ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

GEOPOLITICS OF AVIATION, DECISION OF A POTENTIAL AIRCRAFT AND ECONOMICAL MODELLING OF A HELICOPTER MAINTENANCE CENTER IN RELATED REGION

M.Sc. THESIS

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Department of Aeronautics and Astronautics Engineering

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Thesis Advisor: Dr. Hayri ACAR

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

HAVACILIKTA JEOPOLİTİĞİN ÖNEMİ, UYGUN HAVA ARACI SEÇİMİ VE BELİRLENEN BÖLGEDE HELİKOPTER BAKIM MERKEZİNİN EKONOMİK MODELLEMESİ

YÜKSEK LİSANS TEZİ

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Uçak ve Uzay Mühendisliği Ana Bilim Dalı

Uçak ve Uzay Mühendisliği

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MAYIS 2019

Baran Emre Sonuç, a M.Sc. student of İTU Graduate School of Science Engineering and Technology student ID 511151104, successfully defended the thesis/dissertation entitled "GEOPOLITICS OF AVIATION, DECISION OF A POTENTIAL AIRCRAFT AND ECONOMICAL MODELLING OF A HELICOPTER MAINTENANCE CENTER IN RELATED REGION", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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Date of Submission : 03 May 2019
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To my family,

FOREWORD

Üniversite eğitimimde öğrettikleriyle uçak mühendisliği mesleğini sevmemde önemli katkılarda bulunan ve bu tezi yazmamda destek olan Dr. Hayri ACAR'a teşekkürü bir borç bilirim. Ayrıca akademik hayatımda her zaman yanımda olan ve elinden gelen yardımı esirgemeyen Prof. Dr. İbrahim ÖZKOL'a şükranlarımı sunuyorum.
Beni iyi bir insan olarak yetiştirmek için her türlü fedakarlığı yapan ve benim bugüne gelmemde çok büyük emeği olan hakkını ödeyemeyeceğim Annem'e, her daim arkamda olup beni desteklemekten hiç vazgeçmeyen ve hayatı boyunca en zor anımda hep yanımda olan Babam'a, abilik duygusunu en güzel şekilde yaşatan çok sevdiğim kardeşime ve bu hayatta benimle her yola elele yürüyen değerli eşime teşekkürlerimi ve minnettarlığımı belirtmek isterim.
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Mayıs 2019

Baran Emre SONUÇ
(Uçak Mühendisi)

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ABBREVIATIONS

ACI : Airports Council International
AHP : Analytical Hierarchy Process
ATAG : Air Transport Aviation Group
CAGR : Compound annual growth rate
CAPA : Centre for Asia Pacific Aviation
DGCA : Directorate of General Civil Aviation
EASA : European Aviation Safety Agency
ECAC : European Civil Aviation Conference
EMS : Emergency and Medical Services
FAA : Federal Aviation Administration
FTK : Freight Tones Kilometer
GAMA : General Aviation Manufacturers Association
GDP : Gross Domestic Product
GNI : Gross National Income
HAB : Ankara Aerospace Organized Industrial Zone
IATA : International Air Transport Association
ICAO : International Civil Aviation Organization
MIC : Middle Income Countries
MRO : Maintenance, Repair and Overhaul
NB : Narrow body aircraft
RJ : Regional jet
RPK : Revenue Passenger Kilometer
SAR : Search and Rescue
SARS : Acute respiratory insufficiency
SSM : Under secretariat for defense industries
TSK : Turkish Armed Forces
UNWTO : World Tourism Organization
WB : Wide body aircraft

SYMBOLS

CI	: Consistency Index
CIF	: Cash inflows in t
COF	: Cash outflows in t
$\mathbf{D}^{-t}$	: Discount rate in t
FH	: Flight Hour
i	: Interest rate
n	: Number of criteria
RI	: Random Consistency Index
t	: Time index
T	: Project life
λ	: Eigenvalue
λmax	: Maximum eigenvalue

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GEOPOLITICS OF AVIATION, DECISION OF A POTENTIAL AIRCRAFT AND ECONOMICAL MODELLING OF A HELICOPTER MAINTENANCE CENTER IN RELATED REGION

SUMMARY

The aviation industry is a business sector includes not only manufacturing but also operating and performing maintenance activities of all types of aircrafts. Manufacturers focuse to produce more reliable, eco-friendly and fuel efficiency aircrafts with cutting-edge technology. However, commercial trade depends on other factors more than technologies. They adhere to international agreements with authorities and government regulations in terms of safety, security and environment.

Aviation industry connects countries with various links such as cultural, social, commercial and political areas. Aviation removes the borders and creates links between different people, cultures and geographies. By means of these opportunities, aviation provides worldwide transportation network for global tourism and business activities. In this perspective, because of the fact that aviation is vulnerable external factors like crisis and war that make difficult to perform investment in aviation, geopolitics become a key factor for aviation industry.

Geopolitics is a science which examines the impact of political geography conditions on neighbors and their relations with other countries. Political relations between two countries directly affects aviation. The number of tourists changing according to years is the most obvious example of this situation. Significant issues such as where the aviation will develop and in which regions the value of the investments will be appreciated are directly affected by the human factors. For this reason, it would be more reasonable to consider the developments in aviation, growth of airline companies, economic development of countries, location of new facilities and establishment of investment models considering the geopolitical elements. With the determined geopolitical factors and their regular monitoring, the direction of aviation in the future will make it possible to predict potential markets. When examining the aviation industry, dealing with other disciplines will provide assistance in a more accurate decision-making process.

The geographic location of a country refers to its climate, underground resources and its proximity to important transit routes. In terms of aviation, the number of cities or countries that can be reached within the shortest flight distance indicates the importance of the aviation industry. Because in a favorable position for aviation contributes economy of related country. The aviation plays a significant role in economic growth, especially in developing countries. Tourism and its benefits to the country in terms of economy make it easier to get a place in the world transport network. Considering the economies of the sector and the economic dimension of the sector, it is seen as an open sector because of the factors that may adversely affect aviation such as crisis and war hampers significant investments due to uncertainty.

In this study, the arguments of the geopolitical science have been tried to be used in the determination of the current aviation industry. While investigating the factors affecting the aviation industry significantly, a methodology has been created during the selection of aircraft which is planned to be operated for tourism activities by monitoring the changes in these factors. Accordingly, the criteria that are important during the selection are determined and Airbus Helicopters H130 (EC130) model helicopter has been selected. Selected helicopter was purchased by the company and they started to operate.

It was agreed that a maintenance center would be established in accordance with the selected helicopter. Bodrum, Mugla region is the place where the maintenance center will be established by taking into consideration the data and trend observed in the past years of tourism activities. It is estimated that the activities will increase in the determined region. Competition studies were conducted in the surrounding area. The necessary planning was performed by determining capability of maintenance center in the potential area with adding non-existing helicopter types in Turkey in order to be leader in the market for both our countries as well as to fly different types of helicopters has been identified as a target. Thanks to the interdisciplinary perspective, a healthier choice has been made.

Required feasibility studies were performed for the necessary investments, expenditures and budget. The total investment cost was calculated by determining the hangar, equipment to be used, employee salaries, training fees, authorization applications and other routine expenses. Generating revenues were determined and the income model was formed involving routine annual expenses and the first investment study required for the start-up were made. The useful life of the project was defined and necessary calculations were made.

In this study, a methodology has been formed by using interdisciplinary information and a methodology has been introduced to guide the process of decision-making and investment. With this methodology, the investment decision in the potential region was determined. In April, 2019 first annual maintenance was performed in this maintenance center for H130 (EC130) typed helicopter.

HAVACILIKTA JEOPOLİTİĞİN ÖNEMİ, UYGUN HAVA ARACI SEÇİMİ VE BELİRLENEN BÖLGEDE HELİKOPTER BAKIM MERKEZİNİN EKONOMİK MODELLEMESİ

ÖZET

Havacılık endüstrisi, hava aracı üretimi, kullanımı, bakımı ve hava aracı üretiminde gerekli sanayi ürünlerini içerdiği gibi en önemli unsur olan insanı da içinde barındırmaktaıdr. Havacılık, ülkeler arasında sosyo-kültürel bir köprü kurulmasına yardımcı olarak ticari ilişkilerin gelişmesine katkı sağlamaktadır. Farklı kültürdeki insanları birbirine yaklaştırmaktadır. Üreticiler daha ekonomik, daha güvenli ve çevre dostu araçlar üretip piyasada lider konuma gelebilmek için son teknolojiyi kullanarak birbirleriyle rekabet etmeye çalışmaktadırlar. Ancak havacılık teknolojik altyapı dışında birçok unsura bağlıdır. Bunların başında da uluslararası anlaşmalar, otoritelerin zorunlu kıldığı düzenlemeler, emniyet ve çevre gibi ülkeler arası politikalar yer almaktadır. Burada jeopolitik önemli bir faktör olarak göze çarpmaktadır.

Jeopolitik, ülkenin sahip olduğu siyasi coğrafya şartlarının komşularıyla ve diğer ülkelerle olan ilişkilerine olan etkisini inceleyen bir bilimdalıdır. Bu açıdan bakıldığında uluslarası ilişkilerin önemi ön plana çıkmaktadır. İki ülke arasındaki siyasi ilişkiler havacılığı da doğrudan etkilemektedir. Yıllara göre değişen turist sayıları bu duruma verilebilecek en güzel örneklerden biridir. Havacılığın özellikle nerelerde gelişeceği hangi bölgelerde yatırımların değer kazanacağı gibi hususlar beşeri faktörlerden doğrudan etkilenmektedir. Bu yüzden havacılıktaki gelişmeleri, havayolu firmalarının büyümelerini, ülkelerin ekonomik kalkınmalarını, yeni açılacak tesislerin yerlerinin belirlenmesinin ve yatırım modellerinin oluşturulmasını jeopolitik unsurları düşünerek ele almak daha mantıklı olacaktır. Belirlenen jeopolitik etkenler ve bunların düzenli olarak izlenmesi sayesinde gelecekte havacılığın ne yöne doğru gelişeceği, potansiyel pazarları önceden tahmin etmeyi mümkün kılacaktır. Havacılık endüstrisi incelenirken diğer disiplinleri de ele almak daha doğru bir karar alma aşamasında yardım sağlayacaktır.

Bir ülkenin coğrafik konumu, sahip olduğu iklimi, yeraltı kaynaklarına ve önemli geçiş yollarına olan yakınlığını ifade etmektedir. Havacılık açısından baktığımızda ise en kısa uçuş mesafesinde ulaşılabilecek şehir veya ülke sayısı havacılık endüstrisi açısından önemini belirtmektedir. Çünkü havacılık açısından elverişli bir konumda olması o ülkenin ekonomisine önemli oranda katkı sağlamaktadır. Havacılık endüstirisi özellikle gelişmekte olan ülkelerde ekonomik büyümede çok önemli bir rol üstlenmektedir. Turizm ve ekonomi açısından ülkeye faydaları, dünya ulaşım ağında yer edinmesini kolaylaştırmaktadır. Bu sayede sınırlar kalkmakta ve iş olanakları artmaktadır. Olanakların bu kadar fazla olması ve sektörün ekonomik boyutu düşünüldüğünde kriz ve savaş gibi havacılığı olumsuz etkileyecek etmenler nedeniyle saldırıya açık bir sektör olarak görülmekte, önemli yatırımların yapılmasını var olan bu belirsizlik nedeniyle sekteye uğratmaktadır.

Havacılık endüstrisi her geçen gün artan yolcu sayısıyla hızla büyümeye devam etmektedir. Bu kadar fazla kullanıcıya yani yolcuya sahip bir sektör, bu yolcuların ulaşımını, güvenliğini ve temel ihtiyaçlarını sağlayabilmek için de birçok insana istihdam alanı yaratmaktadır. İstanbul Havalimanı gibi açılan yeni havalimanları da bu istihdam alanlarına öncülük etmektedir. Yer hizmetlerinden tutun da güvenlik firmalarına kadar pek çok farklı sektörde çalışana ev sahipliği yapmaktadır. Bakım merkezleri tesislerini genişletmekte ya da daha fazla çalışan almaktadır. Artan dünya nüfusu da bu durumu etkileyen bir başka faktördür. Özellikle Asya bölgesindeki artan talep nedeniyle filodaki uçak sayıları da hızlı bir şekilde artmaktadır. Üreticiler siparişleri yetiştirmekte zorlanacak seviyeye gelmektedir. Bu sırada devam eden üretim sürecinde artan AR-GE çalışmalarının uygulamaya geçmesi diğer sektörlere oranla daha yavaş ilerlemektedir. İnsan faktörünün birinci sırada yer alması üreticilerin daha temkinli hareket etmesine sebep olmaktadır. Bu da AR-GE yatırım maaliyetlerini ve sürelerini artmaktadır.

Dünyadaki lider üreticiler pazarlarını genişletmek ve daha fazla ülkeye hizmet etmek için pazarlama faaliyetlerine devam etmekte ve her geçen gün yatırım miktarlarını artırmaktadırlar. Bu planlı büyümeler en az risk göz önünde bulundurularak yapılmaya çalışılmaktadır. Bu yüzden de detaylı bir fizibilite çalışması yapılması gerekmektedir. Bu sayede, yapılacak yatırım miktarı, modeli ve beklentiler belirlenmektedir. Bunun için de özelllikle havacılık gibi ekonomik olumsuzluklardan çok hızlı etkilenen sektörlerde dinamik ve statik yöntemler kullanılmaktadır. Bu yöntemler sayesinde oluşulabilecek riskler minimumda tutulmaya çalışılmaktadır. Aynı zamanda yapılması planlanan yatırımla alakalı geri ödeme süresi, kar miktarı ve bugünkü değeri gibi önemli verilere ulaşım sağlanmaktadır. Statik yöntemler paranın zaman kavramını devre dışı tutarak bugün için bir senaryo oluştururkeni dinamik yöntemler paranın zamana bağlı bir değişken olarak alıp daha realist bir yaklaşım sunmaktadır. Buradaki ana düşünce paranın geçen zaman içinde değerini kaybetmesi veya faiz oranları nedeniyle değerini artırması olarak ele alınmaktadır.

Türkiye Cumhuriyeti'nin kurulmasıyla başlayan havacılık endüstrisi çeşitli nedenlerle sekteye uğrasa da günümüzde emin adımlarla yoluna devam etmektedir. Dünya'da lider şirketler arasına giren ASELSAN. TAI, TEI gibi kurumlar bayrak taşıyıcısı görevi görmektedir. Türkiye bugün kendi tankını, helikopterini, eğitim uçaklarını üretmekle kalmayan aynı zaman da bunu yabancı ülkelere ihraç eden bir ülke konumundadır. Yaptıkları ihracatla ülke ekonomisine büyük katkı sağlamaktadır. Aynı şekilde Türk Hava Yolları, yurt içi ve yurt dışı sponsorluk anlaşmalarıyla adından sıkça söz ettiren milli bir hava yolu firmasıdır. Ancak ülkemizde helikopter kullanımı diğer ülkelere kıyasla fazla yaygın değildir. Ulusal ve uluslararası birçok havalimanı bulundurmasına rağmen heliport sayısı yeterli seviyede değildir. Aynı şekilde helicopter sayısı da yetersiz kalmaktadır. Ancak farklı helikopter tiplerine bakım hizmeti veren birçok bakım kuruluşu mevcuttur. Dünya'da ise helikopter sektörü uçak sektörüne benzer ilerlemektedir.

Bu çalışmada, günümüz havacılık endüstrisinin durum tespiti yapılırken jeopolitik bilim dalının argümanları kullanılmaya çalışılmıştır. Havacılık endüstrisini önemli ölçüde etkileyen faktörler araştırılırken bu faktörlerdeki değişimlerin izlenmesi sağlanarak turizm amacıyla operasyon yapılması planlanan hava aracı seçimi sırasında bir metodoloji oluşturulmuştur. Buna uygun olarak seçim sırasında önem verilen kriterler belirlenmiş ve hava aracı olarak Airbus Helicopters firmasına ait H130 (EC130) model helikopter seçimi yapılmıştır. Seçilen helikopter şirket tarafından satın alınmış ve operasyona başlamıştır.

Seçilen helikoptere uygun olarak bir bakım merkezinin kurulması konusunda mutabakata varılmıştır. Turizm faaliyetlerinin geçmiş yıllardaki veriler ve izlenen trend de göz önünde bulundurularak bakım merkezinin kurulacağı yer Bodrum, Muğla bölgesi olarak belirlenmiştir. belirlenen bölgede faaliyetlerin daha da artacağı yönünde tahmin yapılmıştır. Disiplinler arası geliştirilen bakış açısı sayesinde daha sağlık bir seçim yapılması sağlanmıştır. Çevredeki rakip firma ve kabiliyet araştırması yapılmıştır. Türkiye içinde mevcut olmayan helikopter tipleri de eklenerek gelecek için hem piyasada lider olmak hem de farklı tipteki helikopterlerin ülkemize kazandırılması hedef olarak belirlenmiştir. Potansiyel bölgede kurulması planlanan bakım merkezinin hangi kabiliyette hizmet vereceği saptanarak gerekli planlama ona göre yapılmıştır.

Bu önemli yatırım için gerekli hazırlıklar, harcamalar ve bütçe belirlenerek gerekli fizibilite çalışmaları yapılmıştır. Hangar, kullanılacak ekipman, çalışan maaşları, eğitim ücretleri, yetki başvuruları ve diğer rutin harcamalar belirlenerek toplam yatırım maliyeti hesaplanmıştır. Kazanç sağlayacak gelirler belirlenerek gelir modeli, tek seferlik ve rutin yıllık giderler için gider modeli ve başlangıç için gerekli ilk yatırım çalışması yapılmıştır. Projenin faydalı ömrü belirlenerek gerekli hesaplamalar yapılmıştır.

Bu çalışmada, disiplinler arası bilgiler kullanılarak bir seçim ve yatırım kararı alınması sırasında yol gösterecek farklı yöntemler anlatılmış, bir metodoloji oluşturulmuştur. Oluşturulan bu metodoloji ile potansiyel bölgedeki yatırım kararının doğruluğu saptanmıştır. Bakım merkezi faaliyetlerine başlamış ve Nisan 2019 tarihinde H130 (EC130) tipinde helikopterin ilk yıllık bakımı tamamlanmıştır.

1. INTRODUCTION

Aviation means the design and maintenance of the machines required to fly with aircrafts manufactured by humans. In a more general sense, the term aviation encompasses all actions, industries related to the any unmanned or manned flying vehicles that ability to carrying capacity such as airplane, zeppelin, balloon, drone and also helicopters.

Aviation has a key role between countries. The increase of flights between countries directly leads to commercial, cultural, social and political interactions for related countries. Similarly, the development of aviation is directly affected by some demographic and geographic structures. In this context, these human-based factors and parameters that aviation will follow in the future can be predictable when correctly monitored.

Geopolitics is an understanding of the political geography. It is a science which directly examines the geographical features and political structures of states. It examines the changing political and commercial life under the influence of the geography and historical developments. In Turkey, in terms of geographical location, political structure and demographic structure, it offers important opportunities in terms of aviation development. These factors can explain the rise of Turkish Civil Aviation in last decade.

In this study, it will be tried to explain the connection in different disciplines such as geography including topography of Turkey, politics, country humanities and aviation development. In this thesis, world aviation industry, world civil aviation fleet development and future forecasts, economic models in the aviation industry, aviation industry review by country and region will be included. In this context, economical modelling of the helicopter maintenance center will be established for a potential region to be examined and identified.

It would be pointless to consider the developments in aviation, the growth of airlines and economic developments without considerimg geopolitical elements. With the geopolitical factors identified and monitoring development of these factors, it will be possible to understand the future of aviation and the potential markets. For this reason, in economic analyzes made in the field of aeronautics, potential location determination should be made by examining the parametric factors such as geography, demographic structure and development of trade between countries. With the determination of the potential market, the business model to be established in the aviation area should be determined at this location.

1.1 Purpose of Thesis

Interdisciplinary studies in the aviation industry are very limited. Especially in Turkey, business sectors in the aviation industry, economic models and feasibility studies of these businesses are inadequate. For this reason, following the determination of a potential location for a helicopter maintenance center to be planned by making use of other disciplines and predicting future in aviation area, determining the scope of the helicopter maintenance repair and renovation center, the first investment cost, the revenue model and the expense model to be established in this location.

1.2 Literature Review

Studies in the literature in the field of aviation are mostly technically focused studies. Although inter-disciplinary studies and facility modeling studies in aviation are relatively less than other engineering studies, there are also many studies on geopolitics, aviation and aviation economics in the literature.

Eventhough the studies on geopolitics in the literature differantiate about their topics in accordance with perspective of author, most of them rely on energy sector. Högselius (2019) shows that how energy geopolitics is not only a subject for developed countries but also reason of how actors gain power and control in the underdeveloped countries. Chevalier (2009) provides insights about coming new energy crisis and solutions to overcome this crisis in the fields of geopolitical and economical circumstances.

Grigas (2017) deeply investigates to reveal transforming geopolitics of gas including trends behind forces on gas market. Moreover, as an environmental sociologist, Hannigan (2015) argues that changing of geopolitics in terms of water and ocean energy resources how affect ecology in accordance with global climate changes threats on it. Stavridis (2017) states that oceans formed destinies and geopolitical borders of nations according to their naval armies and success at battles such as Salamis and Lepanto, the Battle of the Atlantic. Dolman (2001) takes a different approach to geopolitics in the matter of space strategies of countries from different continents. In contrast to traditional geopolitics researches, Ingram and Dodds (2009) interrogate relevance between geopolitics and realities of today's world such as colonialism and race. Perkins (1997) argues influences of green revolution in terms of sustanibility and reliability of wheat agriculture starting from 1950s on human nature and increasing population. Geopolitics in Turkey literature review especially concentrates on enerjy industry. Erbaş (2012) in his Ph.D. thesis evaluated the geopolitics significance of Black Sea for Turkey and examine the oil pipeline projects which have a key role on energy industry and geopolitical elements. Inak (2016) in his M. Sc thesis argued energy politics according to geopolitical situaiton of Turkey, dependence to foreign countries in term of natural gas energy and energy projects in the future to decrease dependence.

When the studies in the literature on aviation are examined, Sahay (2012) modeled a maintenance, repair and renovation center in terms of differences on-wing and off-wing maintenance process with information technology needs for producing longer aircrafts. Socha, Hanáková & Lališ (2017) combines scientific papers that are published in an international scientific for interaction experience and ideas about case studies and their methodology for aviation. Dhillon (2009) looks aviation from a different perspective as human factor and human reliability. He illustrates management in engineering areas and gives exact solutions to real problems in aviation field. On the other hand, Saini (2018) investigates efficiencies of thirteen airlines including environmental impacts such as emissions of carbon dioxide by means of a linear programming. Demiral (2006) In her M.Sc. thesis provide solutions to decrease response time about planning of line maintenance approximately 85%, gaining 3 hours by lean thinking to save money. Christ (2011) desined a new maintenance and repair center, he worked towards catching the optimum customer from the aviation market and worked towards low cost maintenance center forecasting modeling by using online real-time data. MacInnes & Pearce (2003) provides a roadmap for a constration model of maintenance and repair organizations. Jorge-Calderón (2014) addresses investment methods about projects for crucial industries espeacially in aviation sector including maintenance centers and the airports to determine the long-term continuity of any debt-financed investment.

1.3 Hypothesis

There is no methodology for the investment decisions taken in aviation industry and the region determination to be chosen for the investment. It will be possible to determine the potential region for investment with the parameters of both aviation and non-aviation parameters. With the interdisciplinary study, it is possible to determine the appropriate region for an aviation investment with the parametrical monitoring of geopolitical factors. In the process of making an investment decision in the aviation industry, an investment decision making methodology can be created by benefiting from the geopolitical discipline. An investment option determined by methodology can be determined by making an investment efficiency assessment and determining whether the investment is an investment that is decided correctly according to the relevant methodology for a helicopter maintenance center.

2. DIRECT FACTORS IN AVIATION

2.1 Geopolitics

Geopolitics, which can be considered as the political science was structured on the geographic reasons that the geographical regions should be controlled for world authority or the reasons for the expand of country lands.

Geopolitics examines population, state borders and globalization. These subjects are about an understanding of geopolitics in terms of representation of power geography and saving of power resistance in a process and feedback model that Flint (2006) examines four geographic concepts and three stages that are in perspective of changing spaces and places; networks versus states and resources and governance including case studies.

Geopolitics word meaning, economic and political geography is about not only country's current foreign policy but also future policy to determine. These policies examine all elements of power and the direction given to the policy by other geographical circumstances. The concept of geopolitics has been important in every period of history and it is a concept which determines the fate of the political relations and orientations that maintain its importance. Geopolitics could be built on universal power and political movement in the region, country and world. This is a science that evaluates the world's power centers that examine the forces of the region in the future.

