodies. There is an additional $22.80 tax per kilogram of NOx emissions. For widebody aircraft, there is a parking fee of $82.66 each 15 minutes (after 90 minutes).

There are, of course, other government taxes in addition to the landing costs. These, too, vary greatly between countries and airports, and they change on a frequent basis. With its Air Passenger Duty (APD) on top of other taxes, the UK has some of the highest such charges.

In most situations, these are included in the ticket price and subsequently passed on to the appropriate government agencies by the airline. However, this isn't always the case. Some low-cost airlines frequently offer ticket costs that are less than the entire taxes (particularly in Europe and the UK, where fares are low and taxes high). This can be beneficial as part of a larger marketing campaign or in conjunction with other sources of money, such as supplementary income. With its Reward Flight Saver tickets, British Airways does the same, charging cash amounts lower than total UK taxes.

Overflight fees are paid by airlines to the governments of each country they pass over on their flights. This includes air traffic control and other navigational services. This will be a single payment based on the aircraft type and length of the flight for a fly just over the US or within Europe (which is centralized under ‘Eurocontrol').

The payments are substantially more complicated for a difficult route that crosses numerous nations. Some countries charge a flat cost, while others charge based on the distance travelled.

Rates in the United States are established by the Federal Aviation Administration. The fees are $61.75 per 100 nautical miles overland and $26.51 per 100 nautical miles over ocean monitored by the FAA. [50]

The rates in Europe are a little trickier. [51] They are determined by the weight of the aircraft, the distance traveled, and a country's "unit rate." Though billing and control are centralized, pricing differ per country.

Slightly altering your path can have a significant impact on your expenses. The Wall Street Journal, [52] for example, reported on a British Airways aircraft from London to Sao Paulo that was rerouted over Europe, saving the airline roughly £3000 ($3980). Instead of flying across Portugal, Spain, and France, it took an Atlantic route and flew over Cornwall, entering UK airspace. Please take a look at the fig. 1.14

Airlines, on the other hand, cannot always pay a charge; they must also obtain approval. This can easily become a political as well as a financial issue. We saw this with Qatar Airways, which was barred from flying in various Gulf countries after 2017. Taiwanese carriers are also unable to fly across Chinese airspace, necessitating route changes.

There are third parties engaged in turning around and serving an aircraft, in addition to the fees paid to airports and governments for landing and using ground services. The amount of work that airlines do themselves versus how much is outsourced varies by airline and area.

Costs for such services are difficult to come by. A regular ground turnaround charge for a 737 aircraft is estimated to be $1,000 to $2,000, according to some discussion on the blog Airliners.net.

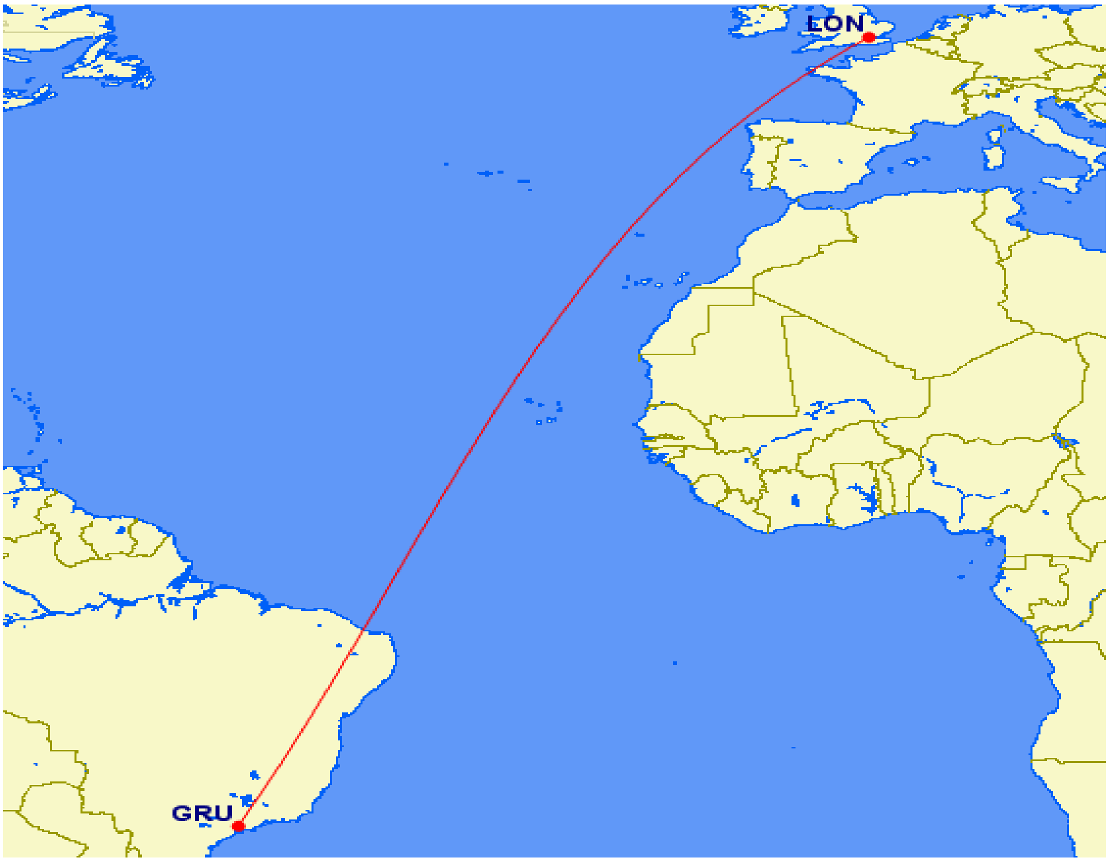

Fig. 1.14 Avoiding European land crossing saves overflights fees from GRI-LON

2. DESIGN PART

Air Transportation Management Department				*NAU.21.06.98 200 EN*					
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Head of the Department	Shevchuk D. O								

2.1 Theoretical and methodological bases of efficiency of use of airline fleet

Fleet planning problems have been gaining increasing importance and relevance, playing nowadays a significant role among researchers' work. It is definitely a problem that affects many companies, since they frequently rely on a private vehicle fleet to transport people, goods or equipment. Generally, fleet planning problems focus on the balanced and efficient correlation between supply and demand: supply of transportation capacity and demand for transportation services. Therefore, the composition of a company's fleet is a crucial decision that must be taken prudently, so the company's demand can be satisfied and the total transportation costs minimized.

The airline fleet planning problem consists essentially in determining the aircraft types and the number of aircraft of each type that an airline needs in order to achieve its goals. A more complex definition, defining airline fleet planning it is - the process by which an airline acquires and manages appropriate aircraft capacity in order to serve anticipated markets over a variety of defined periods of time with a view to maximizing corporate wealth.

As mentioned previously, the decisions concerning the general fleet composition problem are closely interrelated with decisions regarding other fleet management problems, such as fleet replacement, assignment, routing, or scheduling. When it comes to air transportation, the routing problem becomes simpler since a flight route can be defined only by the leg (origin destination pair) and the flight distance between the origin and destination points will always be the same. Thus, the planning of the composition of an airline fleet presents some differences with respect to general planning problems. The choice between a uniform or a diversified fleet can be a challenging task for an airline. With a uniform fleet, maintenance, training and labor cost will be lower. On the other hand, a fleet composed by different aircraft types presents the possibility of choosing an aircraft that can more efficiently respond to market conditions and travel demand.

Airline fleet planning is a complex decision-making process which has been dealt with by several authors, particularly in recent years. For instance, Harasani (2006) proposed a system for the evaluation and selection of a fleet of aircraft for an airline in Saudi Arabia, with operations in domestic and international routes. The types of aircraft were chosen according to the aircraft range and payload for a certain route network. The results, in terms of aircraft efficiency and its contribution to the net profit of the airline, were obtained through an Excel application created by the author. [19]. Along the same lines developed a method to evaluate the fleet composition of an airline integrating fleet planning and fleet assignment components. They calculated the planned direct cost (PDC) for several different fleet composition alternatives, in which they simulated the airline operation according to information on flight schedules, expected reservation demand, and mean price of each flight. The best alternative was the one with the lowest PDC.

Various authors have studied the airline fleet planning problem in different ways. Several took into consideration the close connection between flight frequencies and aircraft size, considering identical factors. For instance, Pai (2007) [20] studied the influence of certain factors on flight frequencies and aircraft size on US airline routes. This author took into account market demographics, airport characteristics, airline characteristics and route characteristics. His research showed that flight frequency and aircraft size increase with population and income. He also concluded that an increase in runway length leads to a higher frequency and larger aircraft sizes, as well as an increase in delay at the route endpoints results in lower frequencies and smaller aircraft, among other things. Givoni & Rietveld (2009)[21] used regression analysis in over 500 routes in the US, Europe and Asia, to investigate the effects of route characteristics (distance, level of demand, level of competition) and airport characteristics (number of runways, being hub or not) on aircraft selection. They concluded that the choice of aircraft size is mainly influenced by route characteristics and almost not at all by airport characteristics.

One of the major concerns of an airline when deciding the composition of its fleet is definitely the minimization of costs. Therefore, one of the key issues in finding an optimal fleet composition for an airline is the clear definition of which types of costs should be taken into account and what value do they have in reality. The factors that offer cost reduction possibilities in airline operations were identified, and the impact of different cost reduction measures are evaluated. The fleet composition, route network, and company policies on remuneration and work rules are the factors that most affect the total costs of an airline.

In terms of optimization models. The optimization airline fleet planning when old aircraft become obsolete and new aircraft types with improved performance become available, and considered a dynamic environment. The utilization of previous models, and was developed a viable model for planning the acquisition and disposal of aircraft, defining the fleet composition for a commercial airline.

In recent years, there have been several authors presenting optimization models as a possible approach to deal and solve airline fleet planning problems. For instance, Wang (2014) [22] developed a model to minimize the fleet planning costs for an airline, by incorporating the passenger mix problem into the fleet composition problem. According to this author, the traditional methods for determining an airline fleet composition do not take into consideration the network effects. Therefore, in order to present a solution for this problem, Wang (2014) [22] studied the network effects (regarding airlines operating in a hub and spoke network), and incorporated the passenger demand transfers from one airport to another into his work. He used three different decision variables in his model: 1) the purchasing number of aircrafts in each fleet type; 2) the frequencies of each aircraft type flying on legs; and 3) the spilling number of passengers from each itinerary. This author demonstrated the feasibility and effectiveness of the model through the use of a numerical example.

Determining the planned production indicators allows to assess the physical feasibility of the chosen strategy of air transportation with the help of the aircraft fleet, transportation capacity and economic potential of the airline, which ensure the implementation of the schedule and the planned revenues.

Sales revenue planning is iterative, and the number of iterations depends largely on the same accuracy in forecasting market parameters.

Thus, the optimization tasks of the route network and the plan of the aircraft fleet are the basis for managing the economic efficiency of the airline, as they determine the initial indicators in the development of its development strategy. The process of creating an optimal fleet of aircraft that will ensure maximum efficiency of the airline is based on a set of appropriate procedures.

