

Global and Regional Air Traffic, Fleet and MRO Outlook in Air Transportation

Özgür YUMAKOĞULLARI
Turkish Airlines Technic
oyumakogullari@thy.com

Asst. Prof. Dr. Resul AYDEMİR
Istanbul Technical University
Faculty of Management
resulaydemir@itu.edu.tr

Prof. Dr. Bulent GULOGLU
Istanbul Technical University
Faculty of Management
guloglu@itu.edu.tr

Abstract

The purpose of this paper is to present the evolution of world air transportation until 2024 with special emphasis on the growth patterns of the number of passengers/cargo, aircrafts and maintenance repair stations that compose the industry. Commercial air transportation necessitates passengers and/or cargo to fly and serviceable aircrafts to transport them. Along with the number of passenger/cargo, number of aircrafts will increase as well during the upcoming years. Therefore, the airline operators will purchase or lease more aircrafts of the required models. Number of skilled workforce and maintenance repair stations ensuring aircrafts to be safe and airworthy will increase similarly. This paper examines how passenger and cargo traffic will grow in the next decade, aircraft orders to meet this growth and also maintenance repair and overhaul organization requirements when aircrafts are delivered. Thus, it provides a current and future outlook of the sub-sectoral interactions of the global aviation industry.

Key Words: Air Transportation, Aircrafts, Air Passengers and Cargo Demand, Maintenance Repair and Overhaul, MRO

Dünya Havayolu Taşımacılığında Yolcu Trafiği, Uçak Filosu ve Bakım Onarım Merkezlerinin Küresel ve Bölgesel Gelişimi

Özet

Bu çalışmanın amacı, dünya havayolu taşımacılığının 2024 yılına kadar küresel ve bölgesel olarak ne şekilde gelişeceğini sektörü oluşturan üç ana temel olan yolcu/kargo, uçak ve bakım merkezi büyüme analizleri ile ortaya koymaktır. Ticari bir havayolu ulaşımı için öncelikle uçakla seyahat edecek yolcu veya kargoya, sonra onu taşıyacak faal bir uçağa gereksinim duyar. Önümüzdeki yıllarda yolcu/kargo sayısının artması ile birlikte gerekli olan uçak sayısı da artacaktır. Buna bağlı olarak havayolu operatörleri ihtiyaçları olan modellerde daha fazla uçak satın alacak veya kiralayacaktır. Bu uçakların her an uçuşa elverişli olmaları için gerekli olan işgücü ve bakım merkezi ihtiyacı da aynı şekilde artacaktır. Bu çalışma önümüzdeki on yılda havayolu yolcu ve kargo trafiğinin ne kadar büyüyeceğini, bu büyümeyi karşılamak için sipariş edilen uçakları, teslimatlara göre bakım onarım merkezi ihtiyacını küresel ve bölgesel olarak analiz etmektedir. Böylelikle çalışmada hava yolu taşımacılığı alt sektörlerinin etkileşimleri ve gelecek beklentileri konusunda toplam bir bakış açısı ortaya konulmuştur.

Anahtar Kelimeler: Hava Taşımacılığı, Uçak Modelleri, Hava Taşımacılığı Yolcu Kargo Talebi, Bakım Onarım Merkezi, MRO

JEL Classification Codes: L10, L93, L99, R41

INTRODUCTION

Time management is tremendously important in today's fast evolving and competitive high technology world. People who travel from one location to another want to shorten time of travel as much as possible to save time and money. The shortest and the fastest transportation way to go longer distances between cities, countries or regions for humans or goods is air transportation. Therefore, air travel demand is increasing every day while world is becoming smaller and smaller for people. Every country or airline wants to increase its network to meet this demand by building new airports / runways / terminals/hangars and by purchasing, leasing or manufacturing new aircrafts, engines or components and also by educating people to operate or to keep them serviceable. Owing to strongly interconnected aviation industry chain, increase in air traffic demand forces airlines to order more aircrafts and a larger fleet of aircrafts requires more maintenance facilities and people.