2.2 Historical Roots of Geopolitics

Geopolitics, which can be considered as the political science was structured on the geographic reasons Although political geography term was appeared first at the end of the 19th century by geographer and ethnographer Ratzel (1987) in his book in Germany as hosted various kingdoms for a long time history, Swedish political scientist Rudolf

Kjellén who inspired by Ratzel used "geopolitics" as a word in his book Stormakterna. After that, this term became popular in English by American diplomat Robert Strausz-Hupé as an instructor of University of Pennsylvani. Moreover, Geopolitics was used by Sir Halford Mackinder of England with his "Heartland Theory" in the beginning of 20th century. Mackinder seperated the world into two different sections, the "World Island" and the "Periphery." The World Island involved Asia, and Africa and also Europe. The "Periphery" involved the Americas, Oceania and British Isles. Mackinder (1919) summarised his theory as: "Who rules East Europe commands the Heartland; who rules the Heartland commands the World-Island; who rules the World-Island commands the world." (Democratic Ideals and Reality, p. 150). His doctrine was inspiring during the World Wars and the Cold War, for both Germany and Russia each hit the wall strengthen the Heartland. Eventough Kjellén defined government as a living organism in classic approach and also it can expand its borders continuously, after World War I, Kjellen's ideas and the term were transformed and extended by numerous scientists such as Karl Haushofer, and Hermann Lautensach in Germany and Paul Vidal de la Blache in France. Haushofer mixed Mackinder's theory with geopolitics into a pseudoscience. He stated that oceanic countries have opportunity to gain grant lebensraum (living space) with dynamic continental countries. Lebensraum was curcial propaganda slogan Hitler's invasion that set World War II in motion with neo-classic approach. The strategic value of certain characteristics of the borders plays a key role in politics. In this period, geopolitics has become the main concept of geostrategy. The new geopolitical discourse mainly deals with the strategic value of geographic factors. Besides, under the influence of positivist thought, the state is an entity that looks after its interests as if it is a human and it considers its security. The physical environment has been considered as a geography that offers constraints and opportunities. From this perspective, eventhough average elevation of Turkey is high according to other countries, there is a huge opportunity to increase usage of helicopters. Moreover, with this way reaching higher points become easier that could be seen on Figure 2.1. Rising using of helicopters reduces using business jets especially for fixed routes. Besides, owing to the fact that heliports do not need wide areas and not much security procedures, it would be advantage for users and owner in means of saving time and providing comfort.

2.3 Geopolitics of Aviation

Technological development has made it necessary to consider not only physical but also human and economic geography in military and political fields. This situation is the basic dynamic that enables the geopolitics to be a science by itself that discipline can be used directly in the future estimation for strategic industries that have a key role on country policies such as aviation and energy industries. These two industries, directly determine the richness and development of related countries,

The aviation industry which will be in a place in order to use the arguments of geopolitics in explaining the aviation industry leads to the increase economic power of the countries in accordance with trade network. In recent years, air transport has become quite common in Turkey due to the increase in airports and aircraft fleets. Rail and road transports can now be carried out more easily and more easily by air transport. Airway transportation is generally a fast and time-consuming transportation method. Especially in long-haul transports, air transport has become the most reliable transportation with the increase of cargo companies doing this work. Air transport is especially preferred in terms of materials such as fruits and vegetables, medicines, books and spare parts that can be decayed and broken, in a safer and faster time.

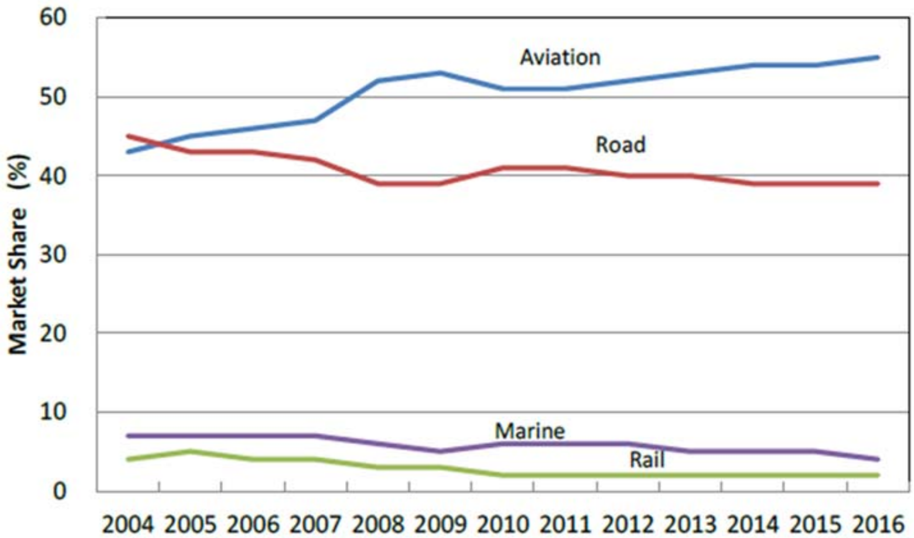


Figure 2.1 : Market share of transportation in the world (JADC, 2018).

Figure 2.2 : Physical relief map of Turkey (Url-6).

Air transportation; in terms of activities, became a part of international phenomenon of globalization. On the other hand, in recent years economic crises and terrorist incidents affected air transport sector negatively. In Turkey, air transport sector activities are performed by private airlines and government support. By developing technology and reducing flight ticket prices, it has entered a rapid growth trend. This growth trend has also increased the demand for freight and passengers. However, the continuous and fast-growing sector revealed problems about capacity. Organization of various types and huge number of aircrafts in order to meet the demands of the passengers, has become an important strategy for airline companies.

2.4 Factors Directly Affecting Aviation Industry

Aviation industry is connected with many other industries. Therefore, it is necessary to be aware of the major factors that directly affect aviation when interpreting the aviation industry. Geographic location is one of the major factors affecting the aviation industry. The advantage of the current geographic location of the country directly supports the development of country aviation. For countries that are in different continents can connect each other with aircraft which can fly more hours. Another factor affecting the aviation industry is the world population distribution and gross domestic product (GDP). According to economical circumstances of country, aircraft olds and quantity of aircraft in fleet changes. Generally, development of aviation could be seen in with middle income levels and above countries. Another factor that directly affects the industry of aviation is the location of world trade in both goods and services. Transportation of these goods is required a well-designed carrier operation depends on connection quality. Moreover, the conflict (war) environment at any geographical location in the world causes the lack of aviation safety and decrease flight trafic on these regions. To conclude, significant factors that directly affect the world civil aviation; geographic location, economic status of countries, demographic structure, trade network development and current conflict environment on the world can be evaluated.

2.4.1 Geographic location

Geographic location is one of the factors that directly affect the aviation industry. The main reason for this situation is owing to the fact that aircrafts produced by the aviation industry in order to fly at a certain distance. So, flight range is a serious constraint in the aviation industry for flight operations.

Manufacturers aim to fly maximum range with minimum fuel consumption and maintenance costs. However, for different purposes, there are different classes of aircrafts. Especially for regional operations, operatures prefer regional jet (RJ) or narrow-body (NB) aircrafts that have maximum 6-abreast seating and below 4 metres cabin width in order to carry passengers in less time. For, overseas flights, operator must fly with wide-body (WB) aircraft due to maximum range criteria and long flight duration. In order to cover the expenses and decrease ticket price, WB aircrafts were manufactured with maximum seat capacity. Today's aviation industry leader manufacturers, first production year, maximum seat carrying capacities and the maximum flight range is given in Table 2.1.

Table 2.1 : Commercial passenger airplanes maximum range comparison chart.

Manufacturer	Type	Class	Year	Seat Capacity	Max. Range
The Boeing Company	B747-400	WB	1989	660	13,450 km
The Boeing Company	B777-300	WB	1998	396	11,135 km
The Boeing Company	B757	NB	1982	295	6,958 km
Airbus S.A.S.	A380-800	WB	2010	853	16,112 km
Airbus S.A.S.	A340-600	WB	1993	475	13,750 km
Airbus S.A.S.	A320	NB	1988	180	5,700 km
Bombardier Inc.	CS100	NB	2014	145	5,463 km
Bombardier Inc.	CS300	NB	2013	150	5,463 km
Bombardier Inc.	Q400	RJ	1983	80	2,552 km
Embraer	E 195	NB	2004	122	4,260 km
Embraer	ERJ-145	RJ	1989	50	2,873 km
Embraer	E 175	RJ	2004	88	4,074 km

In order to carry passenger aircrafts were produced in three main segments in accordance with operating flight hours. Business jets have own configuration with less than 50 seats including 2 or 3 engines. Maximum flying hours depend on their designs. Regional Jets as short-range airplanes have a seat capacity of 50-139 passengers, mid-range passenger airplanes include seat capacity of 140-300 passengers and narrow body (NB) long-range passenger airplanes involves seat capacity of more than 300 passengers are classified as Wide Body (WB). As the designs of commercial passenger aircraft have improved, it has become possible to carry more passengers in longer ranges. In term of flight hour (FH), it has increased from 3-4 FH to 4-6 FH. As an example, importance of geographic location, with NB aircafts, it is possible to fly 55 countries in 5 FH that makes Istanbul a natural hub for global aviation due to its geographic location (Eksi, 2018). World flight time circle map as centered Istanbul could be seen on Figure 2.3

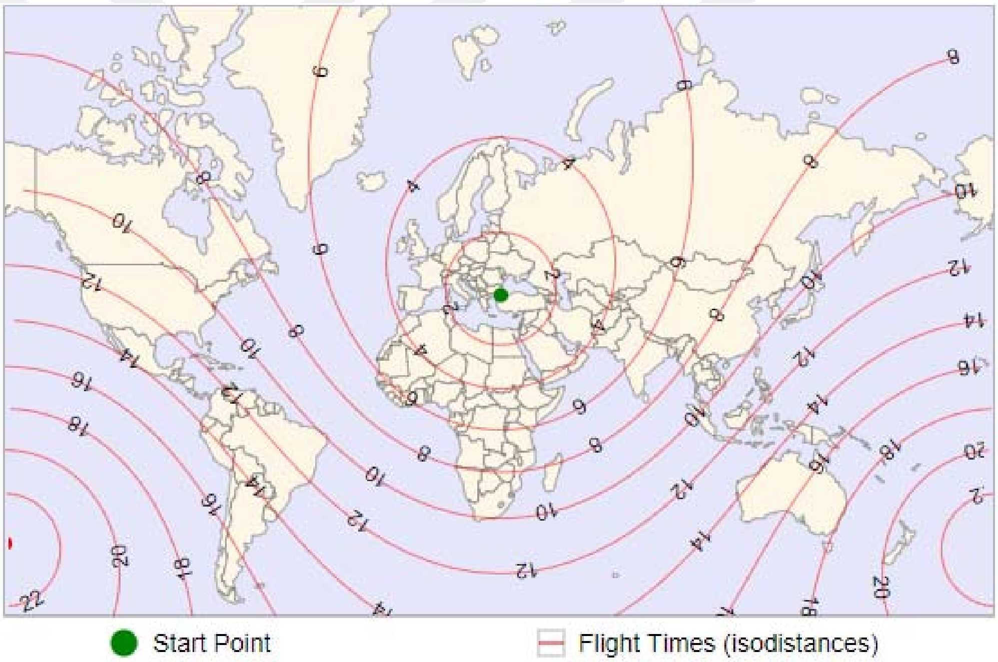


Figure 2.3 : World flight time circle map centered Istanbul (Url-1).

2.4.2 Demographic structure of world

Another important factor affecting the world aviation sector is the world demographic structure. Human is on the focus on aviation industry that needs more infrastructure investment than other transportation options due to required safety and including risk factors. Human population density is a direct factor in the aviation sector. From Hong

Kong International Airport that is reachable to half of the world's population within 5 FH due to crowded populations of China, India, Indonesia and other Asian countries (Url-2). Furthermore, Middle Income Countries (MICs) are consist of economies those Gross National Income (GNI) per capita between $1,025 and $12,475 in 2018 that means 33 percent of global GDP all over the world. Moreover, MICs correspond to 72 percent of the world’s population. Although Turkey has followed same trend with world in term of GNI per capita for twelve years starting from 1990s, according to World Bank data, rising GNI and increasing population in Turkey as a member of middle-income group in last decade will influence aviation industry with ascending expenditures that bring about demand for air transport with both number of airline passengers and airports in the future.

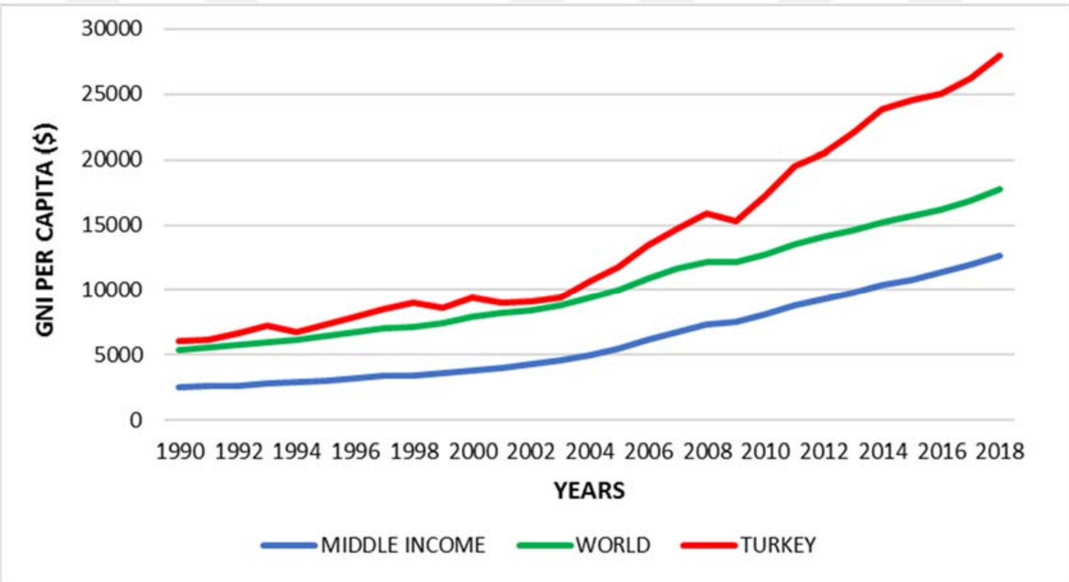


Figure 2.4 : GNI per capita trend in MICs, Turkey and World (Url-3).

Urbanization and population movement from rural to urban is one of the most important trends in the world that carries on in Turkey. In the 1950s, 25 percentage of total population was in rural areas, today opposite position exists. There are current 33 mega cities in the world in 2018 with a population of more than 10 million. With the increase in population in 2030 and migration from rural areas to urban areas, the number of mega cities with population of over 10 million is expected to increase from 33 to 39.

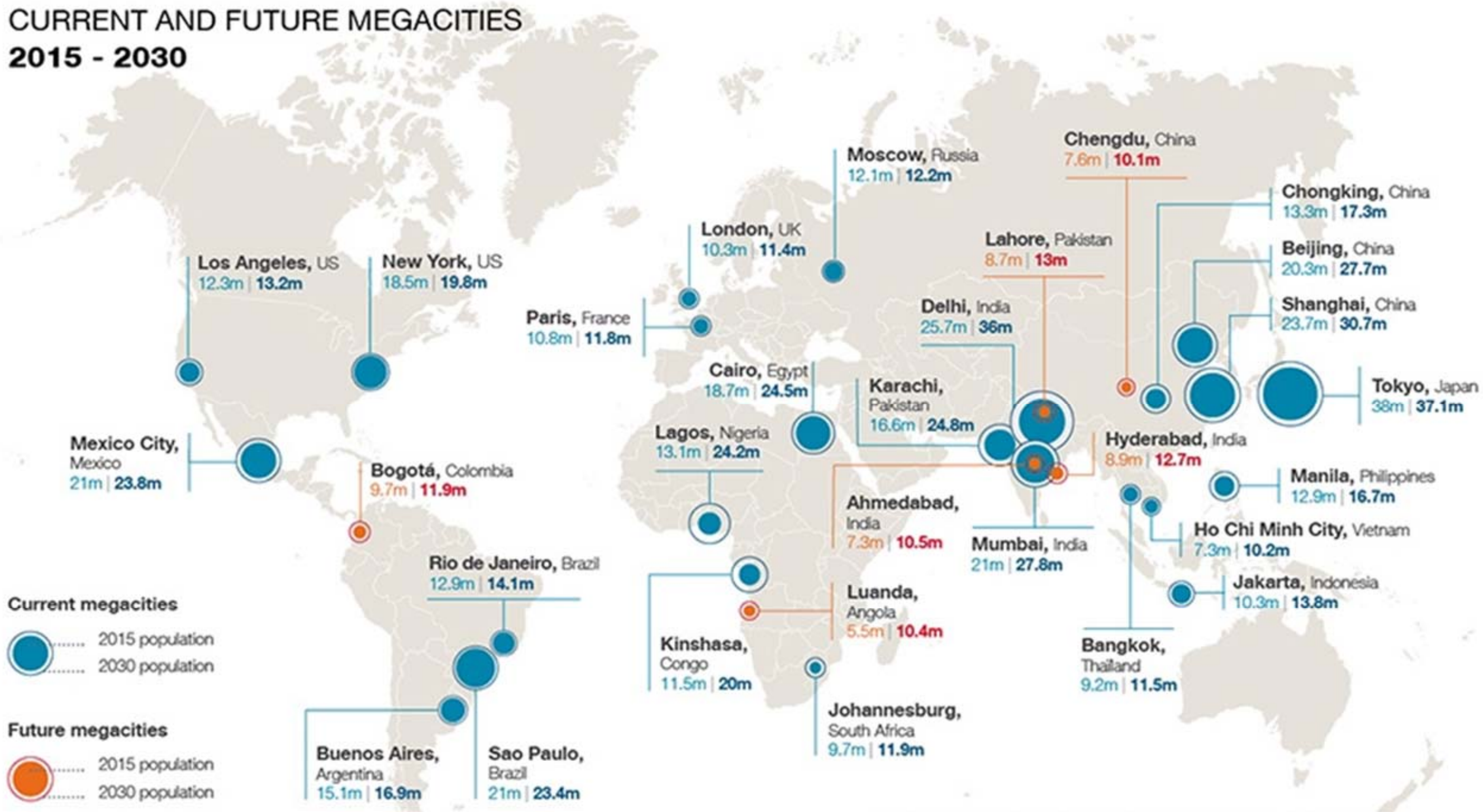


Figure 2.5 : Current and future megacities in 2015 and 2030 (Url-4).

2.4.3 Quality of aviation connectivity

Connection quality and expansion of the flight network widen the economic markets in the world with increasing air transport day by day. This benefit is gained by raised supply chains between cities enabling the flow of capital, goods, technology and ideas that leads to decreasing air transport costs. The quantity of unique city-pair connections has reached over 21,000 in 2018, that doubled the value two decades ago. Air transport costs keep on to diminish with unique city pairs. This change could be seen on below during last 25 years according to IATA report.

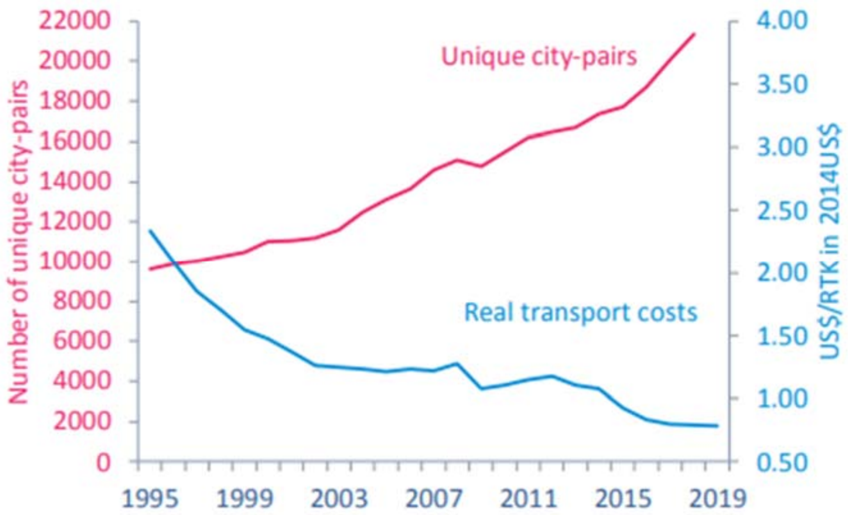


Figure 2.6 : Unique city-pairs and real transport costs (IATA, 2018).

Aviation connectivity includes different types of air connectivity. Direct connectivity is measured by both destinations and flights frequency to the same destination. Indirect connectivity shows their quality based upon connection time and delay. Airport connectivity considers both direct and indirect factors. Hub connectivity is about number of connecting flights. In reference to Airports Council International (ACI) Airport Industry Conductivity Report 2018 statistics, although Germany is in the first position in the cities with the highest hub connectivity especially within Frankfurt Airport, Turkey is the country with the highest increase rates at each connectivity type especially in hub connectivity quality with 534,6 % huge growth in last decade. Geopolitical position ad the economical developments with new airport are major reasons of this situation. More details could be seen at Figure 2.7.

Country	Direct connec-tivity	Indirect connec-tivity	Airport connec-tivity	Hub connec-tivity	GDP 2016 (m€)	Growth 2018 vs 2017				Growth 2018 vs 2013				Growth 2018 vs 2008			
						Direct	Indirect	Airport	Hub	Direct	Indirect	Airport	Hub	Direct	Indirect	Airport	Hub
Spain	19,865	31,056	50,921	25,631	1,319,579	6.2%	10.4%	8.8%	17.6%	31.6%	49.6%	42.0%	62.3%	8.9%	43.8%	27.8%	3.1%
Germany	19,167	53,183	72,351	120,910	3,401,968	3.3%	7.8%	6.6%	12.0%	9.5%	14.7%	13.3%	13.7%	2.2%	33.2%	23.3%	27.3%
United Kingdom	18,290	39,538	57,827	39,306	2,466,984	-0.8%	1.9%	1.0%	3.7%	10.7%	25.2%	20.2%	13.8%	3.9%	29.1%	19.9%	18.5%
France	14,807	30,140	44,947	50,757	2,539,096	2.8%	4.9%	4.2%	2.8%	7.4%	14.5%	12.0%	-4.1%	1.7%	24.1%	15.7%	-3.0%
Turkey	12,653	12,742	25,396	38,675	1,010,781	12.1%	9.3%	10.7%	6.2%	35.0%	23.7%	29.1%	47.1%	191.8%	130.4%	157.4%	534.6%
Italy	12,183	29,296	41,479	16,363	1,876,965	2.9%	5.7%	4.9%	9.9%	14.5%	24.4%	21.3%	11.1%	7.1%	35.1%	25.4%	20.5%
Russian Federation	9,499	12,567	22,066	25,279	1,470,744	21.4%	16.9%	18.8%	15.0%	27.6%	29.8%	28.8%	57.5%	74.0%	85.4%	80.3%	267.8%
Norway	7,509	8,384	15,894	4,535	424,621	1.5%	6.0%	3.8%	6.1%	-4.0%	-0.6%	-2.2%	6.8%	2.4%	28.0%	14.5%	33.2%
Greece	6,259	8,239	14,498	3,302	220,745	16.5%	14.6%	15.4%	14.5%	70.8%	79.7%	75.8%	137.5%	63.3%	77.2%	70.9%	131.6%
Netherlands	5,465	11,540	17,005	57,860	801,205	0.3%	-0.2%	0.0%	2.2%	17.5%	17.1%	17.2%	26.3%	27.4%	19.9%	22.2%	56.0%
Switzerland	4,661	14,967	19,628	18,351	572,755	1.8%	7.2%	5.8%	10.5%	7.0%	15.6%	13.4%	13.9%	15.8%	45.0%	36.8%	33.7%
Sweden	4,545	9,205	13,749	4,011	503,871	0.7%	4.1%	3.0%	2.4%	16.2%	26.2%	22.7%	43.0%	15.2%	39.2%	30.2%	56.1%
Portugal	4,427	10,076	14,503	6,912	208,442	5.9%	28.6%	20.7%	14.9%	51.0%	81.0%	70.6%	74.4%	64.3%	106.0%	91.2%	106.1%
Poland	3,117	7,162	10,279	5,370	515,926	16.8%	20.2%	19.1%	41.0%	49.9%	33.5%	38.0%	188.6%	43.9%	62.7%	56.5%	235.6%
Denmark	3,038	7,735	10,773	5,670	312,047	1.5%	4.1%	3.4%	4.4%	9.7%	22.7%	18.7%	-6.5%	4.5%	46.1%	31.3%	-27.5%
Austria	2,871	8,666	11,537	15,256	376,984	4.6%	9.1%	7.9%	10.2%	1.7%	23.4%	17.2%	20.7%	-11.6%	20.5%	10.5%	5.1%
Ireland	2,822	7,265	10,087	4,229	287,995	5.8%	1.0%	2.3%	9.9%	34.0%	42.1%	39.7%	182.2%	13.0%	64.4%	45.8%	267.0%
Belgium	2,809	6,323	9,132	7,025	464,509	1.4%	6.9%	5.2%	4.3%	14.0%	15.0%	14.7%	31.1%	15.7%	31.8%	26.4%	96.2%
Finland	2,485	6,186	8,672	11,587	226,918	11.4%	9.9%	10.3%	16.0%	13.6%	24.6%	21.2%	70.4%	-0.1%	17.4%	11.8%	74.4%
Romania	1,724	3,455	5,179	343	179,464	1.6%	13.7%	9.4%	12.5%	47.2%	13.4%	22.8%	43.5%	60.7%	31.8%	40.2%	11.3%
Czech Republic	1,650	4,097	5,747	2,025	207,125	7.4%	14.2%	12.1%	5.5%	30.5%	34.9%	33.6%	61.2%	3.3%	38.7%	26.3%	-36.9%
Israel	1,498	5,010	6,508	159	260,861	19.3%	11.6%	13.3%	10.0%	62.2%	54.4%	56.1%	57.2%	90.5%	68.5%	73.1%	190.2%
Croatia	1,307	3,574	4,881	125	54,151	10.5%	21.3%	18.2%	85.7%	55.2%	86.9%	77.2%	1478.9%	96.6%	116.0%	110.4%	1504.7%

Figure 2.7 : Aviation connectivity ranks by countries (ACI, 2018).

Higher air connectivity brings about economical improvement of a country. There is a direct relationship between the developments in the aviation sector and economic growth. Rised growth and connection quality in the aviation sector is a boost for direct economic growth. On the other hand, in economically developing or developed countries, increase in middle income population, urbanization rate and infrastructure investments are observed, the development of countries' trade networks cause economic growth that a trigger for the development of the aviation industry. Air transport plays an important role in the globalization and growth of the economy. The development of air transport is affected by physical barriers and physical constraints of countries. There is a correlation between growth in world air traffic and world GDP data. 20 percent rising in air traffic cause to 1 percent increase in GDP that could found on Figure 2.9.