Key procedures for creating an effective airline fleet: demand for the supply of new aircraft, the volume of air traffic of airlines, assessment of the fleet deficit by the number and types of aircraft, types and composition of a competitive fleet of operating aircraft, demand for air transportation of the chosen airlines, the demand for types and quantities of aircrafts, market capacity, assessment of the degree of tear and resource extension of aircraft.

The increase in the volume of traffic with a constant fleet of aircraft reduces the need for new investments, this is due to the fact that the volume of transport work in this case increases as a result of better use of aircraft in operation. There are two ways to increase the efficiency of the use of means of labor - extensive and intensive, which are reduced to increasing their working time and better use over time. Improving the extensive use of aircraft is called increasing the time of their use, ie the growth of daily, monthly and annual running of hours on the accounting aircraft. Increasing the extensive use of aircraft is: increasing the number of hours per aircraft, increasing the frequency of regulatory forms of maintenance, increase in assigned maintenance resources of the aircraft, reduction of time losses due to weather conditions, reduction of duration of capital repairs and maintenance, Reduction of downtime on regulatory maintenance forms, rationalization of the aircraft turnover schedule, reduction of parking at loading and unloading works.

Regarding the intensive increasing use of aircraft it is - improving their use per unit time, increasing the hourly productivity of flights.

The main directions of increasing the intensive use of aircraft is: optimization of loading types, economic modes of flight of the aircraft, aircraft modernization, improving the regularity of flights, increase marginal productivity and commercial load, ensuring compliance between the demand for transportation and the supply of seats and load capacity.

The maximum commercial loading of the aircraft is provided at the most favorable range of the aircraft. The practical range of non-stop flight does not always coincide with the most profitable, because it is determined by the location of airports on a particular airline.

As was mentioned the fleet planning is very important for any airline. Also the fleet planning determines what type of aircraft the airline should buy, and how many of them, in order to achieve the airline goals. Fleet planners also get involved in the negotiation deals with aircraft and engine manufacturers, most of the decision making would be through fleet planning. So by understanding basic elements of fleet planning one would essentially understand the airline needs and operation parameters. It should be noted that there are other factors that influence the buying of a new aircraft that do not depend on fleet planning, such as alliance, people factors. [23].

A better understanding of fleet planning decision making and the evaluation of an aircraft in an airline would help construct the flight model. One of the most difficult decisions in an airline is whether to buy a new or a used aircraft, and what type, or renew the existing aircraft.

It is important to note that fleet planning is not just aircraft evaluation, aircraft comparison, route analysis, aircraft acquisition, or matching supply to demand in isolation, but includes all these elements simultaneously [23]. A better understanding of fleet planning decision making and the evaluation of an aircraft in an airline would help construct the flight model. One of the most difficult decisions in an airline is whether to buy a new or a used aircraft, and what type, or renew the existing aircraft.

The dilemmas of fleet planning of an airline is that

- The fleet is highly complex
- Decisions must be long term
- Market is volatile
- Networks are heterogeneous

So fleet planning is a compromise and is inevitable as there is no exact right solution. Each airline has a different approach towards the replacement of its aircrafts. There are large airlines which are government supported, small airlines, or capital rich airlines, all would have a different aircraft average age, but they all follow the simpler principle of fleet planning.

Fleet planning is an on going process over the life cycle from the evaluation through disposal and data collection.

2.2 Development of project proposals to increase and compare the efficiency of UIA and virgin atlantic aircraft fleet use

When purchasing a new aircraft, the amount that an airline is willing to spend is equal to the future economic contribution to profit in present value terms minus the marginal cost of funds. Fig.. 2.1 shows the structure of modern commercial aircraft economics. Profitability in airline economics depends on the specific route, traffic density, passenger demand, and aircraft performance. Therefore, it is necessary to consider the Life Cycle Cost (LCC) of an aircraft. Apart from the acquisition cost (the aircraft price), the Direct Operating Cost (DOC) and Indirect Operating Cost (IOC) are two major components making up the LCC. Among these, the DOC is directly related to the aircraft type, while the IOC is more dependent on an airline’s specific strategy. Thus, an accurate evaluation of the DOC is one of the most significant considerations for airlines when adopting new aircraft.

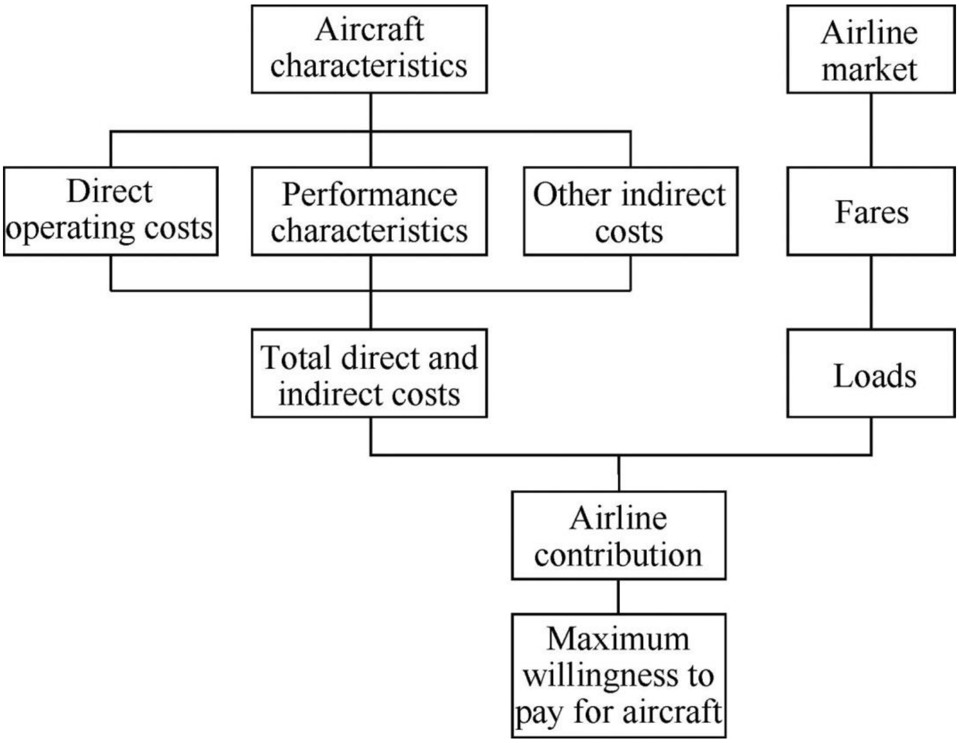

Fig. 2.1 The structure of modern commercial aircraft economics

Analyzing the DOC of wide-body aircraft is more important than other types of aircraft because, despite being relatively few in number, wide-body aircraft make up more than half (54%[9]) of the total value of the overall aviation economy. A passenger-type wide-body aircraft is an aircraft with two aisles, typically equipped with seven or more seats abreast. It is designed for maximum efficiency, passenger comfort, revenue and profit. Wide-body aircraft are most efficient in the hub-and-spoke system, in which flights from multiple different origins converge to a single hub airport and then depart from that hub airport, bound for other destinations. In a typical hub-and-spoke system, the average number of passengers tends to increase significantly,[24] reducing the average cost incurred by airlines.

Because the unit price of wide-body aircraft is considerably higher than that of other aircraft types, it is of greater importance for airlines to evaluate the DOC of wide-body aircraft. However, to the best of my knowledge, DOC data for such aircraft is not available in the open literature. Therefore, the provision of accessible DOC data for modern wide-body aircraft would be valuable to aircraft manufacturers, airlines, aircraft leasing companies, aircraft insurance companies, and their related financial institutions. In this study, I analyze the DOC of wide-body aircraft Boeing 777-200ER(UIA) and Boeing 787 Dreamliner(Virgin Atlantic). We will consider a few range of representative flight scenarios, each with differences in route distance, fuel price, passenger number, and seating arrangement. The most cost-efficient aircraft type for each flight scenario is identified and evaluated in the context of operations from London Heathrow International Airport(Virgin Atlantic) and Kyiv Boryspil International Airport(UIA).

The economic viability of a flight route depends on its distance. Different organizations, airlines and airports have different ways of defining flight distance. Eurocontrol uses the following classification: short-haul (routes shorter than 1500 km), medium-haul (routes between 1500 and 4000 km) and long-haul (routes longer than 4000 km).

Table 2.1

Airport distances from Kyiv Boryspil International Airport(UIA)

Destination	Distance (kilometers)	Distance(nautical mile)
DUBAI	3488	1883
Delhi	4552	2458

Table 2.2

Airport distances from London Heathrow International Airport(Virgin Atlantic)

Destination	Distance (kilometers)	Distance(nautical mile)
Tel Aviv	3593	1940
Boston US.	5254	2837

For our study, we will define the flight distance as that measured from London Heathrow International Airport and Kyiv Boryspil International Airport, but with a slightly more detailed classification. Table 11, 12 shows the distances of world airports from chossen above airports. We define two classes of flight according to these distances. Medium range refers to flights between 1000 and 2000 n mile, long range refers to flights between 2000 and 6000 n mile. This distance classification was chosen for its simplicity, its wide range of flight distances, and its ability to capture the most commonly flown routes. Within this classification, the hub airports considered in our DOC analysis are indicated in bold text in Table 11&12.

We include taken wide-body passenger aircraft in our analysis Boeing 777-200ER, Boeing 787-9, Boeing 767-300ER, Airbus A350-1000, Airbus A330-300. See the technical characteristic of those aircrafts attached. Please take a look at the Table 2.3

Table 2.3

The aircraft engines

Manufacturer	Model	Engine
Boeing	777-200ER	GE90-94B
Boeing	787-9	GEnx-1B
Boeing	767-300ER	PW4000
Airbus	A350-1000	Trent XWB-97
Airbus	A330-300	PW 4000

The price of jet fuel has a significant influence on the operating costs of an aircraft, but is notoriously difficult to forecast. Various factors, such as unpredictable geopolitical trends around the world, especially in the Middle East where oil production is concentrated, can influence the price of jet fuel. Fluctuations in the price of jet fuel can sometimes lead to managerial decisions over whether to enter or leave a given market or route. Therefore, it is necessary to analyze the DOC under different fuel-price scenarios. Fig 2.2 shows the jet fuel price from 2008 till 2017.[25].

It can be seen that the fuel price fluctuates significantly over time. It is therefore crucial to account for fuel-price variations in our DOC analysis. From the 10-year historical data shown in Fig. 2.2, we extract three fuel-price scenarios. The highest jet-fuel price over the last 10 years is 3.89 U.S. Dollars (USD) per gallon (July 2008), which we use for our high-fuel-price scenario. By contrast, the lowest fuel price in the same period is 0.93 USD per gallon (January 2016), which we use for our low-fuel-price scenario. In addition, we use a jet-fuel price of 1.74 USD per gallon (September 2017) for our normal-fuel-price scenario.