In this paper, we first investigate current values and potential future demand of the world passenger and cargo air traffic. We see that world air traffic will continue to grow in the near future. International Air Transport Association (IATA) expects that over 3.5 billion people will be onboard somewhere on Earth in 2015 with a fastest Revenue per Kilometers (RPK) growth rate of %7 since 2010 (IATA, Pearce Brian, 2014). This will require more aircrafts to deliver and operated all over the world. Airline operators continue to deliver ordered aircrafts or lease additional ones to meet current increase of demand and place new orders to fulfill forecasted values. They need different types and size of aircrafts depending on their network types and size. Aircrafts are generally grouped by the industry with their manufacturer types according to fuselage width, seating capacity and range. We can say that there are 3 main groups that can be defined as regional, narrow-body and wide-body.¹

Second, we examine all current commercial aircraft orders and forecast 3 main group of world fleet for the next ten years from the country and region perspective. According to recent net orders, we forecast 38,601 total aircrafts will be inflight in ten years. (Figure 7) This tremendous increase of new ordered aircrafts will bring a fundamental problem for operators when they are delivered. They have to keep all of the operated aircrafts airworthy and safe. Additional aircrafts will increase revenues at the expense of higher costs due to planned and/or unplanned maintenance. Moreover, aircraft

¹ An aircraft with 3 to 4 meters (10 to13 ft.) fuselage width and 2 to 6 abreast along a single aisle is defined as narrow body or single aisle. A narrow body aircraft with a range not allowing transatlantic or transcontinental flights and generally with less capacity than narrow bodies (<150 seat) is defined as regional aircraft. A larger aircraft with a fuselage diameter of 5 to 7 meters (16 to 20 ft.), twin aisles and usually configured with multiple travel classes is defined as wide-body aircraft.

maintenance is a fairly regulated industry and requires highly skilled workers.

Third, we analyze current situation and future forecast of the capacity and cash flows of the global maintenance and repair organizations. The regulations mandate each airline to keep every flying aircraft airworthy by conducting periodic necessary maintenance checks and all kinds of non-routine fault rectifications. Increase in aircraft numbers in service will influence demand for global and regional maintenance facilities due to mandatory maintenance regulations. High retirement rates especially in North America and Western Europe will also increase the demand for maintenance centers to teardown of the aircraft and to reuse some components. To cope with high growth rates of the number of aircrafts particularly in Asia, Middle East and Western Europe, new maintenance facilities will have to be built in the near future. Hence, in line with traffic and fleet growth, maintenance repair stations are growing fast in emerging regions and forecasted to continue in the near future in both facility and revenue dimensions. Highly profitable worldwide maintenance co-operations and joint ventures dominate the maintenance activities in the developed regions.

Different subsectors comprising the aviation industry are strongly tied to each other. Increase in air traffic demand requires more aircrafts to be operated and operating more aircrafts entails more skilled operational/maintenance personnel and additional aircraft maintenance and overhaul capacity. The purpose of this paper is thus to examine the current and future demand and growth prospects of the three main subsectors (air traffic, fleet and maintenance) of the global aviation industry. We present a picture of the sub-sector interactions and future developments of the aviation industry. The rest of the paper is organized as follows: Section 2 provides current and forecasted growth rates of the global air traffic, Section 3 examines existing world aircraft fleet along with current net orders and forecasted potential by aircraft type, country and region, Section 4 analyzes current top maintenance repair stations by revenue, capacity, and number of employees and finally Section 5 concludes.