2.4.4 World conflict environment

Another key factor affecting the world aviation is conflict encironment. It is required to examine the world conflict environment, including the potential region for the aviation sector from the locations with high potential for internal confusion. For this reason, monitoring the world conflict environment is an important indicator for the determination of potential regions and cities in the aviation area. The world now lives in the most peaceful period of history especially after 1950s. The number of deaths caused by conflicts decreased almost zero while the world population is growing rapidly.

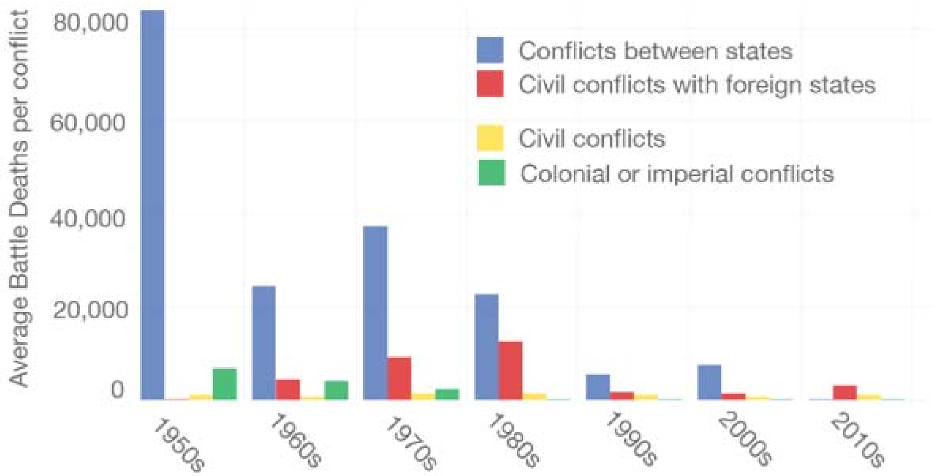
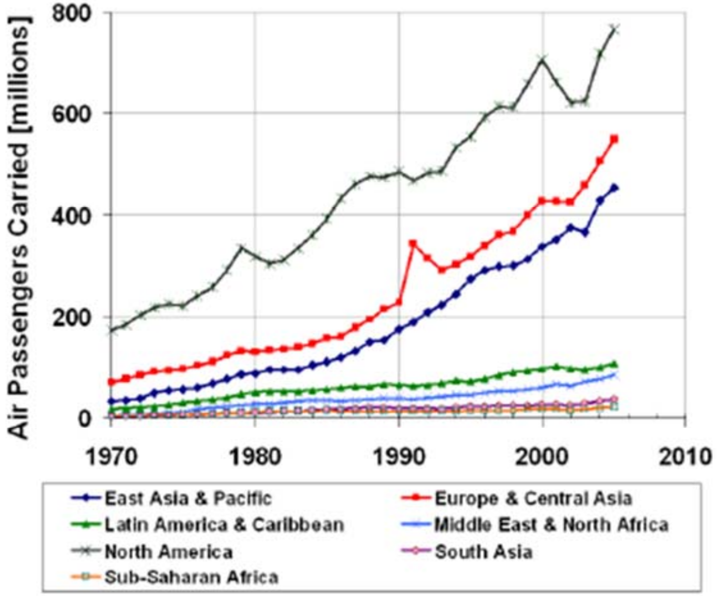
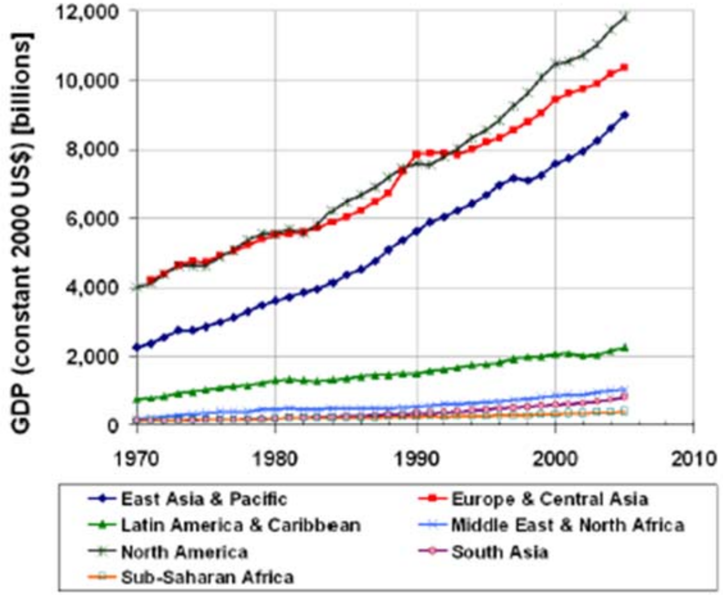


Figure 2.8 : Average battle deaths per conflict (Roser, 2019).



(a) Air passengers carried by airlines registered in those regions. The abnormally high values for years 1991 and 1992 for the Europe & Central Asia aggregate are due to the addition of Russia (1991) and other states (1992) to the aggregate and possible double-counting of some operations following the dissolution of USSR's Aeroflot into 300 regional airlines in December 1991.



(b) GDP (constant 2000 US$): country aggregates by region. The change in years 1989 and 1990 for European aggregate is due to the addition of Russia (1989) and other former USSR states (1990) to the World Bank's European & Central Asia aggregate.

Figure 2.9 : Changes in passenger traffic flows and GDP in the world's regions (Ishutkina & Hansman, 2008).

2.4.5 Global crises affecting economy

The world economy is under risk of financial crisis owing to government failures, money flow from raw materials, global debt levels affect adversely global financial system. Generally, crises for governments drive from consuming more than it produces or not producing the goods and services demanded by the global economy due to planning future problems. Moreover, an epidemic or a major natural disaster can cause a sudden drop in the number of flights and passengers. These negative factors influence aviation industry activity and revenues with taking long time to recover. It is possible to see this situation clearly in a graph prepared by IATA in the period of 2002-2018. In the chart, the world civil airline industry was examined on the basis of the "Revenue Passenger Kilometer (RPK)" and "Freight Tones Kilometer (FTK)". It has been shown how two important developments in this period impacted the airline sector.

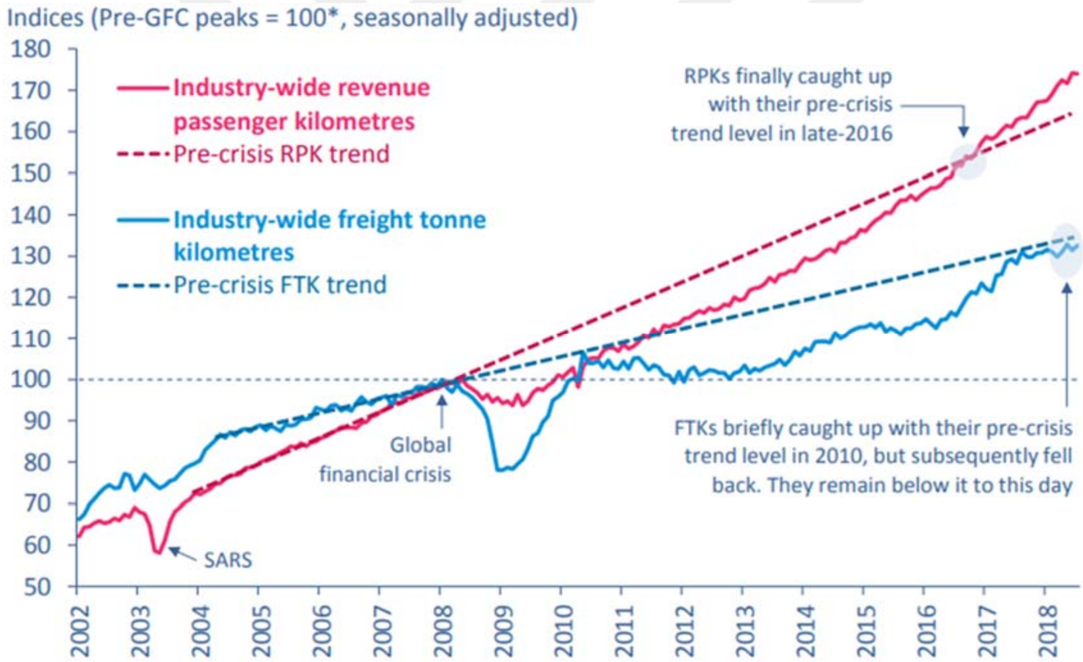


Figure 2.10 : Global financial crisis cost in aviation industry (IATA, 2018).

The first one is an outbreak of acute respiratory insufficiency (SARS) in Southeast Asia during the SARS epidemic, there has been a sharp decline in the number of passengers, with almost no negative impact on the cargo volume. the second is the global financial crisis which has ravaged the world in 2008-2009. Until 2008, while FTK was bigger than RPK. After crisis, the winds have changed and FTK became lower than RPK. In the years of global financial crisis, both the passenger and the cargo transportation have experienced extremely sharp declines owing to the fact that 3 trillion less RPKs and 180 billion less FTKs that corresponds to approximately $280 billion revenue lost in aviation industry over the last ten years. In addition, the number of passengers caught up with the trend before the crisis in late 2016, while the air cargo business took a little longer to recover. Cargo Tons Mileage performance was very close to the trend in the pre-crisis period in 2018. But he hasn't been able to get on it yet. In the coming years, if there is no global crisis, it is estimated that the number of passengers traveling by air will continue to increase strongly. However, the increase in air cargo transportation will be limited.

3. GLOBAL AVIATION DEVELOPMENT

3.1 Aviation Industry by Numbers

Aviation industry is very important in terms of its direct and indirect contribution to the country's economy. The aviation industry around the world provides 2.9 million job in aviation industry for totally 70 million including ‘supply chain’ jobs. The total revenue generated by the aviation industry in 2018 is $821 billion that corresponds to 1 % of the world's total GDP is provided by the aviation sector (IATA, 2018). According to the report of Air Transport Aviation Group (ATAG) in 2018, the aviation industry served 4.1 billion passengers were carried by airlines and 41.9 million flights were scheduled as commercial flights by 1303 airlines. These flights were made on 3759 airports all over the world. There is a significant relationship between world economic growth and aviation. In addition, when developing countries are examined, result of the growing economic forces in Asia and the shift of the world economic center to the east, the fact that the developing economies are higher in the world eastern block boosts the global aviation center to shift to the east over the last 30 years.

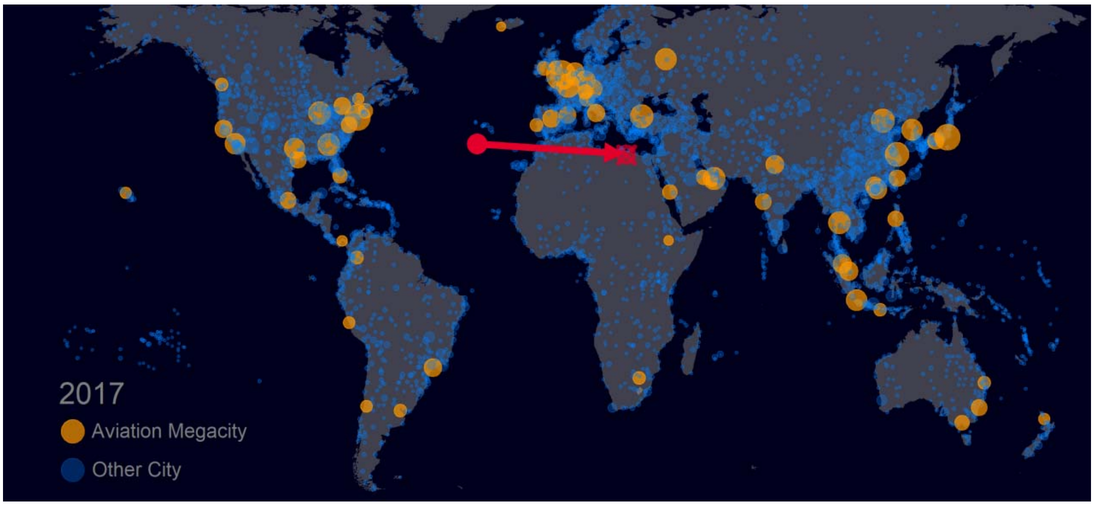


Figure 3.1 : Air transport center of gravity moving trend in last 30 years (Airbus, 2017).

One of the most important indicators of the aviation industry is the development of the number of passengers, which is the most important element of aviation and the commercial source of the sector. The development of the volume of civil aviation passenger traffic by region is an important indicator for understanding the aviation sector.

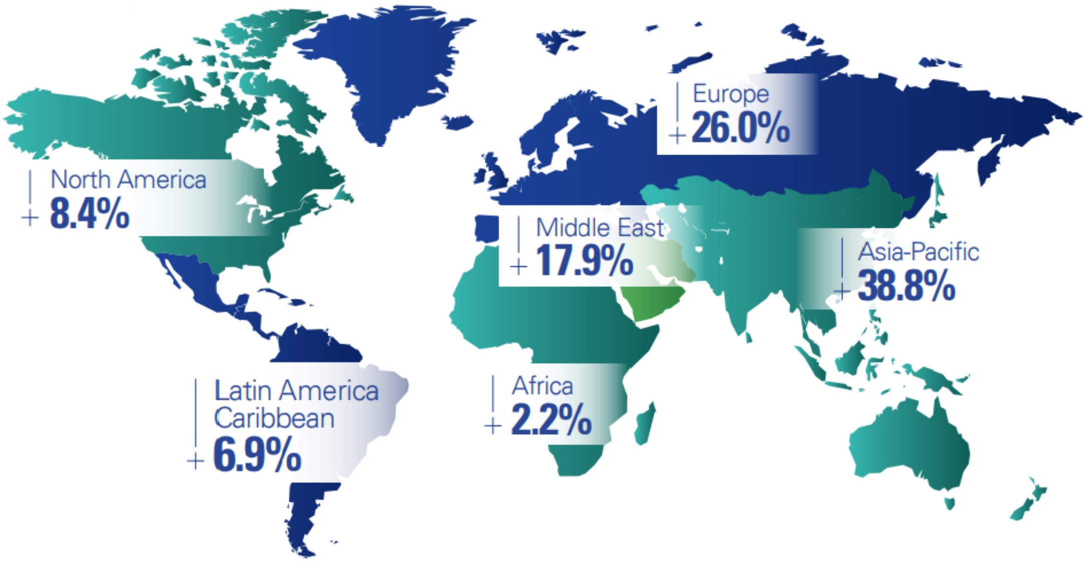


Figure 3.2 : Regional contribution to passenger traffic growth 2017–2040 (ACI, 2017).

As of 2017, about 37% of world commercial passenger traffic is provided in Asia-Pacific region and 26% in Europe. In 2040, world commercial passenger traffic is expected to be 39% in the Asia Pacific region, 26 % in Europe and 18% in the Middle East region.

3.2 World Aircraft Market

There is an increasing trend about travelling with aircraft to travel another city or country with saving time and money owing to technological developments and decrasing expenses. Due to rising demand, manufacturers establishe new facilities and make corporations with other countries in order to enhance number of aircraft rapidly every passing day. According to General Aviation Manufacturers Association (GAMA), more than 446,000 aircrafts go on to fly every day with a diversity from light training aircrafts and single engine helicopters to private business jets in 2018. Approximately one out of every two aircrafts are localized in the United States of America and one out of every three aircrafts are localized in Europe. Moreover, Airbus from Europe and Boeing from

United States have big shares on aircraft market. Last 15 years number of aircraft deliveries by these companies could be seen on below Figure 3.3.

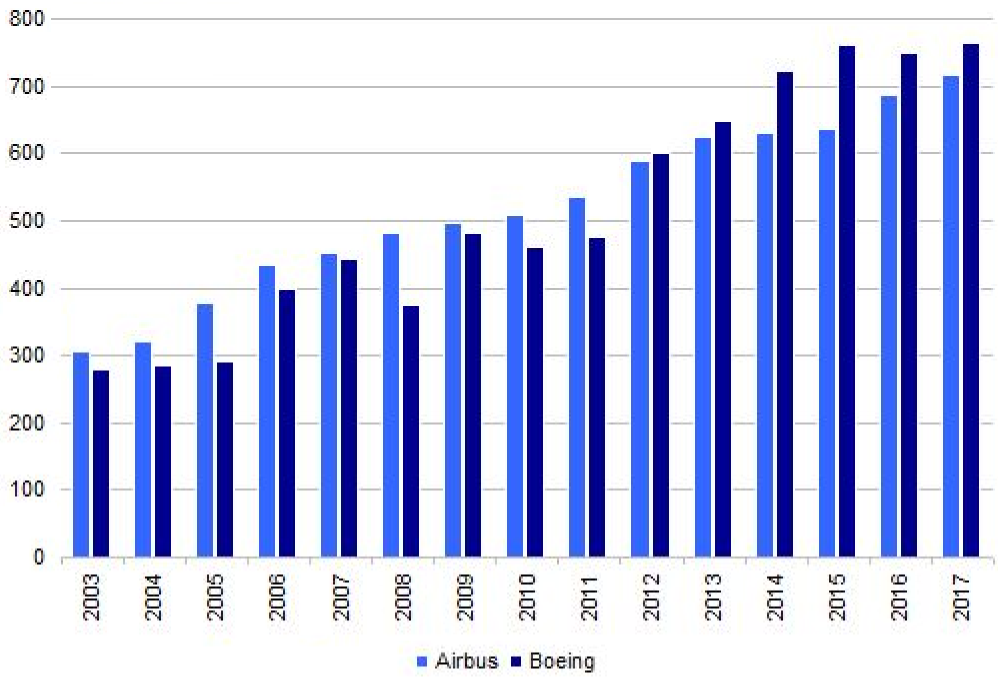


Figure 3.3 : Airbus and Boeing annual aircraft deliveries: 1996 to 2017 (ACI, 2017).

3.2.1 World airplane market

3.2.1.1 World airplane market by region

Approximately 8,500 of current total commercial air transport aircrafts are based in Asia Pacific that is same with North America quantity due to higher population and demand. In this distribution, Europe has a 24 percente share. Middle East and Africa shares same percentages.

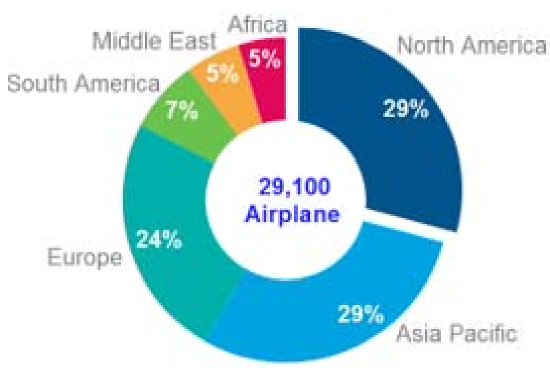


Figure 3.4 : World airplane region distribution (CAPA, 2018).

3.2.1.2 World airplane market by intended use

When the aviation sector is mentioned, aircraft fleet sizes come to mind primarily. As of 2018, the total number of active commercial airplane in the world is is 29,100. Moreover, 55% of the airplanes are narrow-body (NB) airplanes, 19% are wide-body (WB) and 26 percent are regional jets and turboprop power airplanes are formed. The reason for more NB is about quantitiy of regional airlines and low-cost carriers. In addition, owing to developing technology provided by manufacturers, with NB airplanes with increasing maximum distance.

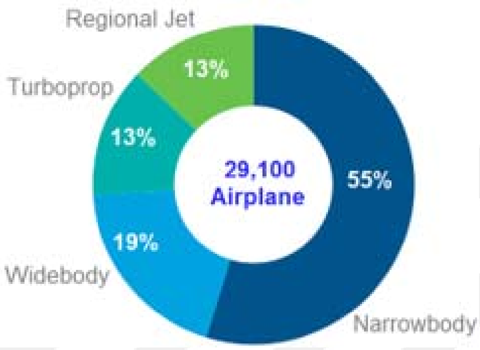


Figure 3.5 : World airplane type distribution (CAPA, 2018).

There is an analogy between fleet size and number of carrying passengers. When passenger quantity by countries was examined, although USA is leader at carring passengers, rising of Turkey could be seen clearly in first 10 countries in last decade.

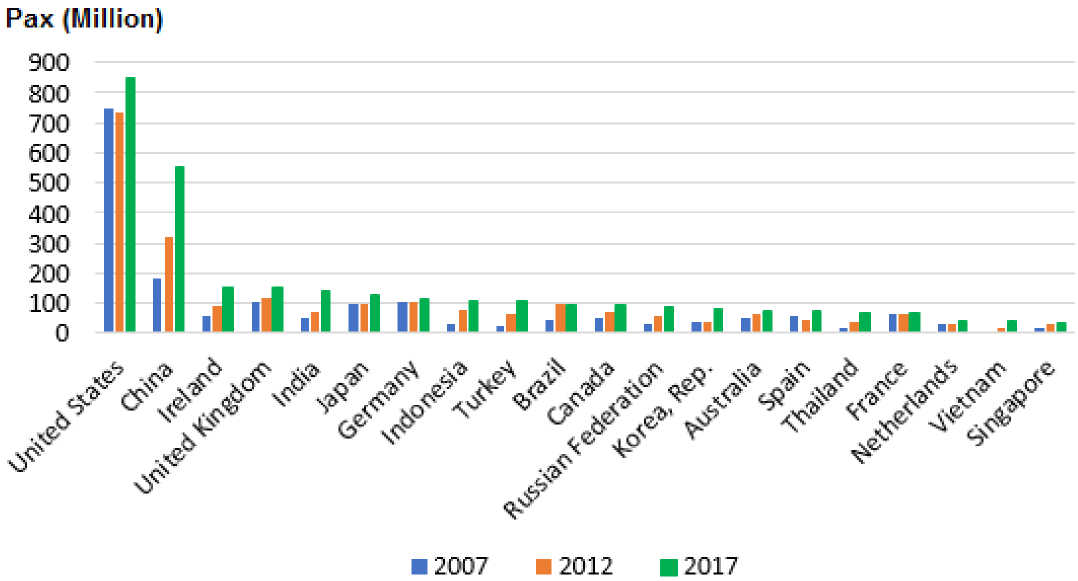


Figure 3.6 : Number of passengers carried by countries.

3.2.2 World general aviation market

General aviation aircraft orders do not follow same trend with airplanes of airlines. Because, there is not too much change in aircraft buying and sellin activities like in airlines. Moreover, these aircraft are not used too much like airline aircrafts. Businessmen spend a lot of money and operating cost per hour increases when it is not used to much. While increasing passenger quantity and opening of new routes require new airplane for better management, scenario is different in civil aviation. From the beginning of 1990s, civil aviation orders rised four times until 2007. However, owing to occurance of economical crisis in 2008, demand was shrinked suddenly. In order to be afloat, manufacturers increased prices.

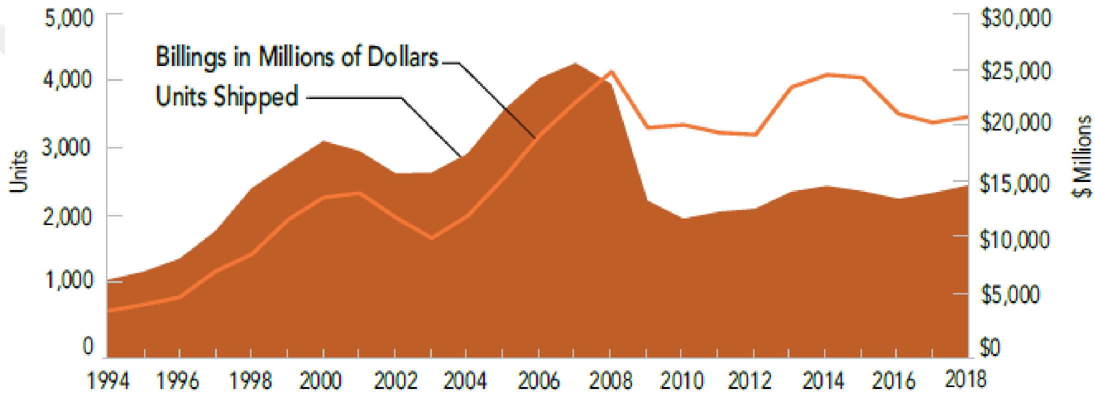


Figure 3.7 : General aviation airplane shipments and billings worldwide between 1994–2018 (GAMA, 2018).

Although there was a decreasing by half in airplane shipments in general aviation in last decade, manufacturers achived to remains almost stable their financial turnover with increasing general aviation airplane prices due to technological developments. When general aviation aircraft manufacturers namely the business jet manufacturers are examined by their revenues, Gulfstream becomes first for the fifth consecutive year with highest revenue with total 2017 sales of $6.5 billion. In second place, Bombardier with revenue of $5.14 billion. Although Textron Aviation (Cessna + Beechcraft) is the overall leader in terms of units sold, it is in 3rd place due to mostly selling smaller aircrafts with $2.87 billion. In fact, Dassault is not in the top 10 according to sold units, but it is in 4th place with 2017 revenue of $2.42 billion followed by other manufacturers due to higher aircraft prices.