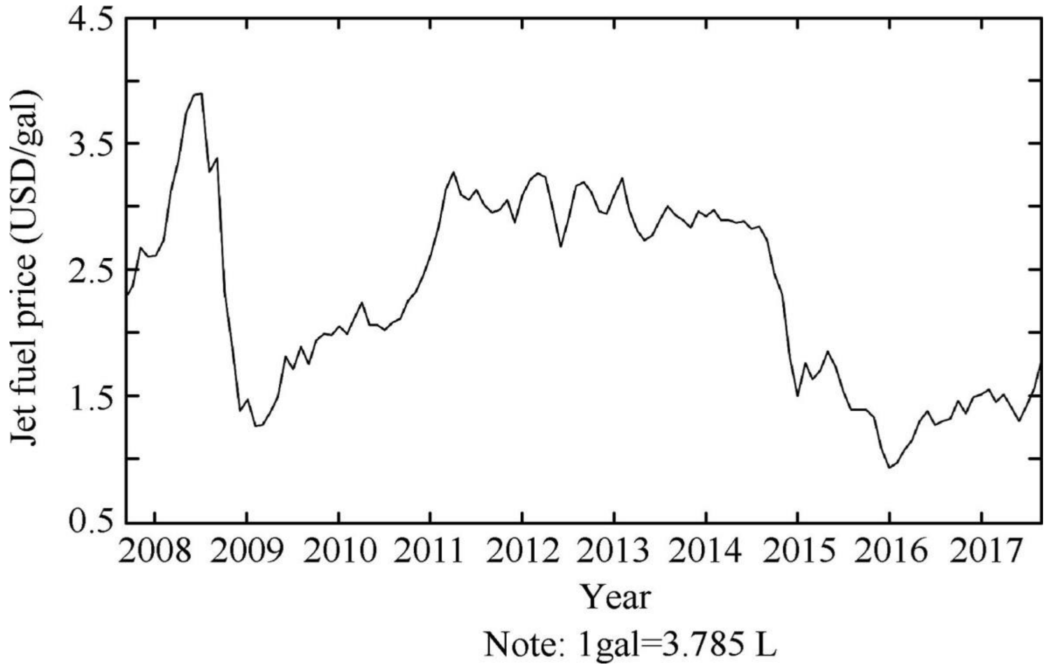

Fig.. 2.2 Jet fuel price in 2008–2017 from U.S. Energy Information Administration [25]

The maximum number of passengers that chosen wide-body aircraft can carry ranges from 261 to 440, depending on the aircraft size and seating arrangement. The seating arrangement varies from single class (all economy) to three class (first-business-economy). For each aircraft, the DOC per passenger decreases as the number of passengers increases. However, because the number of passengers is not proportional to revenue, different airlines may choose to adopt different seating arrangements when configuring the cabin. The maximum number of passengers carried by an aircraft can be defined in two ways: (A) using the standard seating arrangement recommended by the aircraft manufacturer or (B) using the maximum certified number of passengers that the aircraft can legally carry. Table 2.3 shows the maximum number of passengers for each aircraft type and seating arrangement; the data are compiled from Refs.[26;27]

Table 2.3

The maximum number of passengers for each aircraft type and seating arrangement

Aircraft	Standard arrangement	Maximum arrangement
B777-200ER	313	440
B787-9	290	420
B767-300ER	261	351
A350-1000	366	440
A330-300	277	440

The DOC of an aircraft can be calculated in several different ways. For this study, we use the method proposed by the Association of European Airlines (AEA) to evaluate the DOC[28]. Introduced in 1990. Studies have shown that the various DOC evaluation methods proposed over the last few decades are still useful today as a decision-making tool.[29] I will describes the methodology used to evaluate the DOC within the AEA framework below. All units for cost are in USD.

Utilization (U) is calculated by dividing the available hours per year ($t_{available}$) by the sum of the block time (t_{block}) and the Turn Around Time (TAT). The available hours per year and TAT are fixed values subject to the route distance, as listed in Table 2.4

$$U = t_{available}/(t_{block} + TAT) \tag{2.1}$$

Table 2.4

The available hours per year and the Turn Around Time

Range (n mile)	$t_{available}$ (h)	TAT (h)
<1000	4000	0.5
1000–2000	5100	1.4
>2000	6500	3.0

Where t_{block} is calculated by averaging the official scheduled flight time between the departure airport and the destination airport. Here, flight schedule information provided by Virgin atlantic and UIA. The results are shown in Table 2.5

Table 2.5

Block time

Study range	Route	t_{block} (h)
Medium	KBP-DXB	5.1
Long	KBP-DEL	7
Medium	LHR-TLV	5
Long	LHR-BOS	7.5

$U_{UAI/M}$=5100/(5.1+1.4)=784

$U_{UAI/L}$=6500/(7+3)=650

$U_{VA/M}$=5100/(5+1.4)=796.8

$U_{VA/L}$=6500/(7.5+3)=619

To evaluate the financial cost, we first calculate the Total Investment (TI), which is the cost of aircraft and initial spares and is calculated with Eq. (2). The cost of Air Frame Spares (AFS) is estimated to be 10 percent of the airframe price, while the cost of Spare Propulsion Units (SPU) is estimated to be 30 percent of the total engine price, as given by the manufacturer. Eqs. (3), (4) are used to calculate the costs of airframe spares and spare propulsion units:

$$TI = MSP + AFS + SPU \tag{2.2}$$

$$AFS = 0.10 \times (MSP - ENP \times ne) \tag{2.3}$$

$$SPU = 0.3 \times ENP \times ne \tag{2.4}$$

B777-200ER

$AFS_{UIA(777)}$=0.1*(306.6(mil)-15(mil)*2)= 27.66 (mil$)

B767-300ER

$AFS_{UIA(767)}$=0.1*(217.9(mil)-14(mil)*2)= 18.99 (mil$)

B787-9

$AFS_{VA(787)}$=0.1*(442.2(mil)-13.4(mil)*2)= 41.54 (mil$)

A350-1000

$AFS_{VA(350)}$=0.1*(366.5(mil)-20(mil)*2)= 32.65 (mil$)

$AFS_{VA(330)}$=0.1*(264.2(mil)-14(mil)*2)= 23.62 (mil$)

B777-200ER

$SPU_{UIA(777)}$=0.3*15*2= 9 (mil$)

B767-300ER

$SPU_{UIA(767)}$=0.3*14*2= 8.4 (mil$)

B787-9

$SPU_{VA(787)}$=0.3*13.4*2=8.04 (mil$)

A350-1000

$SPU_{VA(350)}$=0.3*20*2=12 (mil$)

A330-300

$SPU_{VA(330)}$=0.3*14*2=8.4 (mil$)

B777-200ER

$TI_{UIA(777)}$=306.3+27.66+9=342.96 (mil$)

B767-300ER

$TI_{UIA(767)}$= 217.9+18.99+8.4=245.29 (mil$)

B787-9

$TI_{VA(787)}$=442.2+41.54+8.04=491.78 (mil$)

A350-1000

$TI_{VA(350)}$=366.5+32.65 +12=411.15 (mil$)

A330-300

$TI_{VA(330)}$= 264.2+23.62+8.4=296.22 (mil$)

where MSP is the manufacturer's study price, ENP is the engine price and ne is the number of engines. Because the MSP is difficult to determine, it is replaced with the list price of the aircraft, as quoted by Boeing and Airbus.[30] The price of engines is taken from databases.[31][32] The total financial cost is expressed as the sum of the costs of DEPreciation (DEP), INTerest (INT) and INSurance (INS). Eqs. (5), (6), (7), (8) show how each of these financial components is calculated.

$$Total\ financial\ cost = DEP + INT + INS \tag{2.5}$$

$$DEP = TI \div (14 \times U) \tag{2.6}$$

$$INT = 0.05 \times TI \div U \tag{2.7}$$

$$INS = 0.06 \times MSP \div U \tag{2.8}$$

B777-200ER

$DEP_{UIA(777)}$= 342.96 /(14*784) =31246$ for Medium range.

$DEP_{UIA(777)}$= 342.96 /(14*650) =37687$ for Long range.

B767-300ER

$DEP_{UIA(767)}$= 245.29 /(14*784) =22347$ for Medium range.

$DEP_{UIA(767)}$= 245.29 /(14*650) =26954$ for Long range.

B787-9

$DEP_{VA(787)}$= 491.78 /(14*796.8) =44085$ for Medium range.

$DEP_{VA(787)}$= 491.78 /(14*619) =56748$ for Long range.

A350-1000

$DEP_{VA(350)}$= 411.15 /(14*796.8) =36857$ for Medium range.

$DEP_{VA(350)}$= 411.15 /(14*619) =47444$ for Long range.

A330-300

$DEP_{VA(330)}$= 296.22 /(14*796.8) =26554$ for Medium range.

$DEP_{VA(330)}$= 296.22 /(14*619) =34181$ for Long range.

B777-200ER

$INT_{UIA(777)}$=0.05*342.96 /784=21872$ for Medium range.

$INT_{UIA(777)}$=0.05*342.96 /650=26381$ for Long range.

B767-300ER

$INT_{UIA(767)}$=0.05*245.29 /784=15643$ for Medium range.

$INT_{UIA(767)}$=0.05*245.29 /650=18868$ for Long range.

B787-9

$INT_{VA(787)}$=0.05*491.78 /796.8=30859$ for Medium range.

$INT_{VA(787)}$=0.05*491.78 /619=39723$ for Long range.

A350-1000

$INT_{VA(350)}$=0.05*411.15 /796.8=25800$ for Medium range.

$INT_{VA(350)}$=0.05*411.15 /619=33210$ for Long range.

A330-300

$INT_{VA(330)}$=0.05*296.22 /796.8=18588$ for Medium range.

$INT_{VA(330)}$=0.05*296.22 /619=23927$ for Long range.

B777-200ER

$INS_{UIA(777)}$=0.06*306.3/784=23441$ for Medium range.

$INS_{UIA(777)}$=0.06*306.3/650=28273$ for Long range.

B767-300ER

$INS_{UIA(767)}$=0.06*217.9/784=16676$ for Medium range.

$INS_{UIA(767)}$=0.06*217.9/650=20113$ for Long range.

B787-9

$INS_{VA(787)}$=0.06*442.2/796.8=33298$ for Medium range.

$INS_{VA(787)}$=0.06*442.2/619=42862$ for Long range.

A350-1000

$INS_{VA(350)}$=0.06*366.5/796.8=27597$ for Medium range.

INS $_{VA(350)}$=0.06*366.5/619=35525$ for Long range.

A330-300

INS $_{VA(330)}$=0.06*264.2/796.8=19894$ for Medium range.

INS $_{VA(330)}$=0.06*264.2/619=25609$ for Long range.

B777-200ER

Total financial cost $_{UIA(777)}$ = 31246+21872+23441=76559$ for Medium range.

Total financial cost $_{UIA(777)}$ =37687+ 26381+28273= 92341$ for Long range.

B767-300ER

Total financial cost $_{UIA(767)}$ = 22347+15643+16676=54666$ for Medium range.

Total financial cost $_{UIA(767)}$ =26954+ 18868+20113= 65935$ for Long range.

B787-9

Total financial cost $_{VA(787)}$= 44085+30859+33298= 108242$ for Medium range.

Total financial cost $_{VA(787)}$= 56748+39723+42862= 139333$ for Long range.

A350-1000

Total financial cost $_{VA(350)}$= 36857+25800+27597= 90254$ for Medium range.

Total financial cost $_{VA(350)}$= 47444+39723+35525= 122692$ for Long range.

A330-300

Total financial cost $_{VA(330)}$= 26554+18588+19894= 65036$ for Medium range.

Total financial cost $_{VA(330)}$= 34181+23927+25609= 83717$ for Long range.