1. Global Air Traffic Growth Rates

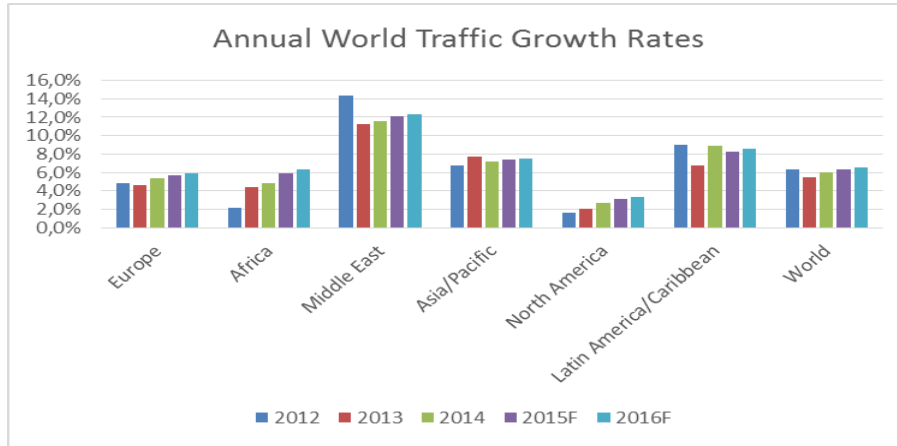
If liberal policies carry on as the current era, additional 5 billion people will be onboard in 20 years. But if some countries close their borders as the worst case scenario, minimum 2.3 billion passengers will be expected to fly during the same time period (IATA-Tourism Economics, 2014). New open sky agreements between countries will be signed to provide more and more trade activity utilizing airlines. Today, around 1,400 airlines worldwide carry 8.6 million passengers with 99,700 flights every day. They operate a global fleet of over 25,000 commercial aircraft across 4,000 international airports (IATA, 2015). Stimulated by lower fares due to competition, more city-pair connections and stronger economic growth of emerging countries these huge industry figures will continue to expand in the future. After low growth rates of air traffic market between 1990 and 2010 as a result of four major events (Gulf War-1990/91, 9/11-2001, SARS-2002 and Global Financial Crisis 2008), now air traffic growth rates is expected to produce the fastest

increasing values since 2010, with 7% growth of RPKs² and the number of passengers forecasted to exceed 3.5 billion in 2015 for the first time. Moreover, number of departures is forecasted to grow from 35 billion to over 60 billion (ICAO , 2014). Overall, air traffic growth has been reinforced by increase in Gross Domestic Product (GDP) in recent years.

Emerging markets, led by Asia, Europe and the Middle East, continue to grow faster than the global average. Especially, the Middle East traffic will continue to grow with double-digit rate. Annual world traffic growth rate is expected to be 6.3% in 2015 with a 0.3% increase from 2014 and continue to increase 6.5% in 2016. If these rates are divided to world regions, there are significant differences between major regions in the world. Middle East has the highest growth value with 11.6% and this increase will go on. Latin America/Caribbean, Asia/Pacific and Europe are the other emerging regions with high growth rates. (Figure 1)

These high growth rates of the emerging regions are supported by the fast developing countries. They dominate more and more business interactions with other countries and stimulate business/leisure trips to extend their commercial territories. The number of passengers flying to/from these countries is growing as living standards rise. India, Indonesia and China have more growth in living standards growth relative to others. Also, we can see that positive population growth and traffic growth move together. In China, Russia, Germany and Japan, although population growth rate is negative, the number of new air travel passengers is increasing due to their large population size. Besides, cost of travel is the main factor for the numbers of air travel passengers as new Low-cost carrier (LCC) and Ultra LCC entrants especially in developing countries pop up. China, India and Indonesia, the top three countries having the highest growth rate in the world are Asian countries. Brazil and Mexico are the drivers of growth in the Latin America region. Russia, UK and Germany are the drivers in Europe with negative population growth and high GDPs. Turkey standing between Europe and Asia comes forward with high population growth rate and low cost of travel. If we consider drivers of additional passenger numbers instead of growth rates, the US will have the second largest increase after China. And the UAE will be displayed as the main driver in the Middle East (IATA, 2014).