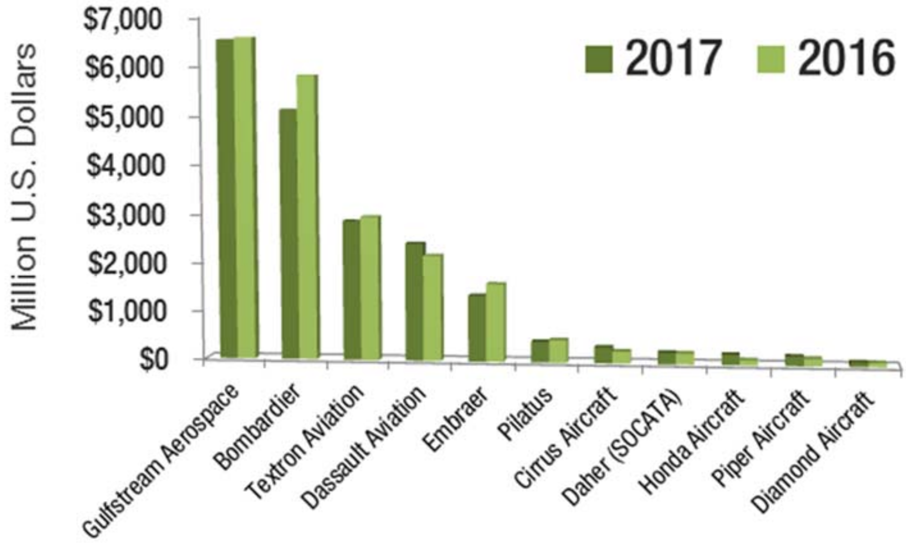


Figure 3.8 : General aviation manufacturers revenues for 2016 and 2017.

487 deliveries were made by Cessna (Textron Aviation) as the largest general aviation aircraft producer at number of aircraft delivered in 2017. Especially in business jet market, CE680A is in demand model. After Cessna, Cirrus Aircraft comes as second manufacturer with 377 aircraft delivered in 2017. After TECNAM Aircraft, Piper and Bombardier come in forth and fifth places respectively with 155 and 138 aircrafts were shipped in 2017. Challenger 300/350 models are popular in business market. 56 Challenger 350 model were delivered to owners. Eventhough, there is a decrease at deliveries for most manufacturers, they reach to year-end target (GAMA, 2018)

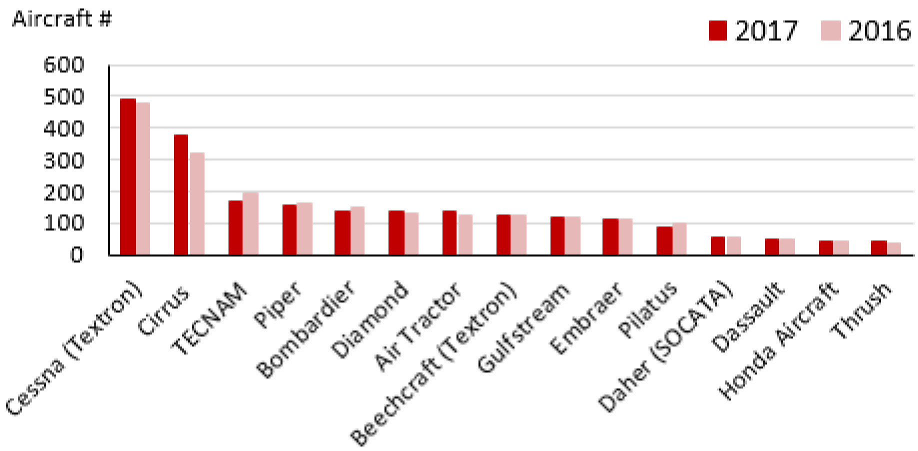


Figure 3.9 : General aviation delivered aircraft numbers for 2016 and 2017.

Cirrus Aircraft increased their deliveries from 282 to 309 in one year at SR22/SR22T models. After merger of Cessna and Beechcraft companies under Cessna, it dominated civil aviation market especially in business jet and turboprop aircraft sectors.

3.2.3 World helicopter market

3.2.3.1 World helicopter market by region

Helicopter manufacturers in the aviation industry goal to meet the needs of airlines in the most efficient way by renewing the designs of existing aircraft. By analyzing the order data received from International Bureau of Aviation database of the new orders produced by the world helicopter manufacturers, a new generation of helicopter market will be examined over total 21,951 helicopters.

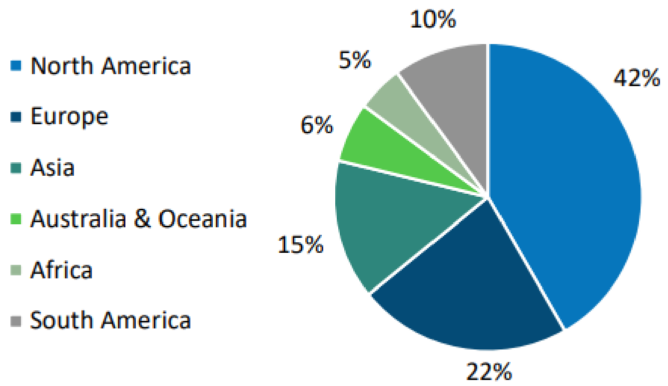


Figure 3.10 : World regional helicopter contribution, (IBA, 2017).

As of 2017, about 42% of world commercial helicopter flies in North America including USA and Canada. Although North America and Europe has increasing rate at helicopter order, especially in Africa and Australia & Oceania fleet size expansion is less than 2% in accordance with pevious year.

3.2.3.2 World helicopter market by intended use

Usage rates of helicopter could change according to its purpose. Biggest proportion of helicopter usage is in general utility and corporate sector. Moreover, Emergency and Medical Services (EMS) with Search and Rescue (SAR) is at third place. In addition, government uses helicopters to provide security at crowded places such as match days or political events.

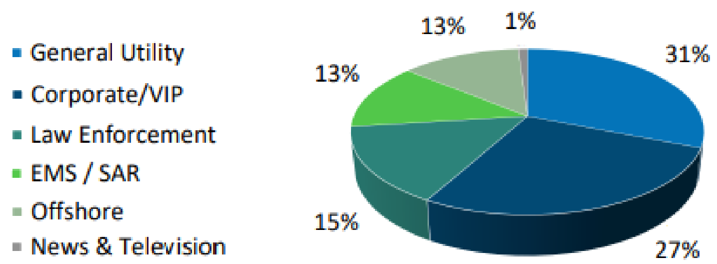
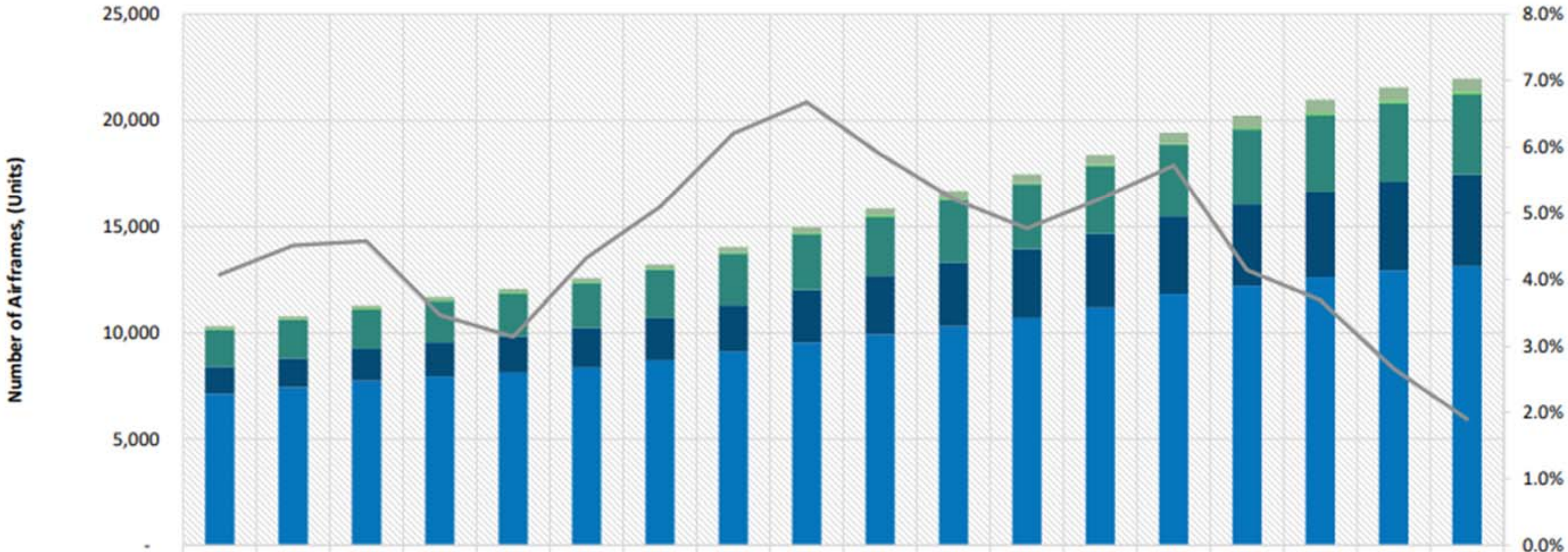


Figure 3.11 : World regional helicopter contribution, (IBA, 2017).

At the beginning of 21st century, there was 10,329 civil helicopters in service, it was doubled in 2017. Altough there is a 100 percent increase in total helicopter quantity, in last a few years there is a decreasing rate in helicopter market. Helicopter types could be separated into 5 types. These are light single engine, light twin engine, medium size, super medium and heavy. Light single and twin engines are operated by companies. This market is generally a cash market owing to easy selling and finding with financing activities. Moreover, these helicopters are popular at Emergency and Medical Services (EMS) and police missions. Super medium and heavy helicopter market is dominated by off-shore helicopter works in order to ferry people between land and oil rigs. The core business depends on investments and new oil rigs. Furthermore, most of oil companies' helicopters are older in comparison with ages of other helicopters. Altough there was a sharp decrease in 2015 crude oil trade, there is a rapid increase in last years that could be seen on super medium helicopter deliveries.

3.3 Forecast in World Aviation Industry

Aviation industry sector forecast is based on growing rate as predicted. Eventough naturally possibility risk of political situation of goverments and unexpected economical crisis such as in 2008 or same aircraft accidents such as Boeing 737-Max performed, predictions will reach to their aim as soon as possible. Because, there is no way as rapid and economical as aviation to reach another place. So, in this view impact on air traffic growth and quantitiy of international travel flights including cargo will results in increasing rate in revenue passenger kilometers.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Heavy	120	125	129	135	150	182	205	249	289	338	372	412	455	512	581	611	619	623
Super Medium	58	58	58	58	58	58	58	58	58	58	58	58	58	58	72	96	104	115
Medium	1,736	1,790	1,853	1,924	1,990	2,106	2,249	2,401	2,611	2,772	2,936	3,066	3,200	3,379	3,529	3,648	3,713	3,763
Light Twin	1,283	1,380	1,499	1,609	1,717	1,847	1,995	2,210	2,463	2,731	2,988	3,224	3,472	3,678	3,846	4,017	4,190	4,331
Light Single	7,132	7,442	7,750	7,955	8,133	8,376	8,702	9,111	9,545	9,949	10,320	10,709	11,195	11,805	12,209	12,612	12,917	13,119
Growth Rate	4.1%	4.5%	4.6%	3.5%	3.1%	4.3%	5.1%	6.2%	6.7%	5.9%	5.2%	4.8%	5.2%	5.7%	4.1%	3.7%	2.7%	1.9%

Figure 3.12 : Annual delivery growth rate and current helicopter quantitiy in operation (IBA, 2017).

3.3.1 Forecast in airplane industry

Aircraft manufacturers anticipate themselves will keep on to save important energy over the next two decades from various new technologies involving efficient engine design, more durable composite material that is used on both usalage and wing and more direct aircraft routing with ADS-B out and Link 2000 modifications with CPDLC that will be mandatory end of 2020 by European Aviation Safety Agency (EASA) and Federal Aviation Administration (FAA). Moreover, some of airline aircraftS will be converted to cargo aircraft with some modification including removal of passenger seats and interior modification. As of 2018, there are 26,307 passenger and cargo airplanes in service, it is predicted that it will be 37,978 in next decade in accordance with Wyman's estimation. In addition, 676 airplanes will be converted to cargo aircraft.

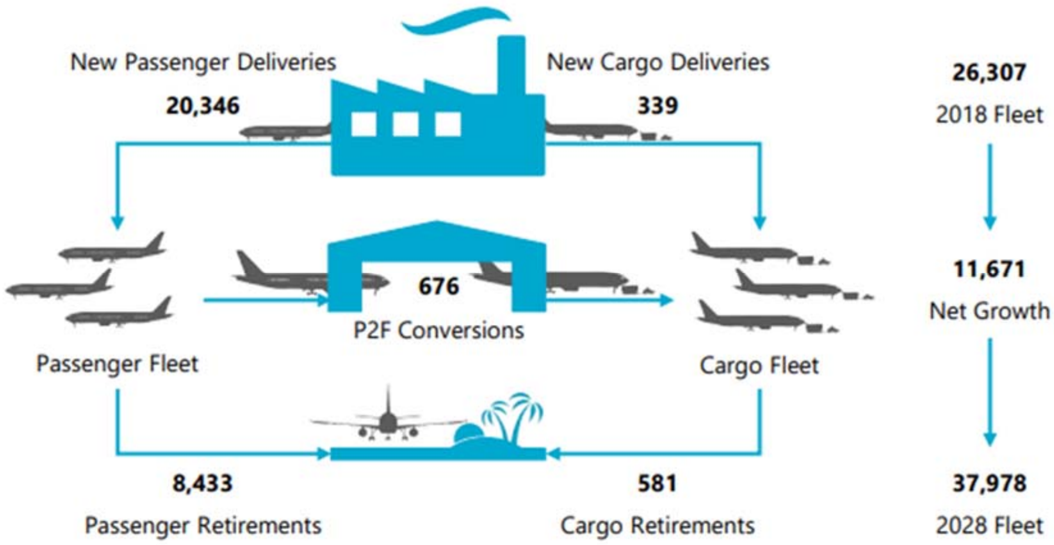


Figure 3.13 : Passenger and cargo estimation for 2028 (Wyman, 2018).

Most of these aircraft are based on Asia-Pacific region. Besides, the biggest growth rate will be seen on this region with Middle East in next 20 years. Due to USA is a saturated market, high increase is not expected as much as other regions. In addition, when commercial passenger and cargo order planes are examined, it is observed that the North American region is considered as the center of aviation, owing to the fact that both the flexibility of the aviation laws and the aviation market, the airline operators and the aircraft leasing companies orders are concentrated in this region.

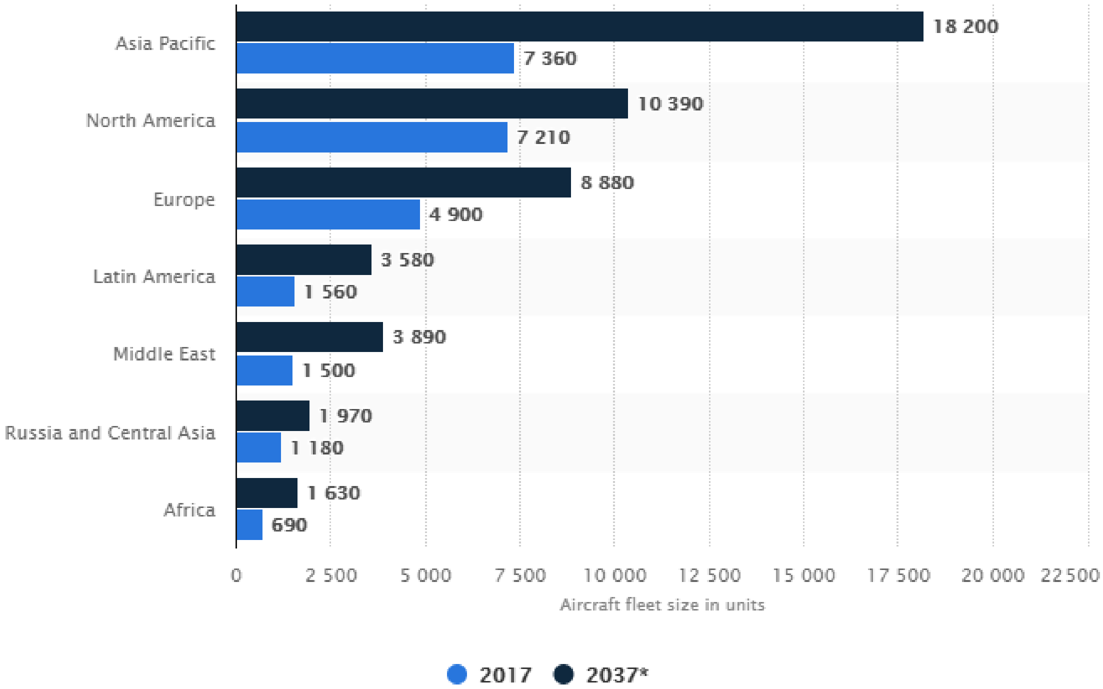


Figure 3.14 : World airline fleet prediction for 2037 (Url-5, 2019).

Due to having popular destinations, manufacturers and base of Maintenance, Repair and Overhaul (MRO) that corresponds to aircraft maintenance center, Europe will be doubled aircraft fleet size. Although Africa does not have so much aircraft for current year, it seems gap between other countries will be decreased.

Asia-Pacific includes 45% of the total orders which it could be describes as the developing regions of aviation, are concentrated in this region. In line with the economic and commercial growth data, it can be concluded that existing orders are concentrated in developing economies. It is the greatest proof that the center of aviation will move towards developing markets in the coming period.

3.3.2 Forecast in helicopter industry

Helicopters meet the needs of people in terms of socio-economic developments in crucial five areas such as public services, emergency operations, to transport passengers to remote areas, for commercial operations and transport people to hard site conditions with minimum landing area. In civil and parapublic helicopter demand trend will keep on to be followed by helicopter manufacturers. Today, 25,000 civil and parapublic helicopters fly in the sky. In next two decades, it is expected that 15,000 of them will be on service and 22,000 new helicopters will be delivered as total €125 billion value. Total order from Asia-Pacific is expecting 8000 civil helicopters. Europe demand equals half of it. North America needs 5000 helicopters in next 20 years. Although Africa does not have so much helicopter for current year, it seems 2000 orders will be made from Africa continent.

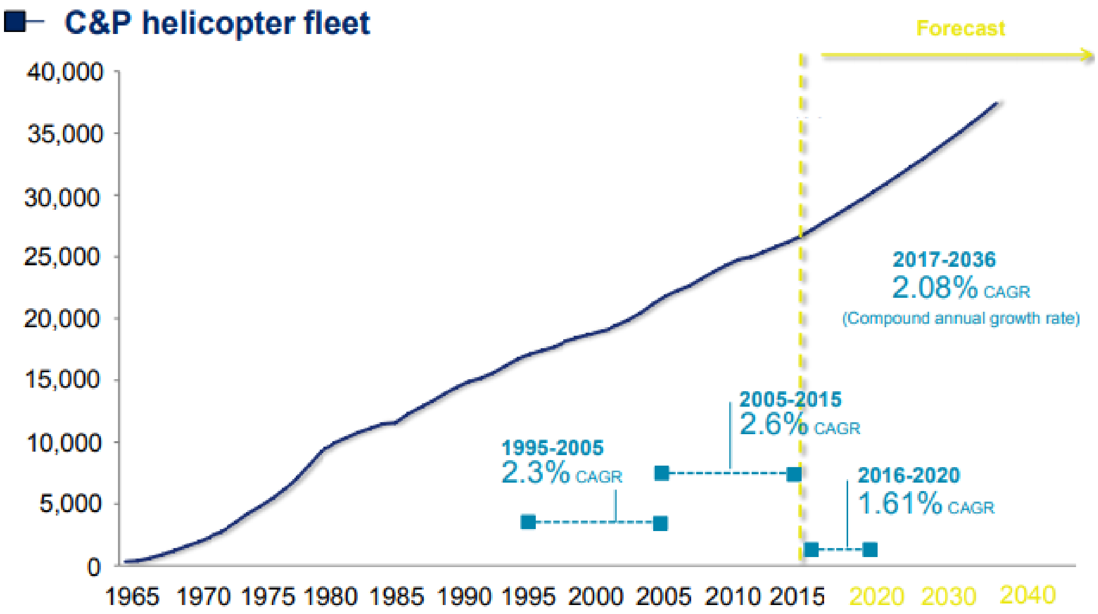


Figure 3.15 : Global helicopter forecast for 2036 (Airbus, 2016).

Light and single engine helicopters will consist half of total new orders with €21 billion. 35% will be light & medium twin having €56 billion and remaining part will be fulled by super medium & heavy helicopters as €48 billion according to global helicopter forecast Spares and components expenses will reach to €155 billion. Moreover €90 billion labor expenses will be paid to maintenance centers. Totally, €370 billion helicopter market value expecting in next two decades.

3.3.3 Forecast in MRO market

The commercial MRO market will keep on to grow in accordance with size of global aircraft fleet. The total MRO expense in 2018 was occurred as $77 billion. Globally, $69 billion of this total amount comes from narrow-body (NB) and wide-body (WB) aircrafts. As of 2018, more than a half of total fleet consists of NB while 45 percent of MRO market share. Besides, 20 % of total fleet consists of WB while 44 % of MRO expense share of MRO market. It is expected that it will rise to $92 billion by the end of

2023 that correspond to 3.5 % compound annual growth rate (CAGR). The growth rate will reach to annually 4.5 % CAGR in the second five years period. Over the next decade, the global commercial MRO market will show average 4 % growth annually, rising to $114.5 billion. Biggest share on MRO market belongs to NB aircrafts that will continue to have most share according to other types due to development on aviation industry that produces aircrafts with longer range but consuming less fuel. So, increasing demand on NB will lead to more share at MRO Market. Besides, although average age of NB is higher than other types, number of NB aircrafts is dominant in this sector.

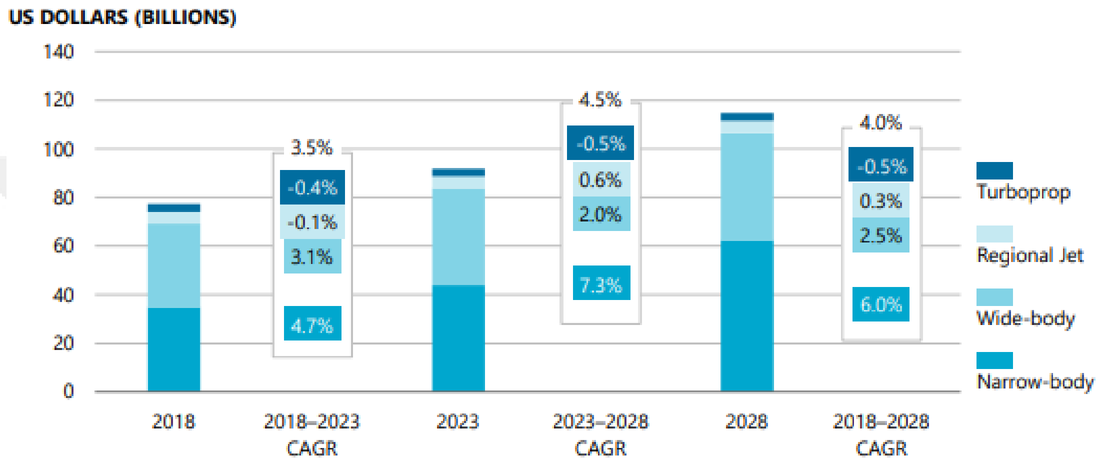


Figure 3.16 : MRO forecast by aircraft type (Wyman, 2018).

Aircraft maintenance cost trend will continue to decrease by means of heavy maintenance inspection intervals extends to 12 years. The reason behind of this scene is more extensive usage of composites materials and alloys in brand new aircrafts, providing less fatigue and corrosion occurance in comparison with previous aircraft generations. NB MRO spend will reach to from $27.5 billion to approximately $62.5 billion by the end of 2028, with overall market share will be more than a half. This share is taken from each aircraft type, as wide-body market share will drop to 38 % due to to high maintenance and fuel consumption cost with decrasing demand. Moreover, owing to increasing technology, WB spend will decrease in next years. Totally $44 billion, and regional jets and turboprops will combine for seven percent of MRO spend totaling $8.2 billion.

New generation engines have opportunity consuming less fuel with higher operating pressures and temperatures. On the other hand, resulting in more expensive shop visits to overhaul or repair engines. Moreover, engine sub components are very expensive and labor hours are higher than a simple check on airframe due to reaching a component, replacing and closing engine takes a lot of hours with expensive materials. Furthermore, 4.9 % average annual growth rate foresight is dominant in engine MRO by the end of 2028. To sum up, global MRO market is expected to become increasingly concentrated sector with aircraft platforms and technological developments.

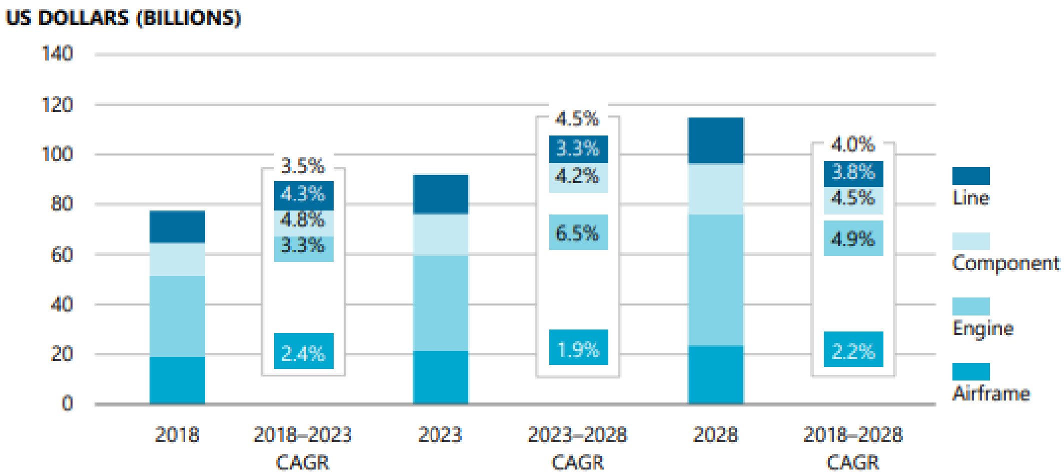


Figure 3.17 : MRO forecast by segment (Wyman, 2018).