The total crew cost consists of the costs of the current and reserve crews. It is the sum of the CockPit crew Cost (CPC) and the CAbin crew Cost (CAC), which are calculated with Eqs. (9), (10), (11). The crew cost equations can be adapted to the actual crew rate. The number of cabin crew (n_{cab}), which is a function of the target comfort level, is calculated by dividing the total number of passengers by 35 (and then rounding up to the nearest integer).

$$Total\ crew\ cost = CPC + CAC \tag{2.9}$$

$$CPC = 380 \times tblock \tag{2.10}$$

$$CAC = 60 \times ncab \times tblock \tag{2.11}$$

B777-200ER

CPC $_{\text{UIA(777)}}$=380*5.1=1938$ for Medium range.

CPC $_{\text{UIA(777)}}$=380*7=2660$ for Long range.

B767-300ER

CPC $_{\text{UIA(767)}}$=380*5.1=1938$ for Medium range.

CPC $_{\text{UIA(767)}}$=380*7=2660$ for Long range

B787-9.

CPC $_{\text{VA(787)}}$=380*5=1900$ for Medium range.

CPC $_{\text{VA(787)}}$=380*7.5=2850$ for Long range.

A350-1000

CPC $_{\text{VA(350)}}$=380*5=1900$ for Medium range.

CPC $_{\text{VA(350)}}$=380*7.5=2850$ for Long range.

A330-300

CPC $_{\text{VA(330)}}$=380*5=1900$ for Medium range.

CPC $_{\text{VA(330)}}$=380*7.5=2850$ for Long range.

B777-200ER

$N_{cab(777)}$=313/35=9 for Standard arrangement

$N_{cab(777)}$= 440/35=13 Maximum arrangement

B767-300ER

$N_{cab(767)}$=261/35=8 for Standard arrangement

$N_{cab(767)}$= 351/35=10 Maximum arrangement

B787-9

$N_{cab\ VA(787)}$=290/35=8 Standard arrangement

$N_{cab\ VA(787)}$=420/35=12 Maximum arrangement

A350-1000

$N_{cab\ VA(350)}$=366/35=11 Standard arrangement

$N_{cab\ VA(350)}$=440/35=13 Maximum arrangement

A330-300

$N_{cab\ VA(330)}$=277/35=8 Standard arrangement

$N_{cab\ VA(330)}$=440/35=13 Maximum arrangement

B777-200ER

$CAC_{UIA(777)}$=60*9*5.1=2754$ for Medium range (Standard arrangement).

$CAC_{UIA(777)}$=60*9*7= 3780$ for Long range (Standard arrangement).

$CAC_{UIA(777)}$=60*13*5.1=3978$ for Medium range (Maximum arrangement).

$CAC_{UIA(777)}$=60*13*7= 5460$ for Long range (Maximum arrangement).

B767-300ER

$CAC_{UIA(767)}$=60*8*5.1=2448$ for Medium range (Standard arrangement).

$CAC_{UIA(767)}$=60*8*7= 3360$ for Long range (Standard arrangement).

$CAC_{UIA(767)}$=60*10*5.1=3060$ for Medium range (Maximum arrangement).

$CAC_{UIA(767)}$=60*10*7= 4200$ for Long range (Maximum arrangement).

B787-9

$CAC_{VA(787)}$=60*8*5 = 2400$ for Medium range (Standard arrangement).

$CAC_{VA(787)}$=60*8*7.5 =3600$ for Long range (Standard arrangement).

$CAC_{VA(787)}$=60*12*5 = 3600$ for Medium range (Maximum arrangement).

$CAC_{VA(787)}$=60*12*7.5 = 5400$ for Long range (Maximum arrangement).

A350-1000

$CAC_{VA(350)}$=60*11*5 = 3300$ for Medium range (Standard arrangement).

$CAC_{VA(350)}$=60*11*7.5 = 4950$ for Long range (Standard arrangement).

$CAC_{VA(350)}$=60*13*5 = 3900$ for Medium range (Maximum arrangement).

$CAC_{VA(350)}$=60*13*7.5 = 5850$ for Long range (Maximum arrangement).

A330-300

$CAC_{VA(330)}$=60*8*5 = 2400$ for Medium range (Standard arrangement).

$CAC_{VA(330)}$=60*8*7.5 =3600$ for Long range (Standard arrangement).

$CAC_{VA(330)}$=60*13*5= 3900$ for Medium range (Maximum arrangement).

$CAC_{VA(330)}$=60*13*7.5=5850$ for Long range (Maximum arrangement).

B777-200ER

Total crew cost $_{UIA(777)}$= 1938+2754 = 4692$ for Medium range (Standard arrangement).

Total crew cost $_{UIA(777)}$= 2660+3780 = 6440$ for Long range (Standard arrangement).

Total crew cost $_{UIA(777)}$= 1938+3978=5916$ for Medium range (Maximum arrangement).

Total crew cost $_{UIA(777)}$= 1938+5460=7398$ for Long range (Maximum arrangement).

B767-300ER

Total crew cost $_{UIA(767)}$= 1938+2448 = 4386$ for Medium range (Standard arrangement).

Total crew cost $_{UIA(767)}$= 2660+3360 = 6020$ for Long range (Standard arrangement).

Total crew cost $_{UIA(767)}$= 1938+3060 =4998$ for Medium range (Maximum arrangement).

Total crew cost $_{UIA(767)}$= 1938+4200 =6138$ for Long range (Maximum arrangement).

B787-9

Total crew cost $_{VA(787)}$= 1900+2400 = 4300$ for Medium range (Standard arrangement).

Total crew cost $_{VA(787)}$= 2850+3600 = 6450$ for Long range (Standard arrangement).

Total crew cost $_{VA(787)}$= 1900+3600 = 5500$ for Medium range (Maximum arrangement).

Total crew cost $_{VA(787)}$= 2850+5400 = 8250$ for Long range (Maximum arrangement).

A350-1000

Total crew cost $_{VA(350)}$= 1900+3300 = 5200$ for Medium range (Standard arrangement).

Total crew cost $_{VA(350)}$= 2850+4950 = 7800$ for Long range (Standard arrangement).

Total crew cost $_{VA(350)}$= 1900+3900 = 5800$ for Medium range (Maximum arrangement).

Total crew cost $_{VA(350)}$= 2850+5850 = 8700$ for Long range (Maximum arrangement).

A330-300

Total crew cost $_{VA(330)}$= 1900+2400 = 4300$ for Medium range (Standard arrangement).

Total crew cost $_{VA(330)}$= 2850+3600= 6450$ for Long range (Standard arrangement).

Total crew cost $_{VA(330)}$= 1900+3900= 5800$ for Medium range (Maximum arrangement).

Total crew cost $_{VA(330)}$= 2850+5850= 8700$ for Long range (Maximum arrangement).

Charges and fees are levied by governmental and airport authorities, and consist of two major components: NAVigation charges (NAV) and LAnding Fees (LAF). Eqs. (12), (13), (14) show how these are calculated in our analysis. Here, the study length is measured in kilometers and the Maximum TakeOff Weight (MTOW) is measured in tonnes. For each aircraft, MTOW data are compiled from Refs.[26;27;36]

$$Total\ Charges\ and\ Fees = NAV + LAF \tag{2.12}$$

$$NAV = 0.5 \times Study\ Length \times (MTOW \div 50^{0.5}) \tag{2.13}$$

$$LAF = 6 \times MTOW \tag{2.14}$$

B777-200ER

$NAV_{UIA(777)}$=0.5*3488*(254/$50^{0.5}$) = 62646 $ for Medium range.

$NAV_{UIA(777)}$=0.5*4552*(254/$50^{0.5}$) = 81756 $ for Long range.

B767-300ER

$NAV_{UIA(767)}$=0.5*3488*(187/$50^{0.5}$) = 46121 $ for Medium range.

$NAV_{UIA(767)}$=0.5*4552*(187/$50^{0.5}$) = 60190$ for Long range.

B787-9

$NAV_{VA(787)}$=0.5*3593*(254/$50^{0.5}$) = 64532 $ for Medium range.

$NAV_{VA(787)}$=0.5*5254*(254/$50^{0.5}$) = 94364 $ for Long range.

A350-1000

$NAV_{VA(350)}$=0.5*3593*(319/$50^{0.5}$) = 81046$ for Medium range.

$NAV_{VA(350)}$=0.5*5254*(319/$50^{0.5}$) = 118512$ for Long range.

A330-300

$NAV_{VA(330)}$=0.5*3593*(230/$50^{0.5}$) = 58434$ for Medium range.

$NAV_{VA(350)}$=0.5*5254*(230/$50^{0.5}$)= 85448$ for Long range.

B777-200ER

$LAF_{UIA(777)}$=6*254=1524$

B767-300ER

$LAF_{UIA(767)}$=6*187=1122$

B787-9

$LAF_{VA(787)}$= 6*254=1524$

A350-1000

$LAF_{VA(350)}$= 6*319=1914$

A330-300

$LAF_{VA(330)}$= 6*230=1380$

B777-200ER

Total Charges and Fees $_{UIA(777)}$= 62646+1524=64170$ for Medium range

Total Charges and Fees $_{UIA(777)}$= 81756+1524= 83280$ for Long range

B767-300ER

Total Charges and Fees $_{UIA(767)}$= 46121 +1122=47243$ for Medium range

Total Charges and Fees $_{UIA(767)}$= 60190+1122= 61312$ for Long range

B787-9

Total Charges and Fees $_{VA(787)}$= 64532+1524 = 66056$ for Medium range

Total Charges and Fees $_{VA(787)}$= 94364+1524 = 95888$ for Long range

A350-1000

Total Charges and Fees $_{VA(350)}$= 81046+1914= 82960$ for Medium range

Total Charges and Fees $_{VA(350)}$= 118512+1914= 120426$ for Long range

A330-300

Total Charges and Fees $_{VA(330)}$= 58434+1380= 59814$ for Medium range

Total Charges and Fees $_{VA(330)}$= 85448+1380= 86828$ for Long range

The Airframe Maintenance Cost (AMC) is the sum of the cost of AirFrame Labor (AFL) and airframe materials (AFM):

$$AMC = AFL + AFM \tag{2.15}$$

$$AFL = (0.09 \times AFW + 6.7 - \left(\frac{350}{AFW+75}\right)) \times (0.8 + 0.68 \times tf) \times Rlabor \tag{2.16}$$

$$AFM = AFP \times (4.2 + 2.2 \times tf) \tag{2.17}$$

B777-200ER

AFW $_{UIA(777)}$=142.4 – 7.9 = 134.5 t.

B767-300ER

AFW $_{UIA(767)}$=90 – 7 = 83 t.

B787-9

AFW $_{VA(787)}$= 128.8 – 6.15 = 122.65 t.

A350-1000

AFW $_{VA(350)}$= 118,1 – 7.55 = 110.55 t.

A330-300

AFW $_{VA(330)}$= 123.1 –7 = 116.1 t.

B777-200ER

$AFL_{UIA(777)}$= (0.09*134.5+6.7 – (350/(134.5+75)))*(0.8+0.68*4.85)*66 = 4634.29 $ for Medium range.