² RPK: Revenue Passenger Kilometres, 1 RPK is flown when a revenue passenger is carried 1 km.



Source: (ICAO, Annual Report of the Council, 2014) (compiled by the authors)

Figure 1. Annual World Traffic Growth Rates.

Air cargo growth rates are similar to world trade growth rates. After high loss of air cargo market, it is now in a cyclical upturn since 2010. The Asia-Pacific airlines carry the largest proportion of the air cargo market, since many products are manufactured in the region. The Middle East airlines are growing very fast in air cargo market by far with 55% growth rate. The second highest growing market is Africa with a value of 16%. Led by emerging markets high growth rates of both global passenger and cargo air traffic requires more number of aircrafts to operate and this enforces airline and cargo operators to order or lease additional ones.

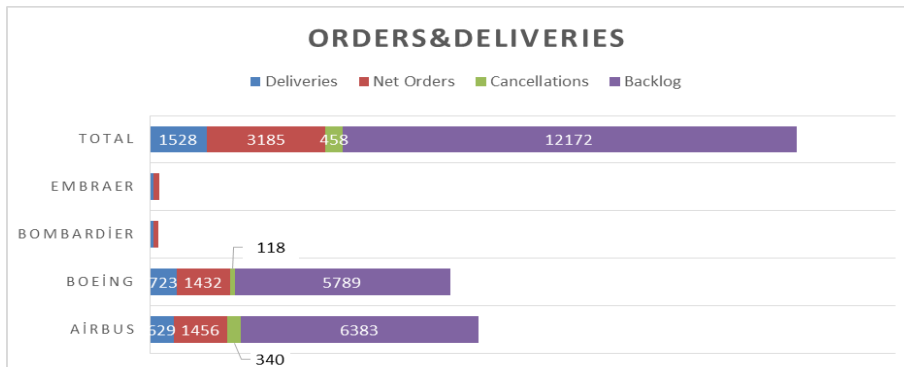
2. Global Aircraft Fleet and Orders

The total air traffic and cargo demand increase necessitate additional commercial/cargo aircrafts. 2014 proved to be a year that exceeded the expectations of manufacturers. Manufacturers successfully have brought new products to their customers and have kept production levels up, keeping airlines and investors happy. Aircraft deliveries have climbed for the fifth consecutive year driven by burgeoning of aviation in Asia Pacific.

Oil prices decreased from USD100 at the beginning of the year 2014 to below USD50 at the end. This will lower the ticket fares and hence raise the traffic. Passenger traffic growth will continue to rise above the long term trend of 5.5%. Particularly in long-haul markets passenger traffic will increase more than expected. Airlines add new capacity to their fleets to accommodate this anticipated demand. New aircrafts also bring other benefits apart from better fuel efficiency with new engines, lower maintenance burden, higher capacity, less noise, greater range and better utilization.

2.1. Orders And Deliveries

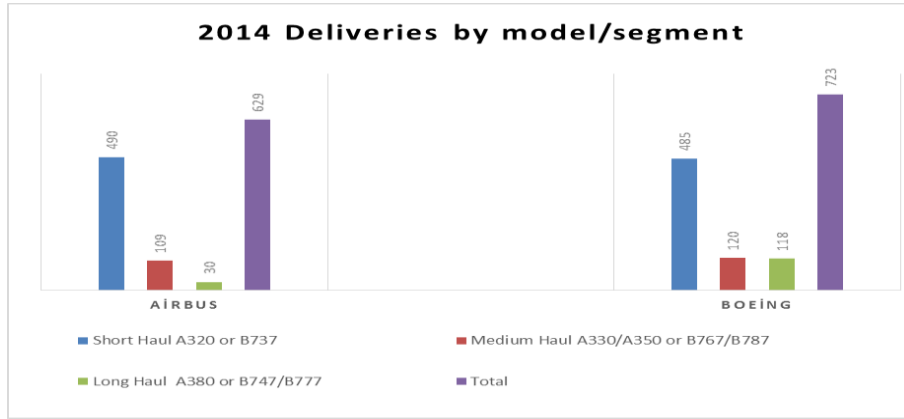
Total 3185 commercial aircrafts were ordered to major manufacturers in 2014. 2888 of these orders were for Airbus and Boeing with the numbers of 1456 and 1432, respectively. (Figure 2) Last year Boeing set to deliver a record of 715-725 aircraft and Airbus around 625-630 per year. Although manufacturers' production numbers are at unprecedented levels, only 46%-47% of orders can be fulfilled. Therefore, backlogs are growing each year. With a rough calculation, if a Boeing aircraft is ordered today it will be delivered to a customer after 8 years earliest. (5789 backlogs/720 annual capacity). On the other hand, if it is an Airbus, it will take 10 years. (6383 backlogs/627 annual capacity).