3.3.4 Forecast in aviation employment

In the future, Maintenance, Repair and Overhaul (MRO) centers will encounter problems to follow technological developments with increasing numbers of maintenance activities due to rising quantity of aircrafts in the fleets. MROs must find innovative solutions such as using drones. Digitalisation and automation with advancing technology, minimising aircraft downtime and maximising revenues will be a challenge for stakeholders. when rapidly increasing fleets is taken into account and traning a pilot or technician as a certified staff takes minimum two years, same issue will occur for operators. By 2037, the aviation sector is expected to provide employment opportunities to more than one million technicians and pilots especially in Asia-Pacific region according to Airbus Global Market Forecast 2018-2037.

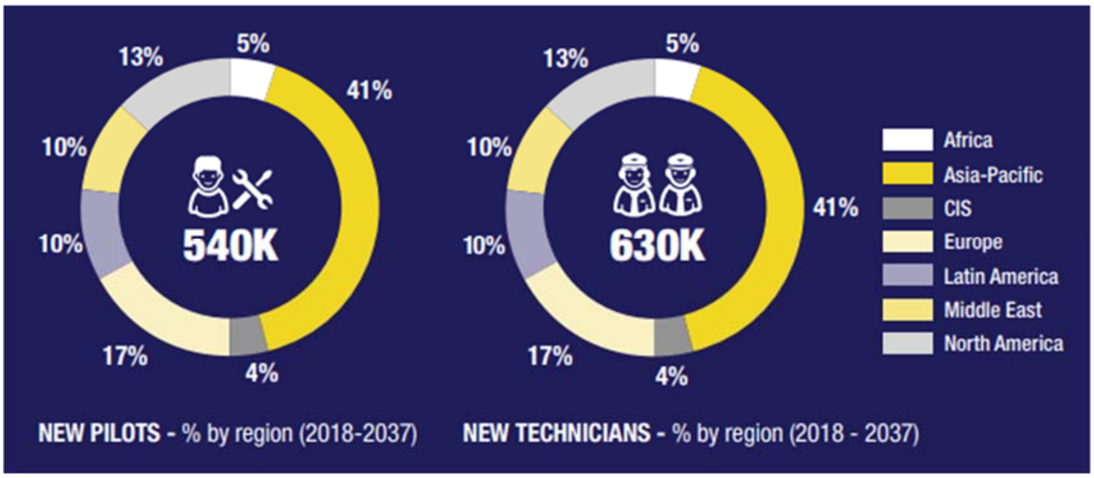


Figure 3.18 : Global market employment forecast 2018-2037 (Airbus, 2018).

As a rapidly growing sector, global aviation sector needs more than half of a million technician in next 20 years. Moreover, 630,000 pilots are required to operate aircrafts. Asia-Pacific region with leader country China dominates aviation sector in MRO, technician and pilot demand. As a big quantity quarter million pilot is required for next 20 years. After Asia-Pacific, biggest share belongs to Europe with 17 percent that corresponds to 91,800 technician and more than 107,000 pilots as a result of more than 5,000 NB aircraft orders are expected from Europe. Opening of new city pairs and routes have a significant contribution on this growing with increasing demand on aviation. The upside for economic growth of European is being sustained by monetary situation, easy access to bank credit, reduced global financial headwinds and business confidence in the long-term trend. Eventough the political situation in Europe was influenced by Brexit which is expected to continue into next term. Long term challenges will remain same in progress of fiscal union as well as the need for reforms on markets liberalisation.

4. AEROSPACE INDUSTRY IN TURKEY

4.1 Defence Industry in Turkey

From the 2000s through the projects carried out for the modernization of the Turkish Armed Forces (TSK) a modern defense industry with a focus on development model and developed in the country such as armored vehicles, corvetes, unmanned aerial vehicles, training aircraft platforms have entered. In this process, defense industry is design-based production from a structure turned into a weighted structure. As a result of defense industry, TSK and security forces in meeting the system needs has reached a certain maturity. Defense industry reaches the system level deepening of this capability and the needed subsystems and technologies to country it is considered important to gain. From the electrical, electronics and software with in aviation and space sectors on the basis of net sales that is seen that the sector is leading the sector. One reason is that ASELSAN and TUSAŞ such as high turnover Turkish Armed Forces Foundation subsidiary companies. Foundation company's turnover-based aircraft sector about 41 % of the general turnover.

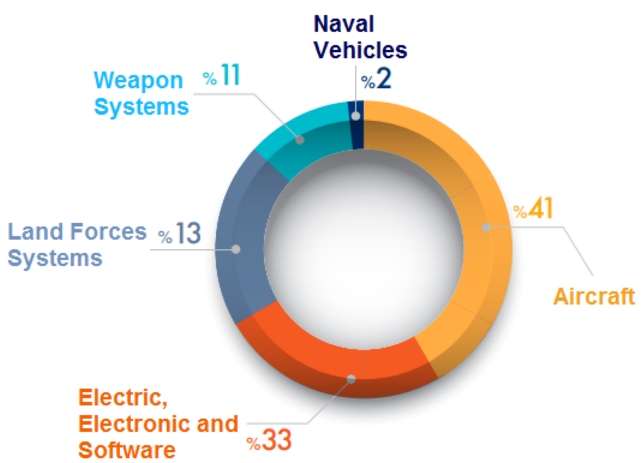


Figure 4.1 : Defence and aviation turnover distribution in sector, 2016 (SSM, 2018).

Turkey has crucial aims tabout future to improve defence industry with succeed in innovation system and reasonable financial investments. Undersecretariat of Defence Industry of Turkey claims that $6 billion investment will be done for Ankara Aerospace Organized Industrial Zone (HAB). Sonuc (2014) states that aim of government is to be one of the world's pioneer countries in defence industry by 2023 that corresponds to centenary of establishment of Republic of Turkey. Furthermore, Turkey projects to produce its regional jet, own car and satellite with innovative technology.

According to Turkish Republic Ministry of Industry and Trade, there is rapid growth on aviation and depence export values in last decade. While total export was $80 million in 1998, it reached $2.035 billion in 2018.

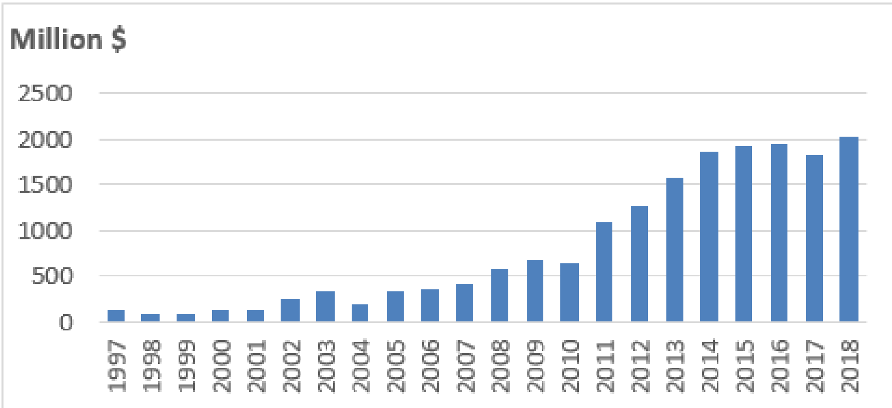


Figure 4.2 : Defence and civil aviation export in Turkey.

4.2 Civil Aviation Industry in Turkey

4.2.1 Civil aviation history of Turkey

In 1912, the first aviation activities in Turkey started in Sefaköy which is located near the Atatürk Airport with two hangars in consideration of Atatürk's quote "THE FUTURE IS IN THE SKIES" to construct future of the country. Turkish Aeronautical Association was established in 1925. Famous pilot/engineer Vecihi Hürkuş manufactured first aircraft VECİHİ K-VI model by himself in 1924 in Turkey. Model XIV with painting the letters TC-S.1 as first Turkish registered aircraft that has CheckoSlovakian license in 1930. Vecihi made 2 long domestic tours with his manufactured aircrafts in order to perform aviation trainings, raise donations and explain importance of aviation to public.

Nuri Demirağ who is a business man making investments about railway construction in Turkey started to make investments for aviation. First of all, he purchased Elmaspaşa Farm that host to Atatürk Airport in Istanbul. Runways and hangars were constructed. The first Civil Air Transportation was launched in 1933 with a name of "Turkish Air Mail" with 5 aircraft fleet and in the same year "State Property Administration Airlines" that would be renamed as ‘’Turkish Airlines’’ established under the Ministry of Defense in 1933. Then, Gok Aviation School was established to train pilots. 290 pilots graduated from until 1943. One of the first aeronautical enginners Selahattin Reşit Alan designed aircrafts that were manufactured. Single-engine NuD-36 and twin-engine NuD-38 passenger aircraft were manufactured. Moreover, first domestic parachute was manufactured in 1939. (Url-8, 2009)

Figure 4.3 : First Turkish TC-S1 registered aircraft model VECİHİ XIV manufactured in 1930 by Vecihi Hürkuş (Url-7, 2019).

"Civil Aviation Department" was established in 1954 under the Ministry of Transportation. Then, became the Directorate of General Civil Aviation (DGCA) in 1987. Turkey has been a member of various international organizations in order to closely monitor the developments. Turkey became became one of the founding members of the International Civil Aviation Organization (ICAO). In addition, the European Civil Aviation Conference in the European Region - ECAC, as founding member in 1956, is also a member of EUROCONTROL including both national and international regulations. With the beginning of 1990s, various airline companies were established resphectively Pegasus, Sunexpress, Onur Air, Atlas and Corendon. Today, Turkish Airlines is the pioneer of Turkish Civil Aviation with more than 308 aircrafts out of total 540 airline aircrafts. Moreover, Turkish Airlines fly to 300 cities all over the world that is the world record.

4.2.2 Current situation of civil aviation in Turkey

In the last decade, Turkish Civil Aviation has made great improvement. While the number of passenger airplane in civil aviation in Turkey was 162 in the year 2003, today there are 540 passenger aircrafts. Moreover, airline passengers were rised from 34 million to 193 million. Besides, 117 helicopters and 114 business jets exist in 43 airtaxi companies. 14 of them are used as fire fighting helicopters and 19 of them are used as ambulance helicopters for search and rescue operations. Remaining 84 helicopters fly under airtaxi companies for commercial operations. Moreover, 26 companies operate 239 hot air balloons especially in Cappadocia region.

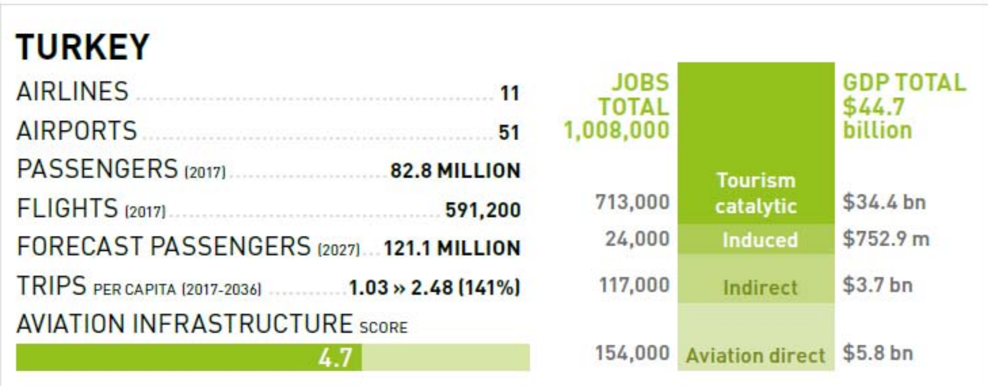


Figure 4.4 : Aviation analyse of Turkey (ATAG, 2018).

As of 2018, 5.3% of Turkey's GDP is produced by the aviation industry. The importance of aviation in Turkey in the next twenty years will expand the scope and create more value it is expected. As of 2036, 7 percent of Turkey's GDP will be provided by aviation industry. Moreover, according to IATA and AIRBUS forecast reports, Turkey will enter the top ten world economy markets, while France and United Kingdom will fall in the rankings with two-digit numbers. So, investment for Turkey will yield a profit for its stakeholders.

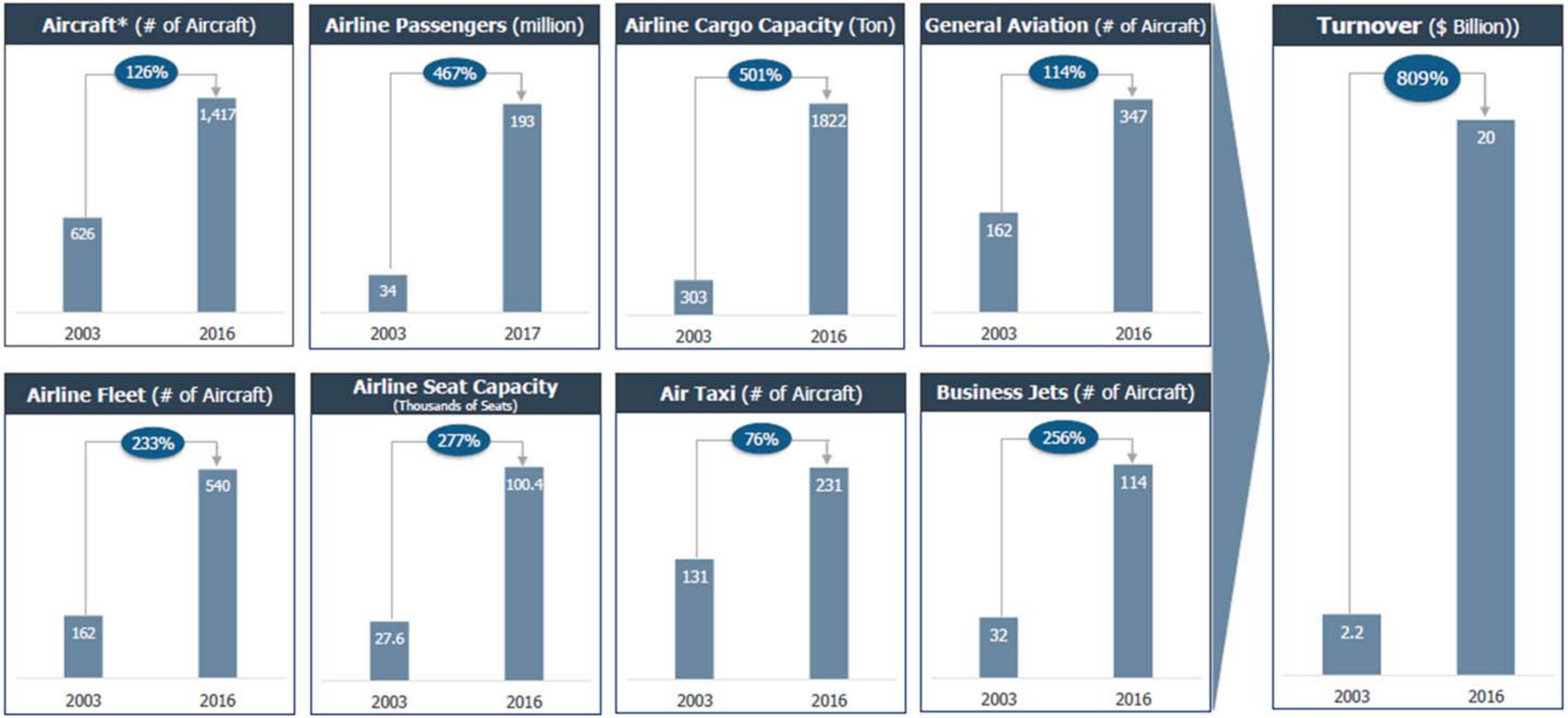


Figure 4.5 : Aviation industry development of Turkey between 2003 and 2016 (DGCA, 2018).

4.2.3 Airports and heliports in Turkey

Ministry of Transport and Infrastructure of Turkey stated that number of active airports was reached to 55 with new airport project Istanbul Airport in red colour that could be seen on Figure 4.6. In 2023, it is aimed that every person in Turkey will reach closest airport by driving maximum 100 km. Most of the projects in country is gone out to tender with a Build-Operate-Transfer (BOT) model such as West Antalya Airport and Izmir Cesme-Alacati. With this way, government do not spend any money to project and investments that are incorporated into their management after 25 years past. Besides, in 2003, while there were just 2 airline companies which operates international flights with 60 points, today 6 airlines operate 121 countries more than 300 points that shows how Turkish Civil Aviation rapidly developed.

The biggest airport all over the world Istanbul Airport started to host passengers for flights with first flight TK 2124 flight number by Turkish Airlines' largest passenger airliner trip to Ankara that is capital city of Turkey at 11:30 on 31 October 2018. New airport aims to service more than annual 200 million passengers. A lot of brand-new technologies are used in this airport such as ground radars, thermal cameras and fiber optic sensors including 7 days 24 hours security. The terminal size of Istanbul New Airport is 1.3 million square meters and the total construction area is 76.5 million square meters. When all the phases are completed, Istanbul New Airport will be the world's largest airport with 6 independent runways, 500 aircraft capacity, 70 thousand vehicles open and closed parking and 200 million passengers annually. 250 airline companies will operate their flights. An investment of €6 billion was made by Istanbul Grand Airport (IGA) the consortium that won the tender for the first phase of the Istanbul New Airport, which was awarded with €26 billion construction, operation and transfer costs.

In 2002, there were 21 heliports accredited by DGCA. As of 2018, total accredited heliport quantity reached to 84. Half of them were concentrated in Istanbul. In addition, 36 of them are in elevated heliport status that means built on the top of building. Moreover, there are 34 emergency landing areas (DGCA, 2018). In the next period, a rapid increase is expected, especially in the number of upgraded heliports. Heliport map of Turkey could be seen on Figure 4.7.

Figure 4.6 : Map of airports in Turkey.

Figure 4.7 : Map of heliports in Turkey.

5. DECISION OF A POTENTIAL HELICOPTER

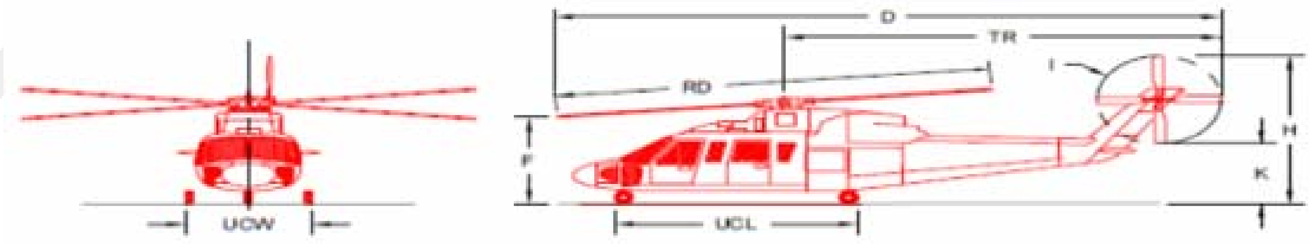
5.1 World Civil Helicopter Market by Type

Global helicopters market has exhibited growth in turnover in the last decade. The market is seperated into two sectors as civil helicopters & defense helicopter. While the demand for defense industry is driven by defense equipment requirement, demand for civil helicopters is driven by energy exploration activities such as oil & gas that steers the world economy and turism activities. Although there is a decreasing in terms of number of deliveries in the last six years, Airbus Helicopters still dominates civil helicopter sector. After Airbus Helicopters, Bell, Leonardo (prev. AgustaWestland) and Sikorsky could be counted as leader manufacturers. However, due to high prices and accidents that causes decreasing in deliveries, Sikorsky will not be involved in decision-making process. Best seller helicopter models having at least 5 passenger seat capacity delivery results and specifications could be found below table that will be examined at helicopter decision. The helicopters will be reviewed have at least average 24 deliveries in a year that correspondes to 2 deliveries in a month.

Table 5.1 : Best seller civil helicopters delivery numbers (GAMA, 2018).

Manufacturer / Model	2014	2015	2016	2017	2018	Last 5 Year Average
Airbus Helicopters						
H125 (AS350)	134	95	104	125	136	119
H130 (EC130)	58	69	54	35	23	48
H145 (EC145)	73	68	107	93	79	84
Bell Helicopter						
212	24	24	35	38	34	31
407	86	99	57	44	43	66
429	53	52	28	36	20	38
Leonardo Helicopters						
AW119Kx	17	16	22	25	33	24
AW139	101	72	63	45	33	63

Table 5.2 : Best seller civil helicopters physical specifications.



Helicopter Model	MTOW (kg)	Lengt h (m)	Height (m)	Main Rotor			Tail Rotor			Main Landing			Engine Number / Type	Crew / Passenger
				Dia. (m)	Blade Number	Clearance (m)	Dia. (m)	Blade Number	Clearance (m)	Type	Length (m)	Wide (m)		
A	B	D	H	RD	E	F	I	J	K	L	UCL	UCW	M	N
Airbus Helicopters														
H125 (AS350)	2.252	12,95	3,35	10,70	3	3,23	1,86	2	0,70	skid	1,43	2,29	1-T	1-2&5-6
H130 (EC130)	2.402	12,65	3,60	10,70	3	3,35	N/A	10	1,62	skid	3,20	2,41	1-T	1-2&6-7
H145 (EC145)	3.588	13,01	3,96	11,00	4	3,44	1,95	2	3,26	skid	2,90	2,41	2-T	1-2&8-9
Bell Helicopter														
212	4.767	17,62	4,42	14,63	2	2,23	2,59	2	1,80	skid	3,69	2,68	1-T	1&14
407	2.384	12,62	3,11	10,67	4	2,38	1,65	2	0,98	skid	3,02	2,47	1-T	1&6
429	3.178	13,11	4,05	10,97	4	2,59	1,65	2	1,07	skid	3,02	2,68	2-T	1&7
Leonardo Helicopters														
AW-119Kx	2.852	12,92	3,60	10,82	4	2,83	1,95	2	1,16	skid	3,38	2,13	1-T	1&6-7
AW-139	6.806	16,67	5,00	12,98	5	3,93	2,71	4	2,29	wheel	4,33	3,05	2-T	1-2& 15

5.2 Helikopter Market in Turkey

Helicopter usage rate is increasing in Turkey day by day. There are 165 TC- registered helicopters in Turkey. 103 of them are in civil category and operated under air taxi companies. 20 of total helicopters are used for EMS and fire operations by government with Airbus Helicopters EC135 model. On the other hand, first Turkish civil helicopter T-625 model was manufactured in 2018. With this production, Turkey became 7th country that manufactured its own helicopter all over the world. In addition, there are a lot of maintenance centers in Turkey for not only aircrafts but also rotorcrafts. In addition, 17 MRO perform maintenances of various helicopters.

Owing to the fact that economical forecast reports indicate that Turkey will be in first ten economies in the world, leader manufacturers started to being in Turkey market. Airbus Helicopters which provides services in 152 countries made cooperation with SBAIR (SB Havacılık A.Ş.) which is Airbus Distributor of Turkey. SBAIR was established end of 2018 with partnership of Swan Aviation and Bayegan Holding.

Table 5.3 : MRO helicopter maintenance approval schedule.

MRO	TYPE	BASE	LINE	MRO	TYPE	BASE	LINE
SBAIR	EC125	X	X	SETAIR	AW139	X	X
	EC130	X	X	SARP AVIATION	S76-C	X	X
	EC135	X	X	KALE AIR	S76-B	X	X
	EC145	X	X		S76-C	X	X
TOP SERVICE	AW109	X	X		BELL 430	X	X
	S76-C		X	GUNEYDOGU AVIATION	EC125		X
SKYLINE	AW109	X	X		EC130		X
	EC135	X	X	KORFEZ AVIATION	BELL 407		X
	BELL 429	X	X	KAAN AVIATION	480B	X	X
GENERAL AVIATION A.S.	BELL 206	X	X		AW109	X	X
	BELL 407	X	X		AW119	X	X
ZORLU AIR AVIATION	BELL 430	X	X		AW139	X	X
	AW139	X	X	ASAL AVIATION	EC135	X	X
SANCAK AIR	BELL 206	X	X	ALPTEKNIK	R44		X
	BELL 407	X	X		S76C		X
	BELL 430	X	X		S76D		X

5.3 Helicopter Decision with Analytic Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) was first introduced by MYERS and ALPERT in 1968, and was developed as a model in 1977 and became useful in solving important decision-making problems by Saaty (1990). AHP can be explained as a method of decision-making that gives the distributions of decision criterias as percentage. AHP defines a hierarchy by using a predefined comparison dashboard which based on one-to-one decisions in terms of the factors and the significance value of these decision criterias. The definition of decision-making problem includes two steps. In the first step, decision points are determined. In other words, the answer to the question of how many criterias will be evaluated. In the second step, factors affecting the helicopter decision are determined. In this thesis, the number of criterias affecting the decision points were symbolized by 'n'. Specifically, it is important to determine the number of factors that will affect the outcome accurately and to make detailed definitions of each factor. This process works for maximum 15 factors. In this analysis, 8 criterias (n) and 8 options were chosen. Differences are transformed into a percentage distribution table for each factor with a mathematical selection process in order to rank designed to select the best option. In accordance with potential area and demand of customers, unit price, operating cost (hangar, insurance, pilot salary, fuel, maintenance, landing / parking fee's etc.), passenger seat (at least 5), angle of visibility, market share, noise level, reliability and range criterias will be examined in order to define optimum helicopter. Hierarchical Structure figure could be found below to sketch route map.