$AFL_{UIA(777)}$= (0.09*134.5+6.7 – (350/(134.5+75)))*(0.8+0.68*6.75)*66 = 6095.37$ for Long range.

B767-300ER

$AFL_{UIA(767)}$= (0.09*83+6.7 – (350/(83+75)))*(0.8+0.68*4.85)*66 = 3233$ for Medium range.

$AFL_{UIA(767)}$= (0.09*83+6.7 – (350/(83+75)))*(0.8+0.68*6.75)*66 = 4252$ for Long range.

B787-9

$AFL_{VA(787)}$ = (0.09*122.65+6.7 – (350/(122.65+75)))*(0.8+0.68*4.75)*66 = 4247.08$ for Medium range.

$AFL_{VA(787)}$ = (0.09*122.65+6.7 – (350/(122.65+75)))*(0.8+0.68*7.25)*66 = 6038.66 $ for Long range.

A350-1000

$AFL_{VA(350)}$ = (0.09*110.55+6.7 – (350/(110.55+75)))*(0.8+0.68*4.75)*66 = 3926$ for Medium range.

$AFL_{VA(350)}$ = (0.09*110.55+6.7 – (350/(110.55+75)))*(0.8+0.68*7.25)*66 = 5583$ for Long range.

A330-300

$AFL_{VA(330)}$ = (0.09*116.1+6.7 – (350/(116.1+75)))*(0.8+0.68*4.75)*66 = 4074$ for Medium range.

$AFL_{VA(330)}$ = (0.09*116.1+6.7 – (350/(116.1+75)))*(0.8+0.68*7.25)*66 = 5792$ for Long range.

B777-200ER

$AFP_{UIA(777)}$= 306.6- 30 = 276.6$

B767-300ER

$AFP_{UIA(767)}$= 217.9- 28= 189.9$

B787-9

$AFP_{VA(787)}$=442.2- 26.8= 415.4$

A350-1000

$AFP_{VA(350)}$=366.5- 40= 326.5$

A330-300

$AFP_{VA(330)}$=264.2- 28= 236.2$

B777-200ER

$AFM_{UIA(777)}$= 276.6*(4.2+2.2*4.85) = 4113.042 for Medium range.

$AFM_{UIA(777)}$= 276.6*(4.2+2.2*6.75) = 5269.23 for Long range.

B767-300ER

$AFM_{UIA(767)}$= 189.9*(4.2+2.2*4.85) = 2823.813 for Medium range.

$AFM_{UIA(767)}$= 189.9*(4.2+2.2*6.75) = 3617.595 for Long range.

B787-9

$AFM_{VA(787)}$= 415.4*(4.2+2.2*4.75) = 6085.61 for Medium range.

$AFM_{VA(787)}$= 415.4*(4.2+2.2*7.25) = 8370.31 for Long range.

A350-1000

$AFM_{VA(350)}$= 326.5*(4.2+2.2*4.75) = 4783.225 for Medium range.

$AFM_{VA(350)}$= 326.5*(4.2+2.2*7.25) = 6578.975 for Long range.

A330-300

$AFM_{VA(330)}$= 236.2*(4.2+2.2*4.75) = 3460.33 for Medium range.

$AFM_{VA(330)}$= 236.2*(4.2+2.2*7.25) = 4759.43 for Long range.

B777-200ER

$AMC_{UIA(777)}$= 4634.29 + 4113.042 = 8747.332$ for Medium range.

$AMC_{UIA(777)}$= 6095.37 + 5269.23 = 11364.6$ for Long range.

B767-300ER

$AMC_{UIA(767)}$= 3233+ 2823.813=6056.813$ for Medium range.

$AMC_{UIA(767)}$= 4252+ 3617.595 = 7869.595$ for Long range.

B787-9

$AMC_{VA(787)}$= 4247.08+ 6085.61 = 10332.69$ for Medium range.

$AMC_{VA(787)}$=6038.66 + 8370.31 = 14408.97$ for Long range.

A350-1000

$AMC_{VA(350)}$= 3926+ 4783.225 = 8709.225$ for Medium range.

AMC $_{VA(350)}$= 5583+ 6578.975 = 12161.975$ for Long range.

A330-300

AMC $_{VA(330)}$= 4074+ 3460.33 = 7534.33$ for Medium range.

AMC $_{VA(330)}$= 5792+ 4759.43 = 10551.43$ for Long range.

where t_f is the flight time, AFW is the airframe weight, Rlabor is the labor rate (USD66 as per Ref.33), and MWE is the manufacturer's weight empty. AFP is the airframe price, which is equal to the MSP less the price of engines. The flight time is 0.25 hours less than the block time (tf = tblock − 0.25) and AFW is defined as MWE less the weight of engines.[38] All weight is taken in tonnes. The relevant data are collected from Refs.[26;27;36]

The Engine Maintenance Cost (EMC) is defined as the sum of cost of Engine Maintenance Labor (EML) and Engine Maintenance Material (EMM), as calculated with Eqs. (18), (19), (20):

$$EMC = ne \times (EML + EMM) \times (tf + 1.3) \quad (2.18)$$

$$EML = 0.21 \times C1 \times C3 \times (1 + Tsl)^{0.4} \times Rlabor \quad (2.19)$$

$$EMM = 2.56 \times (1 + Tsl)^{0.8} \times C1 \times (C2 + C3) \quad (2.20)$$

B777-200ER

EML $_{UIA(777)}$= 0.21*0.47*1.018*(1*468)$^{0.4}$*66 = 77.5

B767-300ER

EML $_{UIA(767)}$= 0.21*0.01*1.082*(1*441)$^{0.4}$*66 = 45

B787-9

EML $_{UIA(787)}$= 0.21*0.53*0.986*(1*298)$^{0.4}$*66 = 70.7

A350-1000

EML $_{UIA(350)}$= 0.21*0.53*0.986*(1*431)$^{0.4}$*66 = 82

A330-300

EML $_{UIA(330)}$= 0.21*0.53*0.986*(1*441)$^{0.4}$*66 = 45

B777-200ER

EMM $_{UIA(777)}$= 2.56*(1+468)$^{0.8}$*0.47*(1.38+1.018) = 395.8

B767-300ER

EMM $_{UIA(767)}$= 2.56*(1+441)$^{0.8}$*0.47*(1.38+1.018) = 377.1

B787-9

EMM $_{UIA(787)}$= 2.56*(1+298)$^{0.8}$*0.53*(1.42+0.986) = 312.1

A350-1000

EMM $_{UIA(350)}$= 2.56*(1+431)$^{0.8}$*0.53*(1.42+0.986) = 418.9

A330-300

EMM $_{UIA(330)}$= 2.56*(1+441)$^{0.8}$*0.53*(1.42+0.986) = 426.7

B777-200ER

EMC $_{UIA(777)}$=2*(77.5+395.8) * (4.85+1.3) = 5821.59$ for Medium range.

EMC $_{UIA(777)}$=2*(77.5+395.8) * (6.75+1.3) = 7620.13$ for Long range.

B767-300ER

EMC $_{UIA(767)}$=2*(45+377.1) * (4.85+1.3) = 5191.83$ for Medium range.

EMC $_{UIA(767)}$=2*(45+377.1) * (6.75+1.3) = 6795.81$ for Long range.

B787-9

EMC $_{UIA(787)}$= 2*(70.7+312.1) * (4.75+1.3) = 4631.88$ for Medium range.

EMC $_{UIA(787)}$= 2*(70.7+312.1) * (7.25+1.3) = 6545.88$ for Long range.

A350-1000

EMC $_{UIA(350)}$= 2*(82+418.9) * (4.75+1.3) = 6060.89$ for Medium range.

EMC $_{UIA(350)}$= 2*(82+418.9) * (7.25+1.3) = 8565.39$ for Long range.

A330-300

EMC $_{UIA(330)}$= 2*(45+426.7) * (4.75+1.3) = 5707.57$ for Medium range.

EMC $_{UIA(330)}$= 2*(45+426.7) * (7.25+1.3) = 8066.07$ for Long range.

where T_{sl} is the engine thrust at sea level, and C1, C2 and C3 are constants defined by the engine specification:

$$C1 = 0.2 \times BPR - 1.27 \tag{2.21}$$

$$C2 = 0.4 \times (OPR \div 20)^{1.3} + 0.4 \tag{2.22}$$

$$C3 = 0.032 \times nc + 0.57 \tag{2.23}$$

B777-200ER

$C1_{(777)} = 0.2* 8.7- 1.27= 0.47$

B767-300ER

$C1_{(767)} = 1.270.2* 6.4- 1.27 = 0.01$

B787-9

$C1_{(787)} = 0.2* 9- 1.27 = 0.53$

A350-1000

$C1_{(350)} = 0.2* 9.6- 1.27 = 0.65$

A330-300

$C1_{(330)} = 0.2* 6.4 -1.27 = 0.001$

B777-200ER

$C2_{(777)}= 0.4*(40/20)^{1.3}+0.4 = 1.38$

B767-300ER

$C2_{(767)}= 0.4*(42.8/20)^{1.3}+0.4 = 1.47$

B787-9

$C2_{(787)}= 0.4*(42/20)^{1.3}+0.4 = 1.42$

A350-1000

$C2_{(350)}= 0.4*(50/20)^{1.3}+0.4 = 1.71$

A330-300

$C2_{(330)}= 0.4*(42.8/20)^{1.3}+0.4 = 1.47$

B777-200ER

$C3_{(777)}= 0.032* 14 + 0.57 = 1.018$

B767-300ER

$C3_{(767)}= 0.032* 16 + 0.57 = 1.082$

B787-9

$C3_{(787)}= 0.032* 13 + 0.57 = 0.986$

A350-1000

$C3_{(350)}= 0.032* 15 + 0.57 = 1.05$

A330-300

$C3_{(330)}= 0.032* 16 + 0.57 = 1.082$

where BPR is the bypass ratio, OPR is the overall pressure ratio, and n_c is the number of compressor stages. Data on the engine specifications are collected from Refs.[34],[35] It is worth mentioning that, perhaps counterintuitively, increasing the number of engines on an aircraft does not necessarily lead to a significant increase in the EMC as a percentage of the total DOC, because this effect is partially offset by a decrease in T_{sl} per engine.

As mentioned above, the cost of jet fuel fluctuates over time. The fuel cost is represented by Eq. (24), where F_{block} is the block fuel:

$$Fuel\ cost = Fuel\ Price \times Fblock \div 6.7 \quad (2.24)$$

It is worth noting that the fuel price in this equation varies as was mentioned above and is in units of USD per Kilogram. The block fuel, F_{block}, is calculated by multiplying the average fuel burn per seat-km (see Table 2.1; 2.2) and the seat number (see Table 2.3). The initial date for F_{block} was taken from [35;26;27]. While it is recognized that the actual fuel burn per seat-km varies depending on the flight conditions (e.g. altitude and speed), aircraft configuration (e.g. standard or maximum seating arrangement) and passenger load factor, we use an average value for the fuel burn per seat-nm, partly to simplify the analysis and partly to be consistent with the AEA method of calculating the Ref.[28] In this study, the average fuel burn per seat-nm for each aircraft is calculated from data provided by Boeing. [26;27]

B777-200ER

$F_{block(777)}$ =2.06*313 = 644.78 (Standard arrangement).