Source: Websites of (Embraer), (Bombardier), (Boeing) and (Airbus) (compiled by authors)

Figure 2. Aircraft Orders And Deliveries, (Jan, 2015)

As a result of the cyclical nature of the aviation industry, airlines have ordered new aircrafts in “good times” and received them in “bad times” due to backlogs until today. Manufacturers have made investments to increase production rates to reduce backlogs. For example, Airbus A320 aircraft was produced in 2014 at the rate of 42/ month and Airbus plans to increase this number to 46/month, ramp up A350 productions to 10/month by 2018 and trying to maintain A380 production at 30/year. Similarly, Boeing is planning to increase B737 production rate from 42/month to 47/month in 2017, then 52/month in 2018 and maintain current rates of B777 (8.3/month) and B787 (10/month). As a result of main improvements on high-technology material, system component and engine design, manufacturers are now producing or planning to produce neo versions of current models. Neo versions of models are more fuel efficient, lighter and less noisy with no major design changes.



Source: Websites of (Airbus) and (Boeing)

Figure 3. Airbus & Boeing Deliveries, (Jan, 2015)

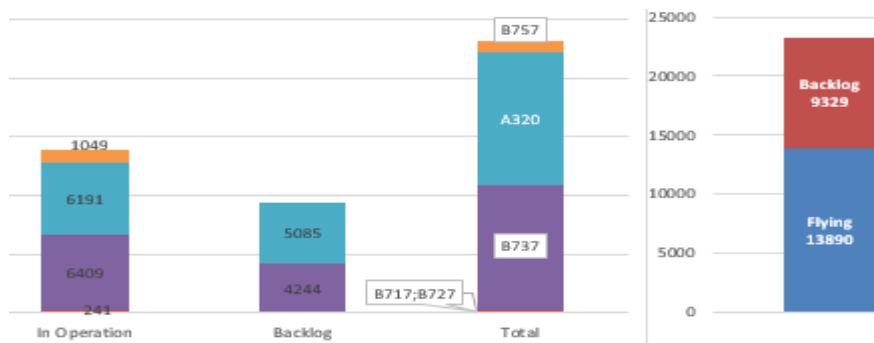
The two major manufacturers of commercial aircrafts, Airbus and Boeing, are in a stiff competition in two main aircraft type markets. In the short haul market, Airbus A320 competes with Boeing B737. Both types give flexibility and commonality to airlines with their different capacity-flight distance sub-models and same operational requirements.³ Airlines can interchange these aircrafts in operation without any additional cost according to passenger demand and flight range. In 2014, 490 of the total 629 Airbus orders were only A320 models and similarly 485 of total 723 Boeing orders were only B737 models. (Figure 3) In the upcoming years, new orders and retirements will be replenished by improved versions of A320neo or B737max series. The competition is also close in the market of two top selling wide bodies which are designed for medium/long haul commercial transportation. They are B777 and A330. The Boeing 777 is still the market leader with the global fleet of the twinjet increasing by 8.1% during the year. Meanwhile, the Airbus A330 fleet growing by 9.3%. In the twin engine medium haul there are two brand new entrants, B787 and A350. The first A350 was delivered to Qatar airways in 22 December 2014 and it has 779 new orders as backlog at the end of the 2014. Twin aisle product competition will be closer than today in future years because Boeing has unveiled B777X and Airbus has announced the re-engined A330neo in Dubai in November 2014.