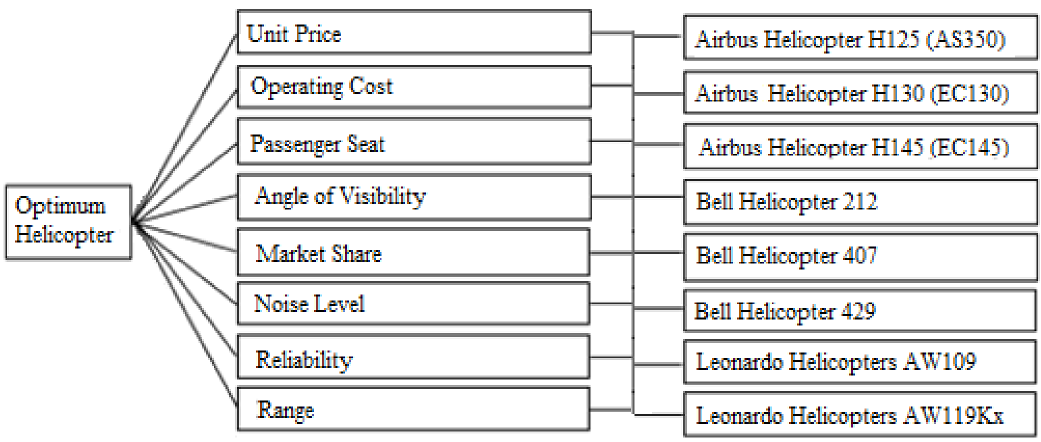


Figure 5.1 : Hierarchical structure.

At first this step, the problem is defined and the hierarchical structure is made with above figure. At the second step, comparison of criterias are made in accordance with below intensity of importance table.

Table 5.4 : Intensity of importance table (AHP).

Intencity of importance	Definition	Explanation
1	Equal Importance	Importance level is same for related factors.
3	Moderate Importance	According to judgement one factor is more significant than the other.
5	Strong Importance	One factor is clearly more important than the other.
7	Very Strong Importance	One factor is strongly preferred at a higher level than the other.
9	Extreme Importance	One of the factors is very significant at a very high rate.
2,4,6,8	Intermediate Values	These are the intermediate rates that used when comparison is needed.

Owing to the fact that the components on the diagonal of the comparison matrix are i = j, each value on diogonal takes the value 1. Because related factor is decided by itself. The comparison of factors is done in pairs by their relative values. The fact sheet in Table 5.5 is used to compare the factors. All criterias are compared by double comparison including superiority and equality states are shown in AHP matrix. After the matrix is formed, normalized AHP Matrix is found. Then each value is normalized by dividing the sum of the same column. By taking the arithmetic average of each line of the normalized matrix, the sum of the row numbers divided by the number of columns, the priority vector matrix is obtained for 8 criterias (n) affecting the helicopter decision.

When normalized matrix was formed, it is required to calculate the consistency ratio to measure whether the decision is consistent according to criteria comparison. In order to calculate it, the sum of each column of the comparison matrix is multiplied by the value in the priority vector of the same criterion in the normalized matrix to obtain the largest eigenvalue (λmax) of the matrix.

Table 5.5 : AHP matrix.

Criterias	Unit Price	Operating Cost / Year	Passenger Seat	Angle of Visibility	Market Share	Noise Level	Reliability	Range	PRIORITY VECTOR
Unit Price	1,00	2,00	5,00	5,00	4,00	5,00	3,00	3,00	28,00
Operating Cost / Year	0,50	1,00	4,00	4,00	3,00	4,00	2,00	2,00	20,50
Passenger Seat	0,20	0,25	1,00	0,50	0,50	1,00	0,33	0,33	4,12
Angle of Visibility	0,20	0,25	2,00	1,00	0,50	1,00	0,33	0,33	5,62
Market Share	0,25	0,33	2,00	2,00	1,00	0,50	0,50	1,00	7,58
Noise Level	0,20	0,25	3,00	2,00	2,00	1,00	0,50	0,50	9,45
Reliability	0,33	0,50	3,00	3,00	2,00	3,00	1,00	2,00	14,83
Range	0,33	0,50	3,00	3,00	1,00	2,00	0,50	1,00	11,33
TOTAL	3,02	5,08	23,00	20,50	14,00	17,50	8,17	10,17	101,43

Table 5.6 : Normalized AHP matrix.

Criterias	Unit Price	Operating Cost / Year	Passenger Seat	Angle of Visibility	Market Share	Noise Level	Reliability	Range	PRIORITY VECTOR
Unit Price	0,33	0,39	0,22	0,24	0,29	0,29	0,37	0,30	0,28
Operating Cost / Year	0,17	0,20	0,17	0,20	0,21	0,23	0,24	0,20	0,20
Passenger Seat	0,07	0,05	0,04	0,02	0,04	0,06	0,04	0,03	0,04
Angle of Visibility	0,07	0,05	0,09	0,05	0,04	0,06	0,04	0,03	0,06
Market Share	0,08	0,07	0,09	0,10	0,07	0,03	0,06	0,10	0,07
Noise Level	0,07	0,05	0,13	0,10	0,14	0,06	0,06	0,05	0,09
Reliability	0,11	0,10	0,13	0,15	0,14	0,17	0,12	0,20	0,15
Range	0,11	0,10	0,13	0,15	0,07	0,11	0,06	0,10	0,11
TOTAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

$$\lambda\text{max} = \sum_{i=1}^{n} (\text{AHP Matrix Total}_i * \text{ Normalized AHP Matrix Priority Vector}_i) \quad (5.1)$$

$$\lambda\text{max} = (3{,}02 * 0{,}28) + (5{,}08 * 0{,}20) + (23{,}00 * 0{,}04) + (20{,}50 * 0{,}06)$$
$$+(14{,}00 * 0{,}07) + (17{,}50 * 0{,}09) + (8{,}17 * 0{,}15) + (10{,}17 * 0{,}11)$$

$$\lambda\text{max} = 8{,}936$$

By using λmax and number of criterias (n), Consistency Index (CI) is found from (5.2)

$$\text{CI} = \frac{\lambda\text{max} - \text{n}}{\text{n} - 1} \quad (5.2)$$

$$\text{CI} = \frac{\lambda\text{max} - \text{n}}{\text{n} - 1} = \frac{8{,}936 - 8}{8 - 1} = \frac{0{,}936}{7} = 0{,}134$$

By means n, Random Consistency Index (RI) could be found from Table 5.7. Owing to the fact that there are 8 criterias, RI is choosen as 1,41 from below table.

Table 5.7 : Table of random consistency index (Saaty, 1990).

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48	1,56	1,57	1,59

After RI is found, Consistency Ratio (CR) could be calculated easily from (5.3).

$$\text{CR} = \frac{\text{CI}}{\text{RI}} \quad (5.3)$$

$$\text{CR} = \frac{\text{CI}}{\text{RI}} = \frac{0{,}134}{1{,}41} = 0{,}095$$

When the CR is less than 0,100, it can be said that the consistency ratio is a desired value. Otherwise higher priority criterias must be chosen and others must be eliminated or paired comparison factors must be prepared again with reasonable factors to increase CR. Because of the fact that CR is 0,095 that is below 0,100, the consistency is acceptable. For this analysis, AHP matris and normalized matrix were prepared for criterias. While a potential helicopter is determined, the evaluation of the criterias will be performed in terms of the information obtained as a result of the detailed researches in the first four chapters of this thesis. Then, comparison matrix and normalized matrix will be prepared according to paired comparison in order to check consistency.

Table 5.8 : Paired comparison matrix for unit price.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	1,00	2,00	3,00	2,00	1,00	2,00	1,00	4,00	16,00
H130 (EC130)	0,50	1,00	3,00	2,00	1,00	2,00	1,00	4,00	14,50
H145 (EC145)	0,33	0,33	1,00	0,50	0,33	0,50	0,33	1,00	4,33
BELL 212	0,50	0,50	2,00	1,00	2,00	0,50	1,00	2,00	9,50
BELL 407	1,00	1,00	3,00	0,50	1,00	2,00	1,00	4,00	13,50
BELL 429	0,50	0,50	2,00	2,00	0,50	1,00	0,50	2,00	9,00
AW119Kx	1,00	1,00	3,00	1,00	1,00	2,00	1,00	3,00	13,00
AW139	0,25	0,25	1,00	0,50	0,25	0,50	0,33	1,00	4,08
TOTAL	5,08	6,58	18,00	9,50	7,08	10,50	6,17	21,00	83,92

Table 5.9 : Normalized paired comparison matrix for unit price.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	0,20	0,30	0,17	0,21	0,14	0,19	0,16	0,19	0,19
H130 (EC130)	0,10	0,15	0,17	0,21	0,14	0,19	0,16	0,19	0,17
H145 (EC145)	0,07	0,05	0,06	0,05	0,05	0,05	0,05	0,05	0,05
BELL 212	0,10	0,08	0,11	0,11	0,28	0,05	0,16	0,10	0,11
BELL 407	0,20	0,15	0,17	0,05	0,14	0,19	0,16	0,19	0,16
BELL 429	0,10	0,08	0,11	0,21	0,07	0,10	0,08	0,10	0,11
AW119Kx	0,20	0,15	0,17	0,11	0,14	0,19	0,16	0,14	0,15
AW139	0,05	0,04	0,06	0,05	0,04	0,05	0,05	0,05	0,05
TOTAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

$\lambda max = 8{,}355 \qquad RI = 1{,}41 \qquad CI = \frac{\lambda max - n}{n - 1} = \frac{8{,}355 - 8}{7} = \frac{0{,}355}{7} = 0{,}051$

$CR = \frac{CI}{RI} = \frac{0{,}051}{1{,}41} = 0{,}036 < 0{,}100$ The consistency is acceptable.

Table 5.10 : Paired comparison matrix for operating cost / year.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	1,00	2,00	2,00	2,00	1,00	2,00	2,00	3,00	15,00
H130 (EC130)	0,50	1,00	2,00	2,00	1,00	2,00	2,00	3,00	13,50
H145 (EC145)	0,50	0,50	1,00	1,00	0,50	1,00	0,50	1,00	6,00
BELL 212	0,50	0,50	1,00	1,00	0,50	1,00	1,00	2,00	7,50
BELL 407	1,00	1,00	2,00	2,00	1,00	2,00	2,00	3,00	14,00
BELL 429	0,50	0,50	1,00	1,00	0,50	1,00	1,00	2,00	7,50
AW119Kx	0,50	0,50	2,00	1,00	0,50	1,00	1,00	2,00	8,50
AW139	0,33	0,33	1,00	0,50	0,33	0,50	0,50	1,00	4,50
TOTAL	4,83	6,33	12,00	10,50	5,33	10,50	10,00	17,00	76,50

Table 5.11 : Normalized paired comparison matrix for operating cost / year.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	0,21	0,32	0,17	0,19	0,19	0,19	0,20	0,18	0,20
H130 (EC130)	0,10	0,16	0,17	0,19	0,19	0,19	0,20	0,18	0,18
H145 (EC145)	0,10	0,08	0,08	0,10	0,09	0,10	0,05	0,06	0,08
BELL 212	0,10	0,08	0,08	0,10	0,09	0,10	0,10	0,12	0,10
BELL 407	0,21	0,16	0,17	0,19	0,19	0,19	0,20	0,18	0,18
BELL 429	0,10	0,08	0,08	0,10	0,09	0,10	0,10	0,12	0,10
AW119Kx	0,10	0,08	0,17	0,10	0,09	0,10	0,10	0,12	0,11
AW139	0,07	0,05	0,08	0,05	0,06	0,05	0,05	0,06	0,06
TOTAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

$\lambda\text{max} = 8{,}153 \qquad \text{RI} = 1{,}41 \qquad \text{CI} = \frac{\lambda\text{max} - \text{n}}{\text{n} - 1} = \frac{8{,}153 - 8}{7} = \frac{0{,}153}{7} = 0{,}022$

$\text{CR} = \frac{\text{CI}}{\text{RI}} = \frac{0{,}022}{1{,}41} = 0{,}015 < 0{,}100$ The consistency is acceptable.

Table 5.12 : Paired comparison matrix for passenger seat.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	1,00	0,33	0,25	0,50	0,50	0,50	0,50	0,20	3,78
H130 (EC130)	3,00	1,00	0,50	2,00	2,00	2,00	2,00	0,33	12,83
H145 (EC145)	4,00	2,00	1,00	3,00	3,00	3,00	3,00	0,50	19,50
BELL 212	2,00	0,50	0,33	1,00	1,00	1,00	1,00	0,25	7,08
BELL 407	2,00	0,50	0,33	1,00	1,00	1,00	1,00	0,25	7,08
BELL 429	2,00	0,50	0,33	1,00	1,00	1,00	1,00	0,25	7,08
AW119Kx	2,00	0,50	0,33	1,00	1,00	1,00	1,00	0,25	7,08
AW139	5,00	3,00	2,00	4,00	4,00	4,00	4,00	1,00	27,00
TOTAL	21,00	8,33	5,08	13,50	13,50	13,50	13,50	3,03	91,45

Table 5.13 : Normalized paired comparison matrix for passenger seat.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	0,05	0,04	0,05	0,04	0,04	0,04	0,04	0,07	0,04
H130 (EC130)	0,14	0,12	0,10	0,15	0,15	0,15	0,15	0,11	0,14
H145 (EC145)	0,19	0,24	0,20	0,22	0,22	0,22	0,22	0,16	0,21
BELL 212	0,10	0,06	0,07	0,07	0,07	0,07	0,07	0,08	0,08
BELL 407	0,10	0,06	0,07	0,07	0,07	0,07	0,07	0,08	0,08
BELL 429	0,10	0,06	0,07	0,07	0,07	0,07	0,07	0,08	0,08
AW119Kx	0,10	0,06	0,07	0,07	0,07	0,07	0,07	0,08	0,08
AW139	0,24	0,36	0,39	0,30	0,30	0,30	0,30	0,33	0,30
TOTAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

$\lambda max = 8{,}200 \qquad RI = 1{,}41 \qquad CI = \frac{\lambda max - n}{n-1} = \frac{8{,}200-8}{7} = \frac{0{,}200}{7} = 0{,}029$

$CR = \frac{CI}{RI} = \frac{0{,}029}{1{,}41} = 0{,}020 < 0{,}100$ The consistency is acceptable.

Table 5.14 : Paired comparison matrix for angle of visibility.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	1,00	0,33	0,50	1,00	1,00	1,00	1,00	1,00	6,83
H130 (EC130)	3,00	1,00	2,00	3,00	3,00	3,00	3,00	3,00	21,00
H145 (EC145)	2,00	0,50	1,00	2,00	2,00	2,00	2,00	2,00	13,50
BELL 212	1,00	0,33	0,50	1,00	1,00	1,00	1,00	1,00	6,83
BELL 407	1,00	0,33	0,50	1,00	1,00	1,00	1,00	1,00	6,83
BELL 429	1,00	0,33	0,50	1,00	1,00	1,00	1,00	1,00	6,83
AW119Kx	1,00	0,33	0,50	1,00	1,00	1,00	1,00	1,00	6,83
AW139	1,00	0,33	0,50	1,00	1,00	1,00	1,00	1,00	6,83
TOTAL	11,00	3,50	6,00	11,00	11,00	11,00	11,00	11,00	75,50

Table 5.15 : Normalized paired comparison matrix for angle of visibility.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	0,09	0,10	0,08	0,09	0,09	0,09	0,09	0,09	0,09
H130 (EC130)	0,27	0,29	0,33	0,27	0,27	0,27	0,27	0,27	0,28
H145 (EC145)	0,18	0,14	0,17	0,18	0,18	0,18	0,18	0,18	0,18
BELL 212	0,09	0,10	0,08	0,09	0,09	0,09	0,09	0,09	0,09
BELL 407	0,09	0,10	0,08	0,09	0,09	0,09	0,09	0,09	0,09
BELL 429	0,09	0,10	0,08	0,09	0,09	0,09	0,09	0,09	0,09
AW119Kx	0,09	0,10	0,08	0,09	0,09	0,09	0,09	0,09	0,09
AW139	0,09	0,10	0,08	0,09	0,09	0,09	0,09	0,09	0,09
TOTAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

$\lambda max = 8{,}020 \qquad RI = 1{,}41 \qquad CI = \frac{\lambda max - n}{n-1} = \frac{8{,}020 - 8}{7} = \frac{0{,}020}{7} = 0{,}003$

$CR = \frac{CI}{RI} = \frac{0{,}003}{1{,}41} = 0{,}002 < 0{,}100$ The consistency is acceptable.

Table 5.16 : Paired comparison matrix for market share.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	1,00	2,00	2,00	4,00	4,00	4,00	3,00	3,00	23,00
H130 (EC130)	0,50	1,00	0,50	4,00	4,00	4,00	3,00	3,00	20,00
H145 (EC145)	0,50	2,00	1,00	4,00	4,00	4,00	3,00	3,00	21,50
BELL 212	0,25	0,25	0,25	1,00	0,50	0,50	0,33	0,33	3,41
BELL 407	0,25	0,25	0,25	2,00	1,00	2,00	0,33	0,33	6,42
BELL 429	0,25	0,25	0,25	2,00	0,50	1,00	0,50	0,50	5,25
AW119Kx	0,33	0,33	0,33	3,03	3,00	2,00	1,00	0,50	10,53
AW139	0,33	0,33	0,33	3,03	3,00	2,00	2,00	1,00	12,03
TOTAL	3,42	6,42	4,92	23,06	20,00	19,50	13,16	11,66	102,14

Table 5.17 : Normalized paired comparison matrix for market share.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	0,29	0,31	0,41	0,17	0,20	0,21	0,23	0,26	0,23
H130 (EC130)	0,15	0,16	0,10	0,17	0,20	0,21	0,23	0,26	0,20
H145 (EC145)	0,15	0,31	0,20	0,17	0,20	0,21	0,23	0,26	0,21
BELL 212	0,07	0,04	0,05	0,04	0,03	0,03	0,03	0,03	0,03
BELL 407	0,07	0,04	0,05	0,09	0,05	0,10	0,03	0,03	0,06
BELL 429	0,07	0,04	0,05	0,09	0,03	0,05	0,04	0,04	0,05
AW119Kx	0,10	0,05	0,07	0,13	0,15	0,10	0,08	0,04	0,10
AW139	0,10	0,05	0,07	0,13	0,15	0,10	0,15	0,09	0,12
TOTAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

$\lambda max = 8{,}820 \qquad RI = 1{,}41 \qquad CI = \frac{\lambda max - n}{n-1} = \frac{8{,}820 - 8}{7} = \frac{0{,}820}{7} = 0{,}117$

$CR = \frac{CI}{RI} = \frac{0{,}117}{1{,}41} = 0{,}083 < 0{,}100$ The consistency is acceptable.

Table 5.18 : Paired comparison matrix for noise level.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	1,00	0,33	0,50	0,50	0,50	1,00	0,50	1,00	5,33
H130 (EC130)	3,00	1,00	2,00	2,00	2,00	3,00	2,00	3,00	18,00
H145 (EC145)	2,00	0,50	1,00	1,00	2,00	2,00	2,00	2,00	12,50
BELL 212	2,00	0,50	1,00	1,00	2,00	2,00	2,00	2,00	12,50
BELL 407	2,00	0,50	0,50	0,50	1,00	2,00	1,00	2,00	9,50
BELL 429	1,00	0,33	0,50	0,50	0,50	1,00	0,50	1,00	5,33
AW119Kx	2,00	0,50	0,50	0,50	1,00	2,00	1,00	2,00	9,50
AW139	1,00	0,33	0,50	0,50	0,50	1,00	0,50	1,00	5,33
TOTAL	14,00	4,00	6,50	6,50	9,50	14,00	9,50	14,00	78,00

Table 5.19 : Normalized paired comparison matrix for noise level.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	0,07	0,08	0,08	0,08	0,05	0,07	0,05	0,07	0,07
H130 (EC130)	0,21	0,25	0,31	0,31	0,21	0,21	0,21	0,21	0,23
H145 (EC145)	0,14	0,13	0,15	0,15	0,21	0,14	0,21	0,14	0,16
BELL 212	0,14	0,13	0,15	0,15	0,21	0,14	0,21	0,14	0,16
BELL 407	0,14	0,13	0,08	0,08	0,11	0,14	0,11	0,14	0,12
BELL 429	0,07	0,08	0,08	0,08	0,05	0,07	0,05	0,07	0,07
AW119Kx	0,14	0,13	0,08	0,08	0,11	0,14	0,11	0,14	0,12
AW139	0,07	0,08	0,08	0,08	0,05	0,07	0,05	0,07	0,07
TOTAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

$$\lambda\text{max} = 8{,}192 \qquad \text{RI} = 1{,}41 \qquad \text{CI} = \frac{\lambda\text{max} - \text{n}}{\text{n} - 1} = \frac{8{,}192 - 8}{7} = \frac{0{,}192}{7} = 0{,}027$$

$$\text{CR} = \frac{\text{CI}}{\text{RI}} = \frac{0{,}027}{1{,}41} = 0{,}019 < 0{,}100$$ The consistency is acceptable.

Table 5.20 : Paired comparison matrix for reliability.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	1,00	0,33	0,25	0,50	1,00	0,50	1,00	0,50	5,08
H130 (EC130)	3,00	1,00	0,50	2,00	3,00	2,00	3,00	2,00	16,50
H145 (EC145)	4,00	2,00	1,00	2,00	4,00	2,00	4,00	2,00	21,00
BELL 212	2,00	0,50	0,50	1,00	2,00	1,00	2,00	1,00	10,00
BELL 407	1,00	0,33	0,25	0,50	1,00	0,50	1,00	0,50	5,08
BELL 429	2,00	0,50	0,50	1,00	2,00	1,00	2,00	1,00	10,00
AW119Kx	1,00	0,33	0,25	0,50	1,00	0,50	1,00	0,50	5,08
AW139	2,00	0,50	0,50	1,00	2,00	1,00	2,00	1,00	10,00
TOTAL	16,00	5,50	3,75	8,50	16,00	8,50	16,00	8,50	82,75

Table 5.21 : Normalized paired comparison matrix for reliability.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	0,06	0,06	0,07	0,06	0,06	0,06	0,06	0,06	0,06
H130 (EC130)	0,19	0,18	0,13	0,24	0,19	0,24	0,19	0,24	0,20
H145 (EC145)	0,25	0,36	0,27	0,24	0,25	0,24	0,25	0,24	0,25
BELL 212	0,13	0,09	0,13	0,12	0,13	0,12	0,13	0,12	0,12
BELL 407	0,06	0,06	0,07	0,06	0,06	0,06	0,06	0,06	0,06
BELL 429	0,13	0,09	0,13	0,12	0,13	0,12	0,13	0,12	0,12
AW119Kx	0,06	0,06	0,07	0,06	0,06	0,06	0,06	0,06	0,06
AW139	0,13	0,09	0,13	0,12	0,13	0,12	0,13	0,12	0,12
TOTAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

$\lambda max = 8{,}079 \qquad RI = 1{,}41 \qquad CI = \dfrac{\lambda max - n}{n-1} = \dfrac{8{,}079 - 8}{7} = \dfrac{0{,}079}{7} = 0{,}011$

$CR = \dfrac{CI}{RI} = \dfrac{0{,}011}{1{,}41} = 0{,}008 < 0{,}100$ The consistency is acceptable.

Table 5.22 : Paired comparison matrix for range.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	1,00	2,00	0,50	4,00	2,00	0,33	2,00	0,33	12,17
H130 (EC130)	0,50	1,00	0,50	4,00	2,00	0,33	0,50	0,33	9,17
H145 (EC145)	2,00	2,00	1,00	5,00	2,00	0,50	2,00	0,50	15,00
BELL 212	0,25	0,25	0,20	1,00	0,33	0,17	0,25	0,17	2,62
BELL 407	0,50	0,50	0,50	3,00	1,00	0,33	0,50	0,33	6,66
BELL 429	3,00	3,00	2,00	6,00	3,03	1,00	3,00	0,50	21,53
AW119Kx	0,50	2,00	0,50	4,00	2,00	0,33	1,00	0,33	10,67
AW139	3,00	3,00	2,00	6,00	3,03	2,00	3,00	1,00	23,03
TOTAL	10,75	13,75	7,20	33,00	15,39	5,00	12,25	3,50	100,84

Table 5.23 : Normalized paired comparison matrix for range.

Criterias	H125 (AS350)	H130 (EC130)	H145 (EC145)	BELL 212	BELL 407	BELL 429	AW119Kx	AW139	PRIORITY VECTOR
H125 (AS350)	0,09	0,15	0,07	0,12	0,13	0,07	0,16	0,10	0,12
H130 (EC130)	0,05	0,07	0,07	0,12	0,13	0,07	0,04	0,10	0,09
H145 (EC145)	0,19	0,15	0,14	0,15	0,13	0,10	0,16	0,14	0,15
BELL 212	0,02	0,02	0,03	0,03	0,02	0,03	0,02	0,05	0,03
BELL 407	0,05	0,04	0,07	0,09	0,06	0,07	0,04	0,09	0,07
BELL 429	0,28	0,22	0,28	0,18	0,20	0,20	0,24	0,14	0,21
AW119Kx	0,05	0,15	0,07	0,12	0,13	0,07	0,08	0,10	0,11
AW139	0,28	0,22	0,28	0,18	0,20	0,40	0,24	0,29	0,23
TOTAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

$$\lambda max = 8{,}652 \qquad RI = 1{,}41 \qquad CI = \frac{\lambda max - n}{n-1} = \frac{8{,}652 - 8}{7} = \frac{0{,}652}{7} = 0{,}093$$

$$CR = \frac{CI}{RI} = \frac{0{,}093}{1{,}41} = 0{,}066 < 0{,}100$$ The consistency is acceptable.