$F_{block(777)}$ =2.06*440 = 906.4 (Maximum arrangement).

B767-300ER

$F_{block(767)}$ =2.2 *261 = 574.2 (Standard arrangement).

$F_{block(767)}$ =2.2*351 = 772.2 (Maximum arrangement).

B787-9

$F_{block(787)}$ =1.69*290 = 490.1 (Standard arrangement).

$F_{block(787)}$ =1.69*420 = 709.8 (Maximum arrangement).

A350-1000

$F_{block(350)}$ =1.72*366 = 629.52 (Standard arrangement).

$F_{block(350)}$ =1.72*440 = 756.8 (Maximum arrangement).

A330-300

$F_{block(330)}$ = 2.12*277 = 587.24 (Standard arrangement).

$F_{block(330)}$ = 2.12*440 = 932.8 (Maximum arrangement).

B777-200ER

Fuel $cost_{(777)}$ = 3.89*644.78/6.7 = 374.3 (Standard arrangement).

Fuel $cost_{(777)}$ = 1.74*644.78 /6.7 = 167.4 (Standard arrangement).

Fuel $cost_{(777)}$ = 0.93*644.78 /6.7 = 89.4 (Standard arrangement).

Fuel $cost_{(777)}$ = 3.89*906.4 /6.7 = 526.2 (Maximum arrangement).

Fuel $cost_{(777)}$ = 1.74*906.4 /6.7 = 235.3 (Maximum arrangement).

Fuel $cost_{(777)}$ = 0.93*906.4 /6.7 = 125.8 (Maximum arrangement).

B767-300ER

Fuel $cost_{(767)}$ = 3.89*574.2 /6.7 = 333.3 (Standard arrangement).

Fuel $cost_{(767)}$ = 1.74*574.2 /6.7 = 149.1 (Standard arrangement).

Fuel $cost_{(767)}$ = 0.93*574.2 /6.7 = 79.7 (Standard arrangement).

Fuel $cost_{(767)}$ = 3.89*772.2 /6.7 = 448.3 (Maximum arrangement).

Fuel $cost_{(767)}$ = 1.74*772.2 /6.7 = 200.5 (Maximum arrangement).

Fuel $cost_{(767)}$ = 0.93*772.2 /6.7 = 107.1 (Maximum arrangement).

B787-9

Fuel $cost_{(787)}$ = 3.89*490.1/6.7 = 284.5 (Standard arrangement).

Fuel $cost_{(787)}$ = 1.74*490.1/6.7 = 127.2 (Standard arrangement).

Fuel $cost_{(787)}$ = 0.93*490.1/6.7 = 68 (Standard arrangement).

Fuel $cost_{(787)}$ = 3.89*709.8/6.7 = 412.1 (Maximum arrangement).

Fuel $cost_{(787)}$ = 1.74*709.8/6.7 = 184.3 (Maximum arrangement).

Fuel $cost_{(787)}$ = 0.93*709.8/6.7 = 98.5 (Maximum arrangement).

A350-1000

Fuel $cost_{(350)}$ = 3.89*629.52/6.7 = 365.4 (Standard arrangement).

Fuel $cost_{(350)}$ = 1.74*629.52/6.7 = 163.4 (Standard arrangement).

Fuel $cost_{(350)}$ = 0.93*629.52 /6.7 = 87.3 (Standard arrangement).

Fuel $cost_{(350)}$ = 3.89*756.8 /6.7 = 439.3 (Maximum arrangement).

Fuel $cost_{(350)}$ = 1.74*756.8 /6.7 = 196.5 (Maximum arrangement).

Fuel $cost_{(350)}$ = 0.93*756.8 /6.7 = 105 (Maximum arrangement).

A330-300

Fuel $cost_{(330)}$ = 3.89*587.24 /6.7 = 340.9 (Standard arrangement).

Fuel $cost_{(330)}$ = 1.74*587.24 /6.7 = 152.5 (Standard arrangement).

Fuel $cost_{(330)}$ = 0.93*587.24 /6.7 = 81.5 (Standard arrangement).

Fuel $cost_{(330)}$ = 3.89*932.8 /6.7 = 541.5 (Maximum arrangement).

Fuel $cost_{(330)}$ = 1.74*932.8 /6.7 = 242.2 (Maximum arrangement).

Fuel $cost_{(330)}$ = 0.93*932.8 /6.7 = 129.4 (Maximum arrangement).

Having considered all of the key factors making up the DOC, we consolidate that information by expressing the DOC of each aircraft as follows:

$$DOC = Total\ Financial\ Cost + Total\ Crew\ Cost + Total\ Charhes\ and\ Fees + Total\ Maintenance\ Cost(AMC, EMC) + Fuel\ Cos\ + Extra\ Costs \tag{2.25}$$

where the extra costs are neglected in this study for simplicity.

B777-200ER

DOC_{777}= 76559 + 4692+ 64170 + 8747.332 + 5821.59 + 374.3 = 160364.222 High Fuel Price (for Medium range); (Standard arrangement).

DOC_{777}= 76559 + 4692 + 64170 + 8747.332 + 5821.59 + 167.4 = 160157.322 Normal Fuel Price (for Medium range); (Standard arrangement).

DOC_{777} = 76559 + 4692 + 64170 + 8747.332 + 5821.59 + 89.4= 160079.322 Lowest Fuel Price (for Medium range); (Standard arrangement).

DOC_{777}= 76559 + 5916 + 64170 + 8747.332 + 5821.59 + 526.2 = 161740.122 High Fuel Price (for Medium range); (Maximum arrangement).

DOC_{777}= 76559 + 5916 + 64170 + 8747.332 + 5821.59 + 235.3 = 161449.222 Normal Fuel Price (for Medium range); (Maximum arrangement).

DOC_{777} = 76559 + 5916 + 64170 + 8747.332 + 5821.59 + 125.8= 161339.722 Lowest Fuel Price (for Medium range); (Maximum arrangement).

DOC_{777}= 92341 + 6440 + 83280 + 11364.6 + 7620.13 + 374.3 = 201420.03 High Fuel Price (for Long range); (Standard arrangement).

DOC_{777}= 92341 + 6440 + 83280 + 11364.6 + 7620.13 + 167.4 = 201213.13 Normal Fuel Price (for Long range); (Standard arrangement).

DOC_{777}= 92341 + 6440 + 83280 + 11364.6 + 7620.13 + 89.4 = 201135.13 Lowest Fuel Price (for Long range); (Standard arrangement).

DOC_{777}= 92341 + 7398 + 83280 + 11364.6 + 7620.13 + 526.2 = 202529.93 High Fuel Price (for Long range); (Maximum arrangement).

DOC_{777}= 92341 + 7398 + 83280 + 11364.6 + 7620.13 + 235.3 = 202239.03 Normal Fuel Price (for Long range); (Maximum arrangement).

DOC_{777}= 92341 + 7398 + 83280 + 11364.6 + 7620.13 + 125.8 = 202129.53 Lowest Fuel Price (for Long range); (Maximum arrangement).

B767-300ER

DOC_{767}= 54666 + 4386 + 47243 + 6056.813+ 5191.83 + 333.3 = 117876.943 High Fuel Price (for Medium range); (Standard arrangement).

DOC_{767}= 54666 + 4386 + 47243 + 6056.813+ 5191.83 + 149.1 = 117692.743 Normal Fuel Price (for Medium range); (Standard arrangement).

DOC_{767} = 54666 + 4386 + 47243+ 6056.813+ 5191.83 + 79.7 = 117623.343 Lowest Fuel Price (for Medium range); (Standard arrangement).

DOC_{767}= 54666 + 4998 + 47243 + 6056.813+ 5191.83 + 448.3 = 118603.943 High Fuel Price (for Medium range); (Maximum arrangement).

DOC_{767}= 54666 + 4998 + 47243+ 6056.813+ 5191.83 + 200.5 = 118356.143 Normal Fuel Price (for Medium range); (Maximum arrangement).

DOC_{767} = 54666 + 4998 + 47243+ 6056.813+ 5191.83 + 107.1 = 118262.743 Lowest Fuel Price (for Medium range); (Maximum arrangement).

DOC_{767}= 65935 + 6020+ 61312 + 7869.595+ 6795.81 + 333.3 = 148265.705 High Fuel Price (for Long range); (Standard arrangement).

DOC_{767}= 65935 + 6020+ 61312 + 7869.595+ 6795.81 +149.1 = 148081.505 Normal Fuel Price (for Long range); (Standard arrangement).

DOC_{767}= 65935 + 6020 + 61312 + 7869.595+ 6795.81 + 79.7 = 148012.105 Lowest Fuel Price (for Long range); (Standard arrangement).

DOC_{767}= 65935 + 6138 + 61312+ 7869.595+ 6795.81 + 448.3 = 148498.705 High Fuel Price (for Long range); (Maximum arrangement).

DOC_{767}= 65935 + 6138 + 61312 + 7869.595+ 6795.81 + 200.5 = 148250.905 Normal Fuel Price (for Long range); (Maximum arrangement).

DOC_{767}= 65935 + 6138 + 61312+ 7869.595+ 6795.81 + 107.1 = 148157.505 Lowest Fuel Price (for Long range); (Maximum arrangement).

B787-9

DOC_{787}= 108242+4300 + 66056 + 10332.69 + 4631.88 + 284.5 = 193846.57 High Fuel Price (for Medium range); (Standard arrangement).

DOC_{787}= 108242+ 4300+ 66056 + 10332.69 + 4631.88 + 127.2 = 193689.77 Normal Fuel Price (for Medium range); (Standard arrangement).

DOC_{787} = 108242 + 4300 + 66056 + 10332.69 + 4631.88 + 68 = 193630.57 Lowest Fuel Price (for Medium range); (Standard arrangement).

DOC_{787}= 108242 + 5500 + 66056 + 10332.69 + 4631.88 + 412.1 = 195174.67 High Fuel Price (for Medium range); (Maximum arrangement).

DOC_{787}= 108242 + 5500 + 66056 + 10332.69 + 4631.88 +184.3= 194946.87 Normal Fuel Price (for Medium range); (Maximum arrangement).

DOC_{787} = 108242 + 5500 + 66056 + 10332.69 + 4631.88 + 98.5= 194861.07 Lowest Fuel Price (for Medium range); (Maximum arrangement).

DOC_{787}= 139333 + 6450 + 95888 + 14408.97 + 6545.88 + 284.5 = 262910.35 High Fuel Price (for Long range); (Standard arrangement).

DOC_{787}= 139333 + 6450 + 95888+ 14408.97 + 6545.88 + 127.2 = 262753.05 Normal Fuel Price (for Long range); (Standard arrangement).

DOC_{787}= 139333 + 6450 + 95888+ 14408.97 + 6545.88 + 68 = 262693.85 Lowest Fuel Price (for Long range); (Standard arrangement).

DOC_{787}= 139333 + 8250 + 95888+ 14408.97 + 6545.88 + 412.1 = 264837.95 High Fuel Price (for Long range); (Maximum arrangement).

DOC_{787}= 139333 + 8250 + 95888 + 14408.97 + 6545.88 + 184.3 = 264610.15 Normal Fuel Price (for Long range); (Maximum arrangement).

DOC_{787}= 139333 + 8250 + 95888 + 14408.97 + 6545.88 + 98.5 = 264524.35 Lowest Fuel Price (for Long range); (Maximum arrangement).

A350-1000

DOC_{350}= 90254+ 5200 + 82960+ 8709.2 + 6060.89 + 365.4 = 193549.49 High Fuel Price (for Medium range); (Standard arrangement).

DOC_{350}= 90254+ 5200 + 82960 + 8709.2 + 6060.89 + 163.4 = 193347.49 Normal Fuel Price (for Medium range); (Standard arrangement).

DOC_{350} = 90254 + 5200 + 82960 + 8709.2 + 6060.89 + 87.3= 193271.39 Lowest Fuel Price (for Medium range); (Standard arrangement).

DOC_{350}= 90254 + 5800+ 82960 + 8709.2 + 6060.89 + 439.3 = 194223.39 High Fuel Price (for Medium range); (Maximum arrangement).

DOC_{350}= 90254 + 5800 + 82960 + 8709.2 + 6060.89 + 196.5 = 193980.59 Normal Fuel Price (for Medium range); (Maximum arrangement).

DOC_{350} = 90254 + 5800 + 82960 + 8709.2 + 6060.89 + 105 = 193889.09 Lowest Fuel Price (for Medium range); (Maximum arrangement).

DOC_{350}= 122692+ 7800+ 120426 + 12161.975 + 8565.39 + 365.4 = 272010.765 High Fuel Price (for Long range); (Standard arrangement).

DOC_{350}= 122692 + 7800 + 120426 + 12161.975 + 8565.39 + 163.4 = 271808.765 Normal Fuel Price (for Long range); (Standard arrangement).

DOC_{350}= 122692 + 7800+ 120426 + 12161.975 + 8565.39 + 87.3 = 271732.665 Lowest Fuel Price (for Long range); (Standard arrangement).

DOC_{350}= 122692+ 8700 + 120426 + 12161.975 + 8565.39 + 439.3 = 272984.365 High Fuel Price (for Long range); (Maximum arrangement).

DOC_{350}= 122692+ 8700 + 120426 + 12161.975 + 8565.39 + 196.5 = 272741.365 Normal Fuel Price (for Long range); (Maximum arrangement).

DOC_{350}= 122692+ 8700+ 120426 + 12161.975 + 8565.39 + 105 = 272650.365 Lowest Fuel Price (for Long range); (Maximum arrangement).

A330-300

DOC_{330}= 65036+ 4300+ 59814 + 7534.33 + 5707.57 + 340.9 = 142732.8 High Fuel Price (for Medium range); (Standard arrangement).

DOC_{330}= 65036+ 4300 + 59814 + 7534.33 + 5707.57 +152.5 = 142544.4 Normal Fuel Price (for Medium range); (Standard arrangement).

DOC_{330} = 65036 + 4300+ 59814 + 7534.33 + 5707.57 + 81.5= 142473.4 Lowest Fuel Price (for Medium range); (Standard arrangement).

DOC_{330}= 65036 + 5800+ 59814+ 7534.33 + 5707.57 + 541.5 = 144433.4 High Fuel Price (for Medium range); (Maximum arrangement).

DOC_{330}= 65036+ 5800+ 59814 + 7534.33 + 5707.57 + 242.2 = 144134.1 Normal Fuel Price (for Medium range); (Maximum arrangement).

DOC_{330} = 65036 + 5800+ 59814+ 7534.33 + 5707.57 + 129.4 = 144021.3 Lowest Fuel Price (for Medium range); (Maximum arrangement).

DOC_{330}= 83717+ 6450 + 86828 + 10551.43 + 8066.07 + 340.9 = 195953.4 High Fuel Price (for Long range); (Standard arrangement).

DOC_{330}= 83717+ 6450 + 86828 + 10551.43 + 8066.07 + 152.5 = 195764.5 Normal Fuel Price (for Long range); (Standard arrangement).

DOC_{330}= 83717 + 6450+ 86828 + 10551.43 + 8066.07 + 81.5 = 195694 Lowest Fuel Price (for Long range); (Standard arrangement).

DOC_{330}= 83717+ 8700+ 86828+ 10551.43 + 8066.07 + 541.5 = 198404 High Fuel Price (for Long range); (Maximum arrangement).

DOC_{330}= 83717+ 8700+ 86828+ 10551.43 + 8066.07 + 242.2 = 198104.7 Normal Fuel Price (for Long range); (Maximum arrangement).

DOC_{330}= 83717+ 8700+ 86828 + 10551.43 + 8066.07 + 129.4 = 197991.9

Lowest Fuel Price (for Long range); (Maximum arrangement).

Table 2.6

DOC for Medium range flights and Standard arrangement of seats in (USD)

Type of aircraft	Lowe Fuel Price	Normal Fuel Price	High Fuel Price
Boeing 777-200ER	160079.322	160157.322	160364.222
Boeing 787-9	193630.57	193689.77	193846.57
B767-300ER	117623.343	117692.743	117876.943
A350-1000	193271.39	193347.49	193549.49
A330-300	142473.4	142544.4	142732.8

Table 2.7

DOC for Medium range flights and Maximum arrangement of seats (USD)

Type of aircraft	Lowe Fuel Price	Normal Fuel Price	High Fuel Price
Boeing 777-200ER	161339.722	161449.222	161740.122
Boeing 787-9	194861.07	194946.87	195174.67
B767-300ER	118262.743	118356.143	118603.943
A350-1000	193889.09	193980.59	194223.39
A330-300	144021.3	144134.1	144433.4

Table 2.8

DOC for Long range flights and Standard arrangement of seats in (USD)

Type of aircraft	Lowe Fuel Price	Normal Fuel Price	High Fuel Price
Boeing 777-200ER	201135.13	201213.13	201420.03
Boeing 787-9	262693.85	262753.05	262910.35
B767-300ER	148012.105	148081.505	148265.705
A350-1000	271732.665	271808.765	272010.765
A330-300	195694	195764.5	195953.4

Table 2.9

DOC for Long range flights and Maximum arrangement of seats in (USD)

Type of aircraft	Lowe Fuel Price	Normal Fuel Price	High Fuel Price
Boeing 777-200ER	202129.53	202239.03	202529.93
Boeing 787-9	264524.35	264610.15	264837.95
B767-300ER	148157.505	148250.905	148498.705
A350-1000	272650.365	272741.365	272984.365
A330-300	197991.9	198104.7	198404

The results of our DOC analysis. Please take a look at few tables above 2.6; 2.7; 2.8; 2.9 which are showing a different flight range: medium range and long range. The DOC per n. mile-pax, for the standard and maximum seating arrangements. These Tables can be used to identify the most cost-efficient wide-body aircraft type when a given number of passengers is to be expected.

The medium range flight analyzed in this study was between Kyiv Boryspil International Airport and Dubai international airport for Boeing 777-200ER and B767-300ER the wide-body aircraft which are in used of UIA. Regarding Virgin Atlantic the medium range was provided on the route London Heathrow International Airport to Ben Gurion Airport for Boeing 787-9, A350-1000 and A330-300.

When configured in the standard seating arrangement, the Boeing B767-300ER is the most cost-efficient wide-body aircraft on medium haul routes in the 350-passenger market, regardless of fuel price. The same result is with maximum seat arrangement on a medium haul route. Boeing B767-300ER is showing the most cost-efficiency on the background of other aircraft.

The long range flight analyzed in this study was that between Kyiv Boryspil International Airport to Delhi International Airport for Boeing 777-200ER and B767-300ER. Regarding Virgin Atlantic long range flight analyzed in this study was that between London Heathrow International Airport to Boston Logan International Airport for Boeing 787-9, A350-1000 and A330-300.

The Boeing B767-300ER once again comes out on top, with the lowest DOC at the 350-passenger point regardless of seating arrangement.

As a result of the calculations it is proved that the use of Direct Operating Cost for aircraft allows obtaining optimal parameters of its operation on the existing or promising network of air routes. The calculations are showing that the DOC per n. mile-pax for Boeing 777-200ER, B767-300ER Boeing 787-9, A350-1000, A330-300 wide-body passenger aircraft configured in the standard and maximum seating arrangement the most cost-efficient wide-body aircraft, as measured in terms of the lowest DOC per n mile-pax under the specific assumptions of this study, was found to be B767-300ER for 261–351 passengers operated by UIA on their main routes. These results were found to be fairly insensitive to fuel price and to whether the route distance is medium (between 1000 and 2000 n mile), long (between 2000 and 6000 n mile).

SUMMARY

Air Transportation Management Department				*NAU.21.06.98 002 EN*					
Done by:	Hrytsiuk B.M.			*SUMMARY*	Letter			Sheet.	Sheets
Supervisor	Akmaldinova V.Ye.						D	92	4
Standards Inspector	Yuliia V. Shevchenko				***FTML 275 ОП- 403Ба***				
Head of the Department	Shevchuk D. O								

Airlines are safer and more profitable mode of transport in modern times than any time in history, but the industry must innovate much more rapidly in order to secure its environmental and financial viability & Safety and Convenience in the future. Aviation Industry plays a key role in the progress of the economy of the country by contributing as a major revenue earning player of the business society and hence it is quite important to dig deep to entail hidden facts of this aspect.

Due to the fact of being the fastest mode of travel, aviation industry is beingused as a preferred mode of travel and thus creating a large chunk of revenue for the economy. Asia is one of the regions where the air travel is being used by many residents for the first time to travel abroad and thus aviation industry has more opportunities to generate more revenues and jobs for the region.

Aviation industry brings people together like families, friends and business colleagues. It also creates a platform where people meet to share ideas with each other. It has made travel so short and flexible that travelers can reach to their destination within 24 hours. Although there are few major challenges also in aviation industry such as safety, convenience, environmental and financial sustainability.

We were faced with one on the strongest and the most complicated challenge for aviation in general. It is difficult to overstate the effect of the COVID-19 pandemic on commercial aviation. In the months since the new strain of coronavirus that causes COVID-19 first emerged, passenger air travel has come to a near standstill. Air carriers around the world are facing extreme financial pressures and are cutting capacity at unparalleled rates in the absence of meaningful passenger demand. Some airlines have shut down completely, a portion of these may never return.

The poor and bad economic recovery from the coronavirus pandemic continues to challenge airline strategies on how much capacity they need to maintain, given unpredictable demand. After pulling almost 70 percent of the global fleet out of service between January and early April, carriers now may be erring on the other side — putting too many planes back online before reliable demand materializes.

The large numbers of older aircraft returning to service may mean more deferrals and cancellations, especially as airlines diligently protect their cashflow.

Major manufacturers have announced production cutbacks and layoffs. Aerospace production rates already exceed airline demand for new deliveries and are likely to remain at reduced levels for four years at least, as the market works through inventory.

The only segment that may benefit from an older fleet will be the maintenance, repair, and overhaul (MRO) aftermarket. Older aircraft would suggest more maintenance needs over the short run.

In the project part the solution of problems concerning efficiency of functioning of system of passenger transportations is offered. This is especially true in post Covid-19 times. Air carriers need to optimally calculate costs on all available routes. As the number of routes is limited due to low demand and financial instability after Covid, it is especially necessary to carefully select aircraft for certain routes based on the following indicators: the intensity of incoming passengers and specific routes, choosing the optimal type of aircraft depending on the route, range, cost fuel, other operating expenses and passenger incoming flow.