At the last stage, compound relative importance is defined as percentage by multiplying the priority vectors of criterias and the priority vectors of the options based on each criterion that shows optimum helicopter decision for us.

$$W_i = \sum_{i=1}^{n} (\text{Normalized AHP Matrix Priority Vector}_i \ * \ \text{Criteria Priority Vector}_i) \quad (5.4)$$

$$W_{H125\,(EC125)} = (0{,}19 * 0{,}28) + (0{,}20 * 0{,}20) + (0{,}04 * 0{,}04) + (0{,}09 * 0{,}06) + (0{,}23 * 0{,}07) + (0{,}07 * 0{,}09) + (0{,}06 * 0{,}15) + (0{,}12 * 0{,}11)$$

$$W_{H125\,(EC125)} = 0{,}14$$

$$W_{H130\,(EC130)} = (0{,}17 * 0{,}28) + (0{,}18 * 0{,}20) + (0{,}14 * 0{,}04) + (0{,}28 * 0{,}06) + (0{,}20 * 0{,}07) + (0{,}23 * 0{,}09) + (0{,}20 * 0{,}15) + (0{,}09 * 0{,}11)$$

$$W_{H130\,(EC130)} = 0{,}19$$

$$W_{H145\,(EC145)} = (0{,}05 * 0{,}28) + (0{,}08 * 0{,}20) + (0{,}21 * 0{,}04) + (0{,}18 * 0{,}06) + (0{,}21 * 0{,}07) + (0{,}16 * 0{,}09) + (0{,}25 * 0{,}15) + (0{,}15 * 0{,}11)$$

$$W_{H145\,(EC145)} = 0{,}13$$

$$W_{BELL\ 212} = (0{,}11 * 0{,}28) + (0{,}10 * 0{,}20) + (0{,}08 * 0{,}04) + (0{,}09 * 0{,}06) + (0{,}03 * 0{,}28) + (0{,}16 * 0{,}20) + (0{,}12 * 0{,}04) + (0{,}03 * 0{,}06)$$

$$W_{BELL\ 212} = 0{,}10$$

$$W_{BELL\ 407} = (0{,}16 * 0{,}28) + (0{,}18 * 0{,}20) + (0{,}08 * 0{,}04) + (0{,}09 * 0{,}06) + (0{,}06 * 0{,}28) + (0{,}12 * 0{,}20) + (0{,}06 * 0{,}04) + (0{,}07 * 0{,}06)$$

$$W_{BELL\ 407} = 0{,}12$$

$$W_{BELL\ 429} = (0{,}11 * 0{,}28) + (0{,}10 * 0{,}20) + (0{,}08 * 0{,}04) + (0{,}09 * 0{,}06) + (0{,}05 * 0{,}28) + (0{,}07 * 0{,}20) + (0{,}12 * 0{,}04) + (0{,}21 * 0{,}06)$$

$$W_{BELL\ 429} = 0{,}11$$

$$W_{AW119Kx} = (0{,}15 * 0{,}28) + (0{,}11 * 0{,}20) + (0{,}08 * 0{,}04) + (0{,}09 * 0{,}06) + (0{,}10 * 0{,}28) + (0{,}12 * 0{,}20) + (0{,}06 * 0{,}04) + (0{,}11 * 0{,}06)$$

$$W_{AW119Kx} = 0{,}11$$

$$W_{AW139} = (0{,}05 * 0{,}28) + (0{,}06 * 0{,}20) + (0{,}30 * 0{,}04) + (0{,}09 * 0{,}06) + (0{,}12 * 0{,}28) + (0{,}07 * 0{,}20) + (0{,}12 * 0{,}04) + (0{,}23 * 0{,}06)$$

$$W_{AW139} = 0{,}10$$

All results could be seen on Table 5.24.

Table 5.24 : Paired comparison matrix.

Criterias	Unit Price	Operating Cost / Year	Passenger Seat	Angle of Visibility	Market Share	Noise Level	Reliability	Range	Relative importance (Wi)	Percantage
Priority Vector	0,28	0,20	0,04	0,06	0,07	0,09	0,15	0,11		
H125 (AS350)	0,19	0,20	0,04	0,09	0,23	0,07	0,06	0,12	0,14	14 %
H130 (EC130)	0,17	0,18	0,14	0,28	0,20	0,23	0,20	0,09	0,19	19 %
H145 (EC145)	0,05	0,08	0,21	0,18	0,21	0,16	0,25	0,15	0,13	13 %
BELL 212	0,11	0,10	0,08	0,09	0,03	0,16	0,12	0,03	0,10	10 %
BELL 407	0,16	0,18	0,08	0,09	0,06	0,12	0,06	0,07	0,12	12 %
BELL 429	0,11	0,10	0,08	0,09	0,05	0,07	0,12	0,21	0,11	11 %
AW119Kx	0,15	0,11	0,08	0,09	0,10	0,12	0,06	0,11	0,11	11 %
AW139	0,05	0,06	0,30	0,09	0,12	0,07	0,12	0,23	0,10	10 %

Considering all the criterias for determining the potential helicopter for carrying passengers and performing turism activities in the aviation area according to the relative significance of the compound with the analytical hierarchical process method, it was determined that the most suitable helicopter is Airbus Helicopters H130 (EC130) with 19%. The most appropriate helicopters are then; H125 (AS350), H145 (EC15) and BELL 407 were identified.

Due to being safe and comfortable with low noise level, making H130 (EC130) a leading choice for tourism activities with larger cabin and wide windows providing amazing views for passengers. In addition, fenestron type tail reduces vibration and noise with increasing reliability. Besides, fuel-efficiency features reduce fuel consumption.

Figure 5.2 : H130 (EC130) outside view (Airbus).

6. BASIC CONCEPTS ABOUT INVESTMENT PROJECTS

6.1 Basic Concepts About Investment Projects

In general perspective, the resources of a company or a country are limited while the need is very high. This situation is the same for all businesses that should be able to use their resources effectively while spending their limited resources for their unlimited needs considering their technological developments and continuously monitoring market in order to keep the competitiveness. For this reason, enterprises should allocate limited resources to sectors and investment projects that will ensure continuous income growth.

The enterprise should provide the structure and equipment that can keep up with the developments in the market and satisfy the demand. The transaction process of providing this structure and equipment constitutes the concept of investment in terms of the enterprise. Agar (2005) defines transaction process for a majority acquisition in 8 key stages. Financial appraisal correspondes third and fourth stages in this process. First stage is identification of target. On this stage, the best strategy to fit such as target sector, extent of geographic area, market expansion, competitive position with cost savings and controlling financial risks are defined. Investments may be classified as profit, non-profit land efficiency investments. Businesses aim to maximize profit while making investment decisions that will enable them to continue their activities. Therefore, when evaluating investment projects, they are interested in projects that will increase the profits, not the overall economic benefit such projects as profit-oriented. On the second stage due diligence, assess management's record are evaluated and operational risks are determined. On next stage involves valuation and pricing by using historical financial information, financial forecast including various scenarios is developed. Other stage is impact analysis that defines negative effects of non-cash situation and debt finance with opportunities to reduce tax. Fifth stage is formal offer that defines approaching the process and key terms to be followed. Following step is further ordinary care by using target's internal knowledge and procedures for inspecting documentation, management data and agreements. Seventh step is reassessment of following due diligence involving possible liabilities, offering price and risks with uncertainties in the trade contracts. Last stage is negotiation from sale and purchase operations. Formal completion is completed considering acquirer and target obligations with warranties and uncertainties.

6.2 Feasibility Study About Investment Projects

New investments have a negative effect on the profit of the enterprise in the beginning period they are made and increases the cost of the unit and the profitability when it is fully completed and started to provide cash inflows. In order to reduce risk, feasibility study has a key role in this period. Generally, feasibility study includes an analysis of the various project components, including its risks, defining its major components and measuring its impacts to decide go/no go. The basic functions that will lead to the project implementation becomes clear on the stage of very pragmatic feasibility study.

Although feasibility experts do not leave no avenue unexplored about defining possible risks such as environmental or political vulnerabilities, enterprises to be ready for unexpected situations. Mesly (2017) states that there is not any feasibility study that scrutinize in all aspects of risk factors. For instance, a project may not request intensive technical research, but every project includes humans and management force is required for the existance of this investment in the future.

6.3 Basic Methods of Investment Evaluation

When evaluating investment projects, it is required to evaluate primarily in terms of profitability. It is possible to classify the methods used to evaluate an investment project in terms of profitability or to compare alternative investment projects with taking into account the time value of money (dynamic) and without taking into account the time value of money (static) methods.

Static Methods;

- Cost comparison method
- Profit comparison method
- Average rate of return method
- Static payback method

Dynamic Methods;

- Net Present Value Method
- Annuity Method
- Internal Rate of Return Method
- Dynamic Payback Period Method

6.3.1 Static methods

Static analysis methods that calculates the profitability of an investment for a defined time period. These methods concentrate a single fiscal measure, so other target measures are neglected.

6.3.1.1 Cost comparison method

Cost comparison method (CCM) method is considered the simplest sorting method. In this method, the project to be carried out by ordering between two or more investment projects is available through project audit. However, the disadvantage of this method is that it is not objective and therefore does not provide accurate decision-making, but it gives general idea about investment.

Table 6.1 : Example investment projects data for static methods.

	Project A	Project B	Project C
Initial Investment (€)	240,000	600,000	360,000
Economic life (years)	6	6	6
Salaries (€ per year)	50,000	50,000	60,000
Wages (€ per year)	90,000	80,000	120,000
Cost of materials (€ per year)	40,000	50,000	60,000
Other variable costs (€ per year)	30,000	30,000	30,000
Capacity (units per year)	8,000	10,000	10,000
Sales Price (€ per unit)	40	40	40
Rate of interest for profit (%)	8	8	8

First, total input and output must be calculated per year for each project. Moreover, Project A has 8,000 product per year capacity and Project B with Project C have capacity 10,000 product per year capacity. So, a conversion is required for B and C to 8,000 product per year. All costs are calculated per year and sum.

$$\text{Project A} = \frac{240,000}{6} + 50,000 + 90,000 + 40,000 + 30,000 = €250,000/year$$

$$\text{Project B} = \frac{600000}{6} + 50,000 + \frac{(80,000 + 50,000 + 30,000) * 8}{10} = €278,000/year$$

$$\text{Project C} = \frac{360000}{6} + 60,000 + \frac{(120,000 + 60,000 + 30,000) * 8}{10} = €288,000/year$$

The comparison of the average total costs per year show that the investment project A is minimum investment option and therefore should be preferred for minimizing expandes. On the other hand, decision should be examined in terms of assumptions and the importance of any deviations from those values.

6.3.1.2 Profit comparison method

Profit comparison method (PCM) is different from the cost comparison method (CCM) in terms of including both the cost and investment projects revenue. The target is measuring average profit. Cost and profit per unit are calculated and decision was made in accordance with results.

$$\text{Project A} = \frac{240,000}{6} + 50,000 + 90,000 + 40,000 + 30,000 = €250,000/year$$

$$\text{Project A} = (8,000\ x\ 40) - 250,000 = €70,000\ profit/year$$

$$\text{Project B} = \frac{600000}{6} + 50,000 + 80,000 + 50,000 + 30,000 = €310,000/year$$

$$\text{Project B} = (10,000\ x\ 40) - 310,000 = €90,000\ profit/year$$

$$\text{Project C} = \frac{360000}{6} + 60,000 + 120,000 + 60,000 + 30,000 = €330,000/year$$

$$\text{Project C} = (10,000\ x\ 40) - 330,000 = €70,000\ profit/year$$

All investment projects provide profitability. Although Project A was a better option for CCM, Project B achieves higher profit at PCM method. So, decision changes in accordance with used method type.

6.3.1.3 Average rate of return method

The average rate of return (ARR) method does not resemble PCM in terms of target measure. ARR method involves a profit measure with interest of it. In this method profit keeps on to gain interest in bank account. Average capital tie-up is arithmetic average of initial investment and liquidation value. Owing to the fact that liquidation values are not provided in Table 5.25, average capital tie-up equals to one-half of initial invested money.

$$\text{Average rate of return} = \frac{\text{Average profit} + \text{Average interests}}{\text{Average capital tie-up}} \tag{5.5}$$

$$\text{Project A} = \frac{70{,}000 + 5600}{120{,}000} = 63\ \%$$

$$\text{Project B} = \frac{90{,}000 + 7200}{300{,}000} = 32\ \%$$

$$\text{Project C} = \frac{70{,}000 + 5600}{180{,}000} = 42\ \%$$

Investment project A is one step ahead in term of profitability owing to its higher rate of return that means project A compensates rapidly. This example illustrates that investment projects can be inconsistent according to used method.

6.3.1.4 Static payback method

The purpose of the static payback period (SPP) method is calculating compensating time of capital used in this investment. It can be found based on average or total values. The payback period is obtained from the average cash flow surpluses. The SPP method provides a risk measurement by investigating absolute and relative profitability of investment projects. However, this method is not suitable for every project. Because any additional cost and revenue occurring after payback period are not considered.

$$\text{Payback period (PP)} = \frac{\text{Capital tie-up}}{\text{Average cash flow surpluses}} \tag{5.6}$$

$$\text{Average cash flow surpluses (ACFS)} = \text{Average profit} + \text{Depreciation} \tag{5.7}$$

$$\text{Depreciation (D)} = \frac{\text{Initial investment outlay} - \text{Liquidation value}}{\text{Economic life in years}} \tag{5.8}$$

$$D_A = \frac{240{,}000 - 0}{6} = €40{,}000 \qquad ACFS_{A} = 70{,}000 + 40{,}000 = €110{,}000$$

$$PP_A = \frac{240{,}000}{110{,}000} = 2{,}2 \text{ years}$$

$$D_B = \frac{600{,}000 - 0}{6} = €100{,}000 \qquad ACFS_{B} = 90{,}000 + 100{,}000 = €190{,}000$$

$$PP_B = \frac{600{,}000}{190{,}000} = 3{,}2 \text{ years}$$

$$D_C = \frac{360{,}000 - 0}{6} = €60{,}000 \qquad ACFS_{C} = 70{,}000 + 60{,}000 = €130{,}000$$

$$PP_C = \frac{360{,}000}{130{,}000} = 2{,}7 \text{ years}$$

These three projects, have different payback periods. Project A seems more profitable project relatively, other both are profitable owing to the fact that their payback periods are not much than 4 years.

6.3.2 Dynamic methods

In parallel with money, price of anything has been considered as static quantity having certain value for an asset. At the end of 1970s, in some sectors especially in air transport and booking hotel, price became a dynamic value. Capocchi (2019) states that new technological developments provides opportunities for instantaneous price comparisons in markets changes in accordance with customer behavior in terms of supply and demand. In addition, the same situation indicates that the price of good could be changed at the same time for different places. For instance, if there is a football match in a city, fans of football team go to away game to support their teams. Due to high demand, airlines increase prices of flight tickets too much on this period.

Dynamic models in other words discounted cash flow methods in contrast to the static methods do not consider one time period and uses the time value of money. Unit cost and income values are not the same in different time periods. Dynamic evaluation methods revenues from the project expected to be obtained during the economic life costs and the value of scrap are taken into account.

6.3.2.1 Net present value method

Net present value (NPV) method will provide net cash inflows and investment for the life of a project expenses are reduced to today with a certain reduction rate reflects the difference between values. Net present value equal to zero for a project to be accepted according to this method or must be greater than zero. In the alternative project selection, value of the project with the largest value (greater than zero) can be choosen. An important point to consider in this method is the project current and future cash flows constitute the basis of the method. Besides, the general assumption of the NPV method is unrestricted capital market. That means there is no limit about interest rate to borrow or using money. Therefore, this interest rate is counted in for not only discounting but also compounding cash flows to any time.

$$\mathrm{NPV} = \sum_{t=0}^{\mathrm{T}} (\mathrm{CIF}_t - \mathrm{COF}_t) \,.\, \mathrm{D}^{-t} \qquad (5.9)$$

t = Time index

T = Project Life

CIF = Cash inflows in t

COF = Cash outflows in t

D^{-t} = Discount rate in t $= \frac{1}{\mathrm{D}^t} = \frac{1}{(1+\mathrm{i})^t}$ i = interest rate

Table 6.2 : Example investment projects data for dynamic methods.

	Project A	Project B	Project C
Initial Investment (€)	100,000	60,000	110,000
Economic life (years)	5	4	5
Liquidation value (€)	5,000	-	-
Interest Rate (%)	8	8	8
Cash Flows (€)			
T=1	28,000	22,000	30,000
T=2	30,000	26,000	33,000
T=3	35,000	28,000	35,000
T=4	32,000	28,000	31,000
T=5	30,000	-	30,000

$$\text{NPV}_A = -100{,}000 + 28{,}000 * 1.08^{-1} + 30{,}000 * 1.08^{-2} + 35{,}000 * 1.08^{-3} + 32{,}000 * 1.08^{-4} + 30{,}000 * 1.08^{-5} + 5{,}000 * 1.08^{-5}$$

$$\text{NPV}_A = €26{,}771$$

$$\text{NPV}_B = -60{,}000 + 22{,}000 * 1.08^{-1} + 26{,}000 * 1.08^{-2} + 28{,}000 * 1.08^{-3} + 28{,}000 * 1.08^{-4}$$

$$\text{NPV}_B = €25{,}469$$

$$\text{NPV}_C = -110{,}000 + 30{,}000 * 1.08^{-1} + 33{,}000 * 1.08^{-2} + 35{,}000 * 1.08^{-3} + 31{,}000 * 1.08^{-4} + 30{,}000 * 1.08^{-5}$$

$$\text{NPV}_C = €17{,}057$$

These results show that project A’s net financial gain surpasses the net financial gain from project B by €1,302 and project C by €9,714. Project A provides profit. However, it is clearly showed that the initial investment for project B is considerably lower than A. In addiition, the economic life of B is shorter by 1 year. From the results, it could be said that NPV is a suitable method for the evaluation of relative profitability if there are differences in initial investment, net cash flows over years and economic lives.

6.3.2.2 Annuity method

Annuity method (AM) uses the NPV method. However, annuity includes equal amount of cash flows in each period of investment economic life. So, this property occurs a limitation of this approach is that it is not suitable to compare relative profitability. Annuity (ANN) of a project can be calculated by multiplying (NPV) with capital recovery factor.

$$\text{ANN} = \text{NPV} * \frac{(1+i)^T * i}{(1+i)^T - 1} \qquad (5.10)$$

$$\text{ANN}_A = 26{,}771 * \frac{(1+0.08)^5 * 0.08}{(1+0.08)^5 - 1} = €6{,}705$$

$$\text{ANN}_B = 25{,}469 * \frac{(1+0.08)^4 * 0.08}{(1+0.08)^4 - 1} = €7{,}690$$

$$\text{ANN}_C = 17{,}057 * \frac{(1+0.08)^5 * 0.08}{(1+0.08)^5 - 1} = €4{,}272$$

All three projects have a positive annuity, so they are profitable in certain terms. The annuity of project B is more reasonable, but it works for shorter time period. For the evaluation of relative profitability, it should be considered that the annuities changes to different economic lives and having various of cash flows. If the annuity of project B is re found for 5-year period it becomes €6,378 that is lower than project A. So, in this situation, the annuity of project A is higher and it is more suitable.

6.3.2.3 Internal rate of return method

Internal rate of return (IRR) method, is largely resembles to the NPV method. But there are two assumptions. These are concerning the investment of free cash flow again and initial investment and economic lives rebalancing. This method is used for isolated investment projects (IIP) that cash flow surpluses in life time of project only cover interest charges repayment of the capital invested. Reinvestment is not made during the project's economic life. Internal rate of return is independent of the interest rates due to possibility of the fact that reinvestments may be occured. For calculations, below figure could be used that is taken by Investment Appraisal Methods and Model book.

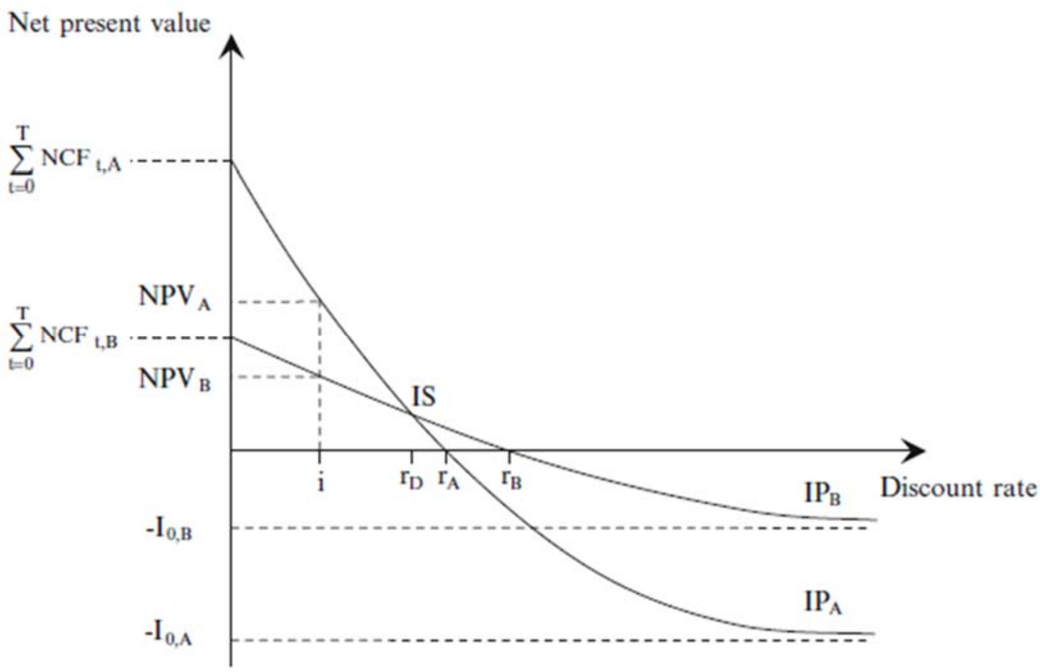


Figure 6.1 : NPV of IIP as a function of uniform discount rate (2015).

IRR method application does not make sense for non-isolated investments for non-considering initial investment or reinvestment assumption. The internal rate of return (r) below is defined interest rate at which the NPV equals to zero.

$$NPV = \sum_{t=0}^{T} (CIF_t - COF_t).(1+r)^{-t} = 0 \qquad (5.11)$$

For this process, (NPV1) is defined for a discount rate i_1. If this is positive, then a bigger discount rate i_2 is found. In the opposite situation lower discount rate i_2 is found After that, net present value (NPV2) is calculated again. Finally, these two discount rates and their related NPVs can be used to find project's IRR with a linear interpolation or an extrapolation for same signed NPV value. A formula or both interpolation and extrapolation can be found in regards of Figure 6.2

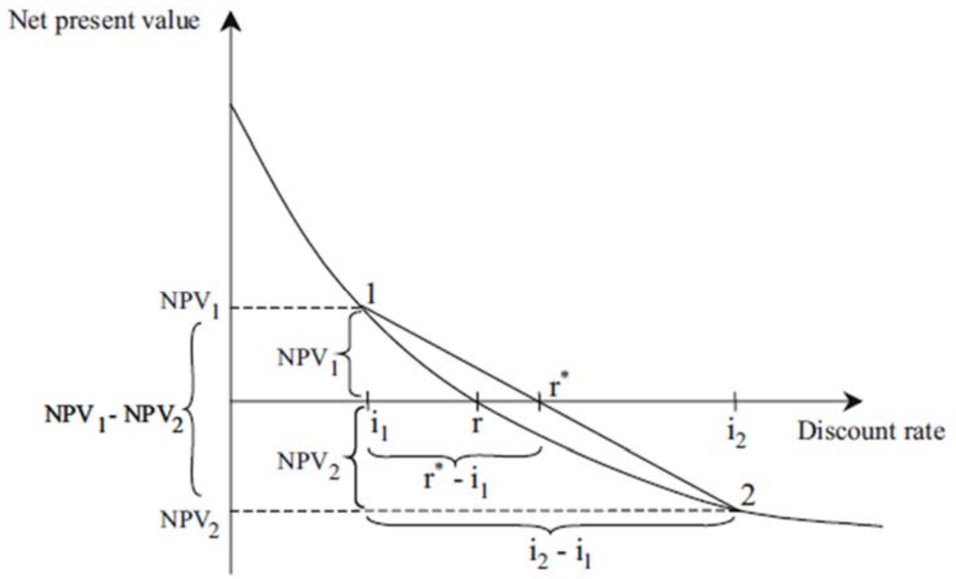


Figure 6.2 : Interpolation to define IRR (2015).

$$\frac{r^* - i_1}{i_2 - i_1} \cong \frac{NPV_1}{NPV_1 - NPV_2} \qquad (5.12)$$

$$r^* \cong i_1 + \frac{NPV_1}{NPV_1 - NPV_2}(i_2 - i_1) \qquad (5.13)$$

For Project A:

NPV_{A1} was found €26,771 with $i_1 = 8$ %. Second one randomly chosed as $i_2 = 18$ %.

From Eqn. 5.9

$$NPV_{A2} = \sum_{t=0}^{T}(CIF_t - COF_t).D^{-t} = \sum_{t=0}^{5}(CIF_t - COF_t).(1+0{,}18)^{-t} = -€1{,}619$$

Due to NPV_{A2} is negative, we try for lower interest $i_1 = 17$ %

$$NPV_{A1} = \sum_{t=0}^{T}(CIF_t - COF_t).D^{-t} = \sum_{t=0}^{5}(CIF_t - COF_t).(1+0{,}17)^{-t} = €740$$

Owing to one of NPV values is positive and other one is negative, NPV_{A2} could be zero when interest value is between 17 % and 18%. So, correlation is required.

By using Eqn. 5.13

$$r^*{}_A \cong i_1 + \frac{NPV_{A1}}{NPV_{A1} - NPV_{A2}}(i_2 - i_1) = 0.17 + \frac{740}{740-(-1{,}619)}(0.18 - 0.17)$$

$$r^*{}_A \cong 0.173 \text{ or } 17.3\ \%$$

Because of the fact that discount rate was taken 8 % in the beginning of project, this project provided profit. Interests over 17.3 % will bring loss.

For Project B:

NPV_{B1} was found €25,469 with $i_1 = 8$ %. Second one randomly chosed as $i_2 = 18$ %.