The method of direct operating cost management makes it possible to make reasonable management decisions by placing the aircraft on the route and maneuvering the resources of the airline's fleet depending on the intensity of the incoming flow of passengers.

The calculations are showing that the DOC per n. mile-pax for Boeing 777-200ER, B767-300ER Boeing 787-9, A350-1000, A330-300 wide-body passenger aircraft configured in the standard and maximum seating arrangement the most cost-efficient wide-body aircraft, as measured in terms of the lowest DOC per n mile-pax under the specific assumptions of this study, was found to be B767-300ER for 261–351 passengers operated by UIA on researched route. These results were found to be fairly insensitive to fuel price and to whether the route distance is medium (between 1000 and 2000 n mile), long (between 2000 and 6000 n mile).

REFERENCES

1. Perederiy V.V. Research of strategic priorities of development of aviation companies and ways to increase their competitiveness / V.V. Perederiy // Scientific works of the National University of Food Technologies / Nat. un-t food. technologies. - K., 2013. - №48. - P. 202-208.

2. Revutska T.V. Formation of tariffs at interaction of the transport forwarding enterprise with subjects of the market of air transportations [Text]: the dissertation of the candidate. econ. Sciences: 08.07.04 / Revutska T.V; National Aviation University - K., 2004. - 170 sheets. page 17

3. Smerichevsky S.F. Peculiarities of transformation of the world market of air transportation / Smerichevsky S.F, Mikhalchenko IG // Scientific Bulletin of Uzhhorod University. Series: Economics: a collection of scientific works / Uzhhorod. nat. un-t. - Uzhhorod, 2015. - Issue. 2 (46). - P. 29-37

4. Chyhrynets O.A. Methods of forecasting the volume of transport services / Nat. transp un-t. - K., 2000. - 11 p.

5. Aviation data and economic analysis [Electronic resource], - Access mode: https://www.icao.int/annual-report-2016/Pages/RU/progress-on-icaos-strategic-objectives-economic-development-icao-aviation-data.aspx

6. GROWTH AND FORECAST 2020– 2039 [Electronic resource], - Access mode: https://www.grupooneair.com/analysis-global-growth-commercial-aviation/#fleet

7. International Monetary Fund [Electronic resource], - Access mode: https://www.imf.org/en/Publications/WEO/Issues/2020/06/24/WEOUpdateJune2020,free

8. The World Tourism Organization [Electronic resource], – Access mode: https://www.unwto.org/statistics

9. Global Market Forecast – Airbus [Electronic resource]. - Access mode: https://www.airbus.com/content/dam/corporate-topics/strategy/global-market-forecast/GMF-2019-2038-Airbus-Commercial-Aircraft-book.pdf

10. IATA: Value of Aviation for Regions & Countries [Electronic resource], – Access mode: https://www.iata.org/en/policy/business-freedom/value-for-regions/#tab-1

11. Boeing Commercial Market Outlook 2020–2039 [Electronic resource], – Access mode: https://www.boeing.com/commercial/market/commercial-market-outlook/

12. FAA Aerospace Forecasts FY 2017 [Electronic resource], - Access mode: https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/fy2017-37_faa_aerospace_forecast.pdf

13. GAMA - Quarterly Shipments and Billings (2017) [Electronic resource], – Access mode: https://gama.aero/facts-and-statistics/quarterly-shipments-and-billings/

14. Commercial Aircraft Market - Global Industry Analysis, Size, Share, Growth, Trends, and Forecast 2019 – 2027 [Electronic resource], – Access mode: https://www.transparencymarketresearch.com/commercial-aircraft-market.html

15. GLOBAL FLEET AND MRO MARKET FORECAST 2021-2031 [Electronic resource], – Access mode:

https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2021/jan/Global_FLeet_and_MRO_Market_Forecast_2021-2031.pdf

16. UAI official site. UIA BACKGROUND [Electronic resource], – Access mode: https://www.flyuia.com/ua/en/about/uia-about

17. Planespotters ,[Electronic resource], – Access mode:

https://www.planespotters.net/

18. Virgin Atlantic [Electronic resource], – Access mode:

https://www.virginatlantic.com/

19. Harasani, W. I. (2006) 'Evaluation and Selection of a Fleet of Aircraft for a Local Airline', Journal of King Abdulaziz University: Engineering Sciences, 17(2), pp. [Electronic resource], – Access mode:

https://www.kau.edu.sa/Files/320/Researches/52703_23009.pdf

20. Pai, V. (2010) ‘On the factors that affect airline flight frequency and aircraft size, Journal of Air Transport Management. Elsevier Ltd, 16(4), pp. 169–177. [Electronic resource] , – Access mode:

https://core.ac.uk/download/pdf/6340135.pdf

21. Givoni, M. and Rietveld, P. (2009) ‘Airline’s choice of aircraft size – Explanations and implications’, Transportation Research Part A. Elsevier Ltd, 43(5), pp. 500–510, [Electronic resource], – Access mode:

https://www.researchgate.net/publication/223798588_Airline's_choice_of_aircraft_size_-_Explanations_and_implications

22. Wang, Y. (2014) ‘PMP-Based Optimization Method for Determining Airline Fleet Composition. [Electronic resource],– Access mode: https://www.hindawi.com/journals/jopti/2016/8089794/ , free

23. Paul Clark, “Buying the Big Jets, Fleet Planning for Airlines” [Electronic resource],– Access mode: https://coccidian.yolasite.com/ws/media-library/bc5a20f4e8e344b19c9ce030d90aadf7/buying-the-big-jets-fleet-planning-for-airlines.pdf

24. W. O’Connor An introduction to airline economics (6th ed.), Praeger Publishers, Westport, CT (2001), p. 23, [Electronic resource],– Access mode: https://books.google.com.ua/books?hl=ru&lr=&id=_HWipZu51_UC&oi=fnd&pg=PR9&ots=tXLioPWFDu&sig=FXniTIYX_kSDb5SgiNVdUleP6Vk&redir_esc=y#v=onepage&q&f=false

25. U.S. Energy Information Administration. Jet fuel daily price [Electronic resource],– Access mode:

https://www.eia.gov/petroleum/data.php 26. 787 Airplane Characteristics for Airport Planning [Electronic resource],– Access mode:

https://www.boeing.com/commercial/airports/plan_manuals.page , free

27. 777-200LR/-300ER/-Freighter Airplane Characteristics for Airport [Electronic resource],– Access mode:

https://www.academia.edu/30003751/777_200LR_300ER_Freighter_Airplane_Characteristics_for_Airport_Planning_Boeing_Commercial_Airplanes

28. SCHOLZ, Dieter. DOC - A Method to Evaluate Aircraft Systems [Electronic resource],- Resource access mode:

https://cupdf.com/document/docsyspaper.html

29. GEORGE VAN BODEGRAVEN. Commercial aircraft DOC methods [Electronic resource], - Mode of access to the resource:

https://arc.aiaa.org/doi/abs/10.2514/6.1990-3224

30. Boeing. Current products & services [Electronic resource],– Access mode: http://www.boeing.com/commercial/#/products-and-services , free

31. Deagel. GE90-94B. [Electronic resource],– Access mode: http://www.deagel.com/Propulsion-Systems/GE90-94B_a001376001.aspx.

.32. Deagel. GEnx1B64. [Electronic resource],– Access mode: http://www.deagel.com/Propulsion-Systems/GEnx-1B64_a001388001.aspx.

33. GE90 Commercial Aircraft Engine, [Electronic resource], – Access mode: https://www.geaviation.com/commercial/engines/ge90-engine

34. The GEnx Commercial Aircraft Engine, [Electronic resource] - Access mode: https://www.geaviation.com/commercial/engines/genx-engine

35. Fuel burn & operating performance [Electronic resource], - Access mode:

https://www.aircraftcommerce.com/sample_article_folder/121_FLTOPS_A.pdf

36. TYPE-CERTIFICATE DATA SHEET,[Electronic resource] - Access mode:

https://www.easa.europa.eu/sites/default/files/dfu/TCDS%20IM%20E%20102_issue10_20191213.pdf

37. The GE90 - An Introduction - (Kimerius) ,[Electronic resource] – Access mode:

https://www.kimerius.com/app/download/5781574315/The%2BGE90%2B-%2BAn%2Bintroduction.pdf

38. The GEnx Commercial Aircraft Engine, [Electronic resource] - Electron. text. Data. – Access mode: https://www.geaviation.com/commercial/engines/genx-engine

39. The Future of Flight in a Post-COVID World, 2021, Charley Steed, [Electronic resource] –

Access mode: https://www.unomaha.edu/news/2021/03/the-future-of-flight-in-a-post-covid-world.php

40. Akmaldinova V., Volkovska G. Aircraft Fleet Operation Efficiency: Comparative Analysis / Scientific Journal "Scientific Notes". Series: "Technical Sciences", Coll. Science. etc. - K .: Tavriya National VI University Vernadsky 2021. - issue. 32 (71) № 2 - P. 13-19.

41. Vysotska I.I. Management of airline costs in the implementation of domestic passenger traffic. : special. 08.00.04 "Economics and management of enterprises (by type of economic activity)

42. The impact of COVID-19 on the airport business and the path to recovery- [Electronic resource] Access mode: https://aci.aero/news/2021/03/25/the-impact-of-covid-19-on-the-airport-business-and-the-path-to-recovery/

43. Jean-Paul Rodrigue The Geography of Transport Systems - [Electronic resource] Access mode: https://transportgeography.org/wp-content/uploads/GTS_Third_Edition.pdf

44. Emirates Working To Stablilze Costs After 42% Increase In Fuel Prices - [Electronic resource] Access mode: https://simpleflying.com/emirates-fuel-price-increases/

45. How Much Does It Cost to Fuel up an Airliner? - [Electronic resource] Access mode: https://thepointsguy.co.uk/guide/cost-of-fueling-an-airliner/#:~:text=On%20average%2C%20aircraft%20fill%20up,11%2C587)%20on%20the%20high%20end.

46. Airlines for America Daily Jet Fuel Spot Prices - [Electronic resource] Access mode: https://www.airlines.org/dataset/argus-us-jet-fuel-index/

47. International Council on Clean Transportation (ICCT) - [Electronic resource] Access mode: https://theicct.org/sites/default/files/publications/Transatlantic_Fuel_Efficiency_Ranking_20180912.pdf

48. Heathrow Conditions of Use - [Electronic resource] Access mode: https://www.heathrow.com/content/dam/heathrow/web/common/documents/company/doing-business-with-heathrow/flights-condition-of-use/conditions-of-use-documents/Heathrow_Conditions_of_Use_2020.pdf

49. The FAA - [Electronic resource] Access mode:

https://simpleflying.com/faa-washington-air-traffic/

50.Customer Guide to Charges - [Electronic resource] Access mode: https://www.eurocontrol.int/sites/default/files/2020-01/2020-01-23-customer-guide-to-charges.pdf

51. Calculating Costs in the Clouds - [Electronic resource] Access mode: https://www.wsj.com/articles/SB117314795095227844

52. Ground Handling Charges For A 737 - [Electronic resource] Access mode:

https://www.airliners.net/forum/viewtopic.php?t=432049