From Eqn. 5.9

$$NPV_{B2} = \sum_{t=0}^{T}(CIF_t - COF_t).D^{-t} = \sum_{t=0}^{5}(CIF_t - COF_t).(1+0{,}18)^{-t} = €8{,}800$$

Due to NPV_{B2} is still positive, we try for higher interest $i_1 = 28$ %

$$NPV_{B1} = h\sum_{t=0}^{T}(CIF_t - COF_t).D^{-t} = \sum_{t=0}^{5}(CIF_t - COF_t).(1+0{,}28)^{-t} = -€3{,}161$$

Owing to one of NPV values is positive and other one is negative, NPV_{B2} could be zero when interest value is between 18 % and 28%. So, correlation is required.

By using Eqn. 5.13

$$r^*_B \cong i_1 + \frac{NPV_{B1}}{NPV_{B1} - NPV_{B2}} (i_2 - i_1) = 0.28 + \frac{-3{,}161}{-3{,}161 - 8{,}800} (0.18 - 0.28)$$

$r^*_B \cong$ 0.254 or 25.4 %

Because of the fact that discount rate was taken 8 % in the beginning of project, this project provided profit. Interests over 25,4 % will bring loss.

<u>For Project C:</u>

NPV_{C1} was found €17,057 with $i_1 = 8$ %. Second one randomly chosed as $i_2 = 18$ %.

From Eqn. 5.9

$$NPV_{C2} = \sum_{t=0}^{T} (CIF_t - COF_t) . D^{-t} = \sum_{t=0}^{5} (CIF_t - COF_t) . (1 + 0{,}18)^{-t} = -€10{,}471$$

Due to NPV_{C2} is negative, we try for lower interest $i_1 = 12$ %

$$NPV_{C1} = \sum_{t=0}^{T} (CIF_t - COF_t) . D^{-t} = \sum_{t=0}^{5} (CIF_t - COF_t) . (1 + 0{,}12)^{-t} = €4{,}729$$

Owing to one of NPV values is positive and other one is negative, NPV_{C2} could be zero when interest value is between 12 % and 18%. So, correlation is required.

By using Eqn. 5.13

$$r^*_C \cong i_1 + \frac{NPV_{C1}}{NPV_{C1} - NPV_{C2}} (i_2 - i_1) = 0.12 + \frac{4{,}729}{4{,}729 - (-10{,}471)} (0.18 - 0.12)$$

$r^*_C \cong$ 0.139 or 13.9 %

Because of the fact that discount rate was taken 8 % in the beginning of project, this project provided profit. Interests over 13,9 % will bring loss.

$r^*_A \cong$ 0.173 or 17.3 % $\quad$ $r^*_B \cong$ 0.254 or 25.4 % $\quad$ $r^*_C \cong$ 0.139 or 13.9 %

Unlike NPV method, project B is more profitable due to its bigger IRR. This is the reason that IRR method uses interest rate gained from capital. Moreover, because of the fact that Project B works with less initial invest, it seems more profitable. Usually profitable projects with less capital initial investment often chosen in IRR profitability comparison, unlike NPV method.

6.3.2.4 Dynamic payback period method

Dynamic payback period method (DPP) combines static payback period method with the discounting cash flow used in the NPV model. This method does not bring about same solution for profitability like NPV method. Even though absolute profitability relies on the project life, differences at relative profitability could result from cash flows. The payback period could be found in the point when this value goes to zero or first point it becomes positive. When first non-negative value passes zero, then payback is found between last two periods. This value could be approximated by interpolation.

$$DPP \cong t^* + \frac{NPV_{t^*}}{NPV_{t^*} - NPV_{t^*+1}} \qquad (5.14)$$

To see clearly, NPV table could be prepared for each project.

<u>For Project A:</u>

Table 6.3 : NPV table for project A.

Time	Net Cash Flow	Discounted Net Cash Flow	Cumulative NPV
0	-100,000	-100,000	-100,000
1	28,000	25,926	-74,074
2	30,000	25,720	-48,354
3	35,000	27,784	-20,569
4	32,000	23,520	+ 2,951
5	30,000	23,820	+26,771

The DPP is exceeded four years owing to the fact that NPV becomes positive. So, the DPP is reached in time between 3 and 4 years after first day.

$$DPP_A \cong 3 + \frac{NPV_3}{NPV_3 - NPV_4} = 3 + \frac{-20{,}569}{-20{,}569 - 2{,}951} = 3 + 0.87 = 3.87\ years$$

For Project B:

Table 6.4 : NPV table for project B.

Time	Net Cash Flow	Discounted Net Cash Flow	Cumulative NPV
0	-60,000	-60,000	-60,000
1	22,000	20,370	-39,630
2	26,000	22,291	-17,339
3	28,000	22,227	4,888
4	28,000	20,581	25,469
5	-	-	-

The DPP is exceeded three years, because of the fact that NPV goes positive.

So, the DPP is achieved in time between 2 and 3 years after initial point.

$$\text{DPP}_\text{B} \cong 2 + \frac{\text{NPV}_3}{\text{NPV}_3 - \text{NPV}_4} = 2 + \frac{-17{,}339}{-17{,}339 - 4{,}888} = 2 + 0.78 = 2.78\ years$$

For Project C:

Table 6.5 : NPV table for project C.

Time	Net Cash Flow	Discounted Net Cash Flow	Cumulative NPV
0	-110,000	-110,000	-110,000
1	30,000	27,778	-82,222
2	33,000	28,292	-53,930
3	35,000	27,784	-26,146
4	31,000	22,786	-3,360
5	30,000	20,417	17,057

The DPP is exceeded five years, due to the fact that cumulative NPV changes to positive. So, the DPP is achieved in time between 4 and 5 years after start.

$$\text{DPP}_\text{C} \cong 4 + \frac{\text{NPV}_4}{\text{NPV}_4 - \text{NPV}_5} = 4 + \frac{-3{,}360}{-3{,}360 - 17{,}057} = 4 + 0.16 = 4.16\ years$$

In contrast to NPV results, project B appears profitable in comparion with others. Absolute profitability relies on the time limit. If 4 years is mentioned, both investments are clearly profitable but if the time period was set 3 years, then investment B would be defined profitable with DPP method.

7. ECONOMIC MODELING OF NEW MRO IN BODRUM LOCATION

In the economic modeling of a potential maintenance, repair and overhaul (MRO) facility to be established in Bodrum location, it is necessary to plan the scope and capability of the facility. In order to determine the capability, it is necessary to define aviation activities in this region. In addition, the competitor analysis of the size, scope and capabilities of the MRO companies located in the identified region and the surrounding region should be analyzed and the environmental aviation and maintenance repair market should be evaluated.

According to providing services in MRO facility in the sub-business maintenance activities will be derived from a revenue model should be determined from the framework. Maintenance costs of maintenance activities of sub-branches of business should be determined within in term of a specific expense model. This maintenance activities include out of base maintenances, renting tool and selling parts. Moreover, due to bein distributor of Airbus Helicopters, selling and operating aircrfats will be considered in operations.

During the establishment of the facility, it is obvious that determine the amount of investment needed for the tools and equipment required for maintenance, and the investment costs required for the construction of the heavy maintenance and component maintenance facility. It is necessary to calculate the effect of depreciation expenses on total expenses arising from total investment amount.

Following the determination of the economic model of the MRO facility to be established, the profit-loss statement of the project should be determined according to the years and the return of the total investment will be evaluated and the efficiency of the investment should be evaluated.

7.1 Analysis of Related Region

Although turism crisis in 2016, Turkey recovered quickly with most significant increases especially foreign Russian tourists tripled by previous year according to World Tourism Organization (UNWTO) annual report (2019) in 33 European countries. The number of tourists visiting Turkey increased in comparison of previous year with a record more than 22 %. According to the calculations, the number of tourists for the first time in history reached 47 million that is more than a half of total population of Turkey in 2018. Changes in the turist levels established as one of the factors for the increase in tourism compared to other countries it has shown that Turkey is a cheaper vacation. Although this situation becomes a problem for Turkish economy, in turism become an advantage for it. Turkey has 11,554 accommodation facilities including about 1,5 million bed capacity within first 10 countries all over the world.

Except Estonia and Monaco, the only country that experienced a huge decline in tourism income was the UK which was having a difficult period due to Brexit in addition to visa application problems. The rising value of the US dollar against the Euro lead to general increase in the number of American tourists who visiting European region.

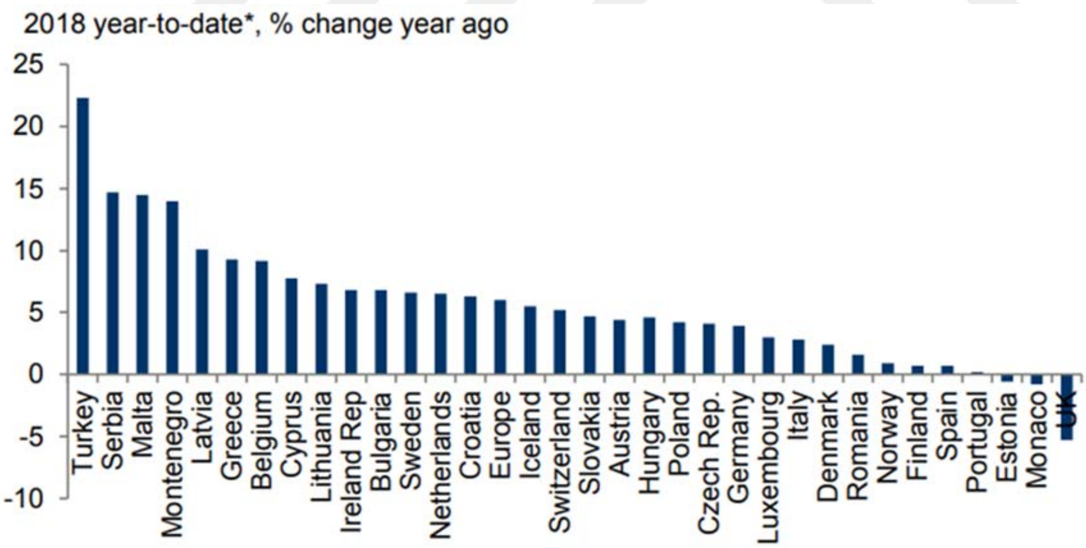


Figure 7.1 : International tourist change by European countries in 2018, (UNWTO).

MRO will be published in Bodrum which is district of Mugla city in Aegean region of Turkey with high demand in turism. Bodrum hosts the most turists after Istanbul and Antalya out of 81 cities in Turkey. In 2018, 2,8 million turist visited Mugla with 34% increase in comparison with previous year.

Owing to a lot of hotel options and 1484 km seaside, Mugla is very popular place for turism. Due to high demand and beautiful landscape, customers want to fly with helicopter from airport to their hotels. Rising operating hours especially in summer season cause to perform maintenance frequently. To overcome this issue, construction of an MRO was decided in this area.

There are 100 H130 model helicopters in European region and 20 of them belong to Turkey. ASAL and Skyline performs maintenance on these helicopters. In foreign area, GreekAir and Romania Airbus Helicopters performs maintenance on this region.

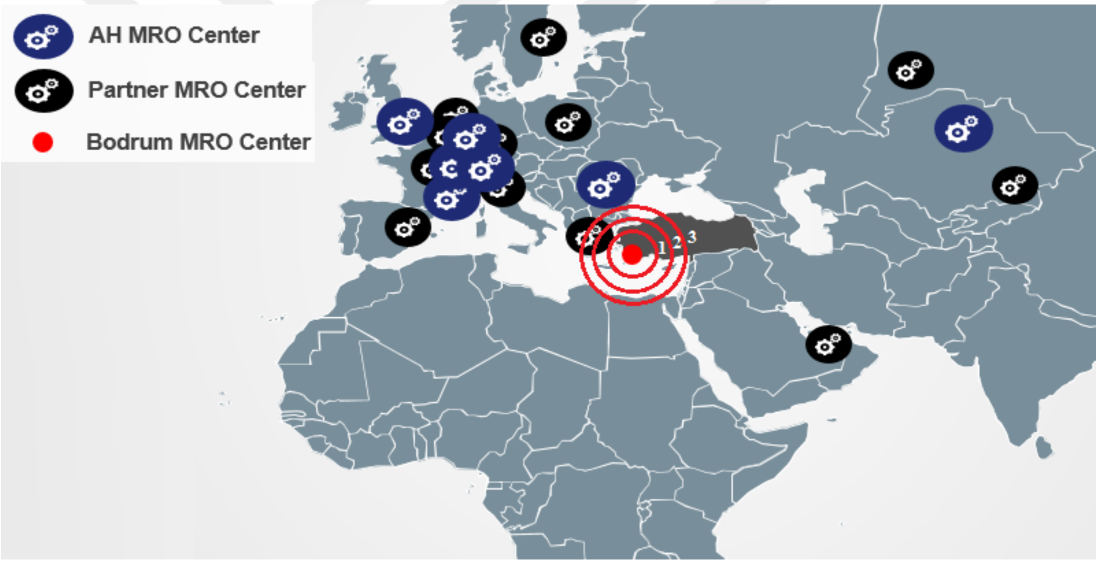


Figure 7.2 : Airbus Helicopter MROs within 3 flying hours, (Airbus).

7.2 MRO Modelling

The economic model of the MRO, income / expenditure models and their relations with each other are given in Figure 7.3 which shows investment evaluation options are given as economic model outputs. After determining providing services in MRO facility, the efficiency of the investment will be calculated and return times.

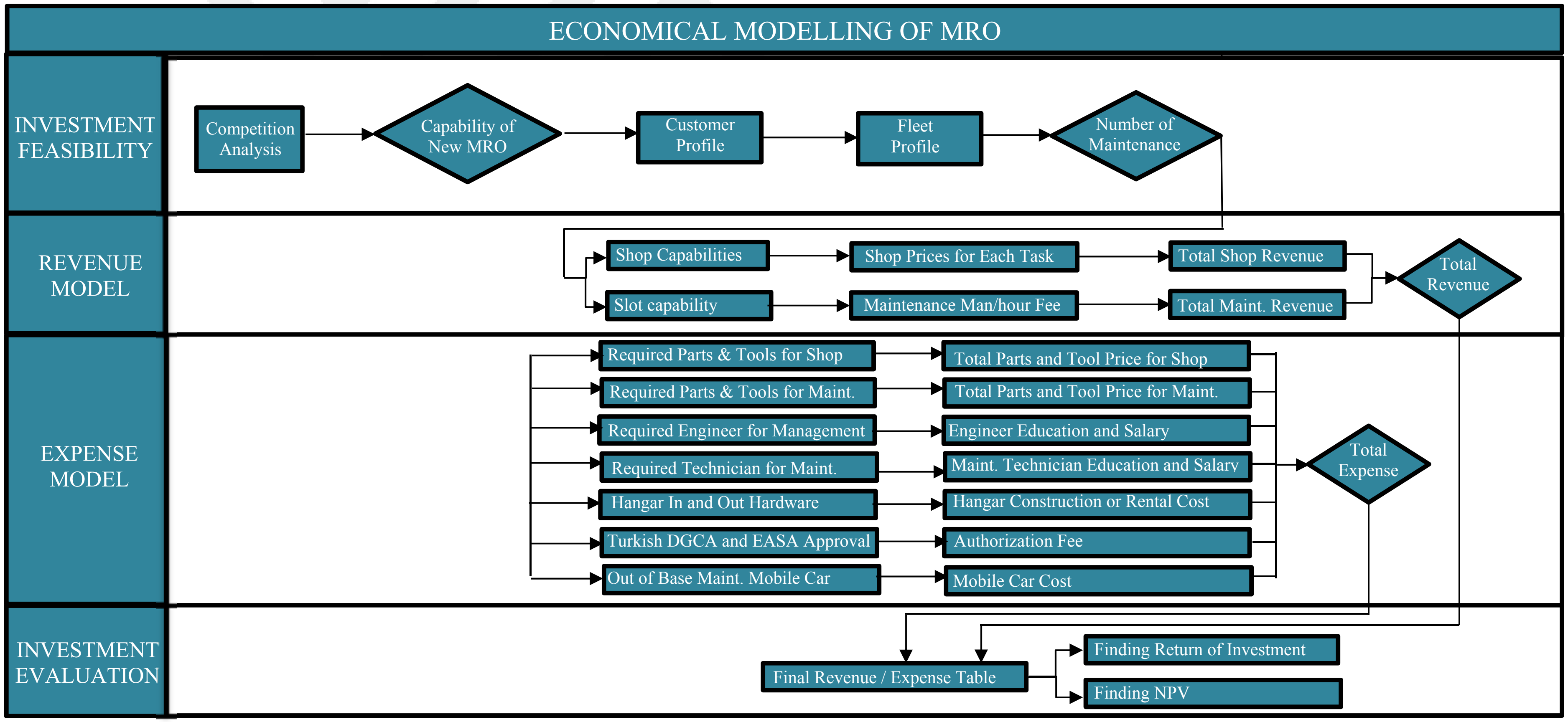


Figure 7.3 : Economical modelling of MRO diagram.

7.2.1 Revenue model of MRO

Maintenance activities will be main business that will serve. Moreover, additional custom fees from changed parts on helicopters and selling helicopter commission will be extra revenue for this maintenance center at base and out of base maintenances due to being distributor. Within this framework, it is possible to accept that maintenance service is provided with the increasing customer catching rate of the aircraft in the accessible market. In the first years, it was assumed that the customer catch rate would be 30% and then 40% and 50%.

Revenues generated from the lines of business within the scope of the activities are calculated within economic life of 5 years.

Table 7.1 : Revenue items for MRO.

Annual Revenue (K Euro)	2019	2020	2021	2022	2023
Base Maint.	100	110	115	120	125
Out of Base Maintenance	18	20	22	25	28
Helicopter Sales Commission	400	430	490	520	580
Total	518	560	627	665	733

7.2.2 Expense model of MRO

Certain expenses are required for the realization of these activities. These are employee salaries (technician), consumable expenses, part costs, general management expenses. Within the framework of the calculations, personnel costs, material expenses and other related expenses required to realize the business lines within the scope of the facility's activities are calculated in term of 5 years total economic life. Expense model do not include cost and fees for inintial investment.

Table 7.2 : Expense items for MRO.

Annual Expense (K Euro)	2019	2020	2021	2022	2023
Hangar Routine	10	12	14	16	18
Mobile Car	5	7	9	11	13
Employee Salary	300	315	330	345	360
Storage Routine	20	23	26	29	32
Total	335	357	379	401	423

7.2.3 Initial investment of MRO

Initial investment defines compense time and expectation from project. These are tool costs, hangar cost with furniture, mobile maintenance car cost for interior tools and requied modification, authorization fee and storage cost. Initial investment will be made within the scope of the facility's activities are calculated in term of 10 years total economic life in order to compense.

Hangar construction investment for maintenance activities of different helicopter types is required to provide maintenance at the same time for two helicopters. So, minimum dimensions must be 25m x 25 m. For the construction of the chosen hangar have 800 square meters with required investment cost of square meter is € 250 that corresponds to total €200,000. Tool investments are required in order to perform routine and non-routine maintenances for different type helicopters such as H130, H135 and H145. Moreover, tools and tool box ingredients change in accordance with to helicopter type.

Third issue is education. Education is required for type rated technicians to perform special tasks that are required to use special tools or engine tasks that must be performed after taken approval from authorized manufacturers. Moreover, familiarization education is required for managers.

Table 7.3 : Initial investment items for MRO.

Initial Investment	Cost (Euro)
Hangar Construction	200,000
Hangar Hardware	20,000
H130-H135 Tools	120,000
H145 Tools	44,000
Special Tools	120,000
B1/B2 Technician Tool Boxes	24,000
Type Certificate Education Fee	30,000
Familiarization Education Fee	14,000
Storage Cost	32,000
Mobile Car Cost	30,000
Total	634,000

7.3 Evaluation of Investment

In order to evaluate investment project in Bodrum, Mugla, NPV method will be use. NPV method of a project includes the net cash inflows and investment expenses that it will provide throughout its life. Values that have been reduced to today with a certain reduction rate reflects the difference between future and today that was chosen as 10%. Acceptance of a project according to this method net present value must be equal to or greater than zero. MS for the economic modeling of the facility. Facility revenue and expense tables are prepared and calculated in the profit and loss table.

Table 7.4 : Dynamic data table for NPV method of project.

	MRO Project
Initial Investment (€)	634,000
Economic life (years)	5
Interest Rate (%)	10
Cash Flows (€)	
T=1	183,000
T=2	203,000
T=3	248,000
T=4	264,000
T=5	310,000

$$\text{NPV} = -634{,}000 + 183{,}000 * 1.10^{-1} + 203{,}000 * 1.10^{-2} + 248{,}000 * 1.10^{-3} + 264{,}000 * 1.10^{-4} + 310{,}000 * 1.10^{-5}$$

$$\text{NPV} = €259{,}260$$

This result show that project's net financial gain is profitable. From the results, it could be said that this project could be realized due to NPV value is greater than zero. By using NVP values, dynamic payback period could be calculated. Even though absolute profitability relies on the project life, differences at relative profitability could result from cash flows.

Table 7.5 : NPV table for DPP.

Time	Net Cash Flow	Discounted Net Cash Flow	Cumulative NPV
0	-634,000	-634,000	-634,000
1	183,000	166,364	-467,636
2	203,000	167,768	-299,868
3	248,000	186,326	-113,542
4	264,000	180,315	+66,773
5	310,000	192,487	+259,260

The DPP is exceeded four years, owing to the fact that cumulative NPV becomes positive. So, the DPP is achieved in time between 3 and 4 years after the start.

$$\text{DPP} \cong 3 + \frac{\text{NPV}_3}{\text{NPV}_3 - \text{NPV}_4} = 3 + \frac{-113{,}542}{-113{,}542 - 66{,}773} = 3 + 0.63 = 3.63\ years$$

8. RESULTS AND SUGGESTIONS

Investment decision in the aviation industry, identifying the regions to be invested and the economic activity of a facility in these regions modeling could be considered as independent disciplines. Owing to the fact that investments include high amount of money and impact possibility of projects exist in geographical, social, political reasons, to make an investment decision is quite difficult and a process that is affected by external factors. Besides, the parameters affecting the development of the aviation industry are clear and it can be estimated in which regions the aerospace industry will provide great development.

In order to determine the potential region to be invested in the aviation sector, firstly, the world aviation industry and the world maintenance, repair and overhaul (MRO) industry, which is planned to be invested, is given. A methodology has been developed to identify the potential factors that directly influence the development of the aviation industry and to identify potential promising regions by monitoring the developments in these factors. With this investment methodology developed, the most suitable location to be invested among investment options has been determined. The investment location which has the greatest potential among the investment alternatives by analyzing the parameters affecting the turism industry is determined as Bodrum, Mugla, Turkey.

After the potential area was identified, an economic modeling of an MRO was carried out. The capability of the facility to provide maintenance, repair and overhaul was determined by competence assessment of competing MRO companies in the region. In this context, it is determined that there will be two maintenance types. Main base and line maintenances will be performed in designed hangar. Moreover, for aircraft on ground (AOG) positioned that means helicopter is not airworthy, maintenance will be performed with mobile maintenance car.

In order to perform the economic modeling of the MRO within the framework of the defined capabilities, the revenue and expense models of the facility have been established and adding inintial investment calculation, the annual profit to be derived from the main activity areas has been calculated. In this context, the amount of investment required to provide aviation services locally and globally was calculated. When we analyzed the efficiency of the investment with the net present value method, the NPV value increased to about €260,000. When investment is evaluated with the net present value method, it is found that it has the status of investable project.

In this master's thesis, general research was figured out in aviation industry especially in helicopter industry in regard of different disciplines such as geopolitics due to so much studies do not exist in this area. Moreover, global aviation data used and aviation industry in our country was explaned. On the other hand, a methodology has been tried to be taken in the process of making an investment decision in aviation industry. Various investment options were described and optimum solution was found to have an investable status when the investment efficiency assessment was performed. Future studies can work on elaboration of the relevant methodology. The parameters have effect on the aviation industry and the significance of these parameters in the determination of the relevant regions and business lines can be evaluated with a specific mathematical model. Studies on the determination of the related parameters with a mathematical model to be used for weight coefficients can be developed and continued. By calculating the criterion weight coefficients with a specific mathematical model, the investment option evaluation model can be more precise and consistent.

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EDUCATION :

- **B.Sc.** : 2014, ISTANBUL Technical University – Faculty of Aeronautics and Astronautics – Aeronautical Engineer

PROFESSIONAL EXPERIENCE AND REWARDS:

Swan Aviation, Istanbul, Turkey **Jul 2014 - present**
Aeronautical Engineer
- Participated in entrance of new aircrafts to our fleet by investigating documents
- Revised minimum equipment lists (MEL) of more than ten types of aircrafts.
- Controlled aircraft parts for inventory and recorded archive to check CAMP website
- Evaluated technical documents such as Airworthiness Directive (AD), Service Bulletin (SB) about fleet.
- Adapted maintenance programs of more than ten types of aircraft MPD.
- Organized maintenance plans, reviewed invoices and made agreements with MROs.
- Prepared monthly reliability reports in order to present for DGCA.

Onur Air, Istanbul, Turkey **Jun 2013 - Jun 2014**
Powerplant Engineering Intern
- Gained knowledge about jet propulsion principles.
- Reported engine parameters such as exhaust gas temperature, fuel flow indications.
- Prepared required aircraft folders such as Airworthiness Directive (AD), Service Bulletin (SB) and Life Limited Parts.

Turkish Airlines, Turkish Technic, Istanbul, Turkey **Jun 2012 - July 2012**
Engineering Intern
- Found opportunity to inspect wide-body aircrafts such as Boeing 777 closely.
- Gained hands on experience about continued airworthiness for flight safety.
- Participated in maintenance program revision by taking reference for Boeing 737-600/700/800/900 Maintenance Planning Data

McDonald's, Westerly, RI, USA **Jun 2010 – Sep 2010**
Team Member
- Received McDonald's global service team member training to prepare food
- Assisted to restaurant maintenance according to the restaurant's cleaning policies
- Checked equipment to ensure it is working efficiently.