2.2. World Fleet Forecast (2014-2024)

Narrow-Body (single aisle) fleet: The leading models of narrow-body aircraft in operation are B737 series manufactured by Boeing and A320 series by Airbus. Many of the B737 old generation aircrafts called B737CL(classical) are retired but new generation models called B737NG (next generation) dominate narrow-body aircrafts in operation today with a total value of 6409 aircrafts as of March 2015. We expect that B737 demand will continue to increase in future years with B737MAX model which has already received 2715 orders by airlines. Total number of B737 orders

³ Airbus A320 sub-models are A318/A319/A320/A321 and Boeing B737 sub-models are B737-600/700/800/900ER.

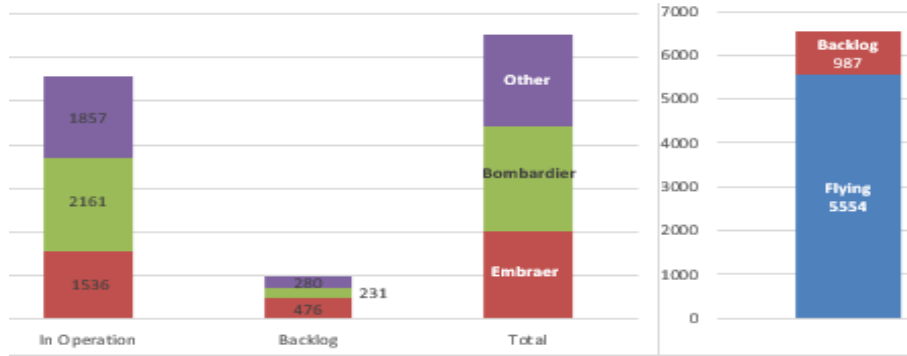
waiting to be manufactured in the next 8 to 10 years has been 4244 and with flying aircrafts added to the total number of B737's will be 10653 in near future. Another Boeing manufactured single aisle aircraft is B757s with high capacity and medium range. Its market size is quite less than the other narrow-bodies. On the other hand, Airbus A320 is the main competitor of B737 with 6191 of aircrafts in operation and 5085 new orders to manufacture. Total number of A320 aircrafts flying today and backlog is 11276, exceeding B737 for the first time. 13890 narrow-body aircrafts are flying today and 9329 aircrafts will fly additionally in the near future. (Figure 4) **Hata! Başvuru kaynağı bulunamadı.**



Source: (CAPA, 2014) and Websites of (Airbus) and (Boeing). (Shows commercial fleet status for March, 2015).

Figure 4. World Narrow-Body Aircraft Fleet, (2015)

Regional Fleet: Regarding the small narrow-body aircrafts side that fly regional, there are 9 different manufacturers worldwide which build commercial passenger aircrafts. 5554 total regional aircrafts are flying all around the world with 987 backlogs. According to (Bombardier)-one of the main regional aircraft manufacturer- Market Forecast 2014-2033, there will be 16,300 regional aircrafts (net of retirements) that will fly in 2033. Nearly half of the regional aircraft fleet has been equipped with turboprop engines. The most popular family of turboprop engine installed regional aircrafts is (ATR) aircrafts with a value of 32% market share. Bombardier, Fokker, Saab, Antonov and AVIC I (Xian MA60 model) are the remaining manufacturers in the sector. Excluding Bombardier, due to limited manufacturing capacity and market share, we illustrate them on the Figure 5 as "Other" category. In this category, 1857 aircrafts are in operation with 280 backlogs. Also, we exclude Russian Antonov and Chinese Xian MA60 which are not used worldwide by the airlines yet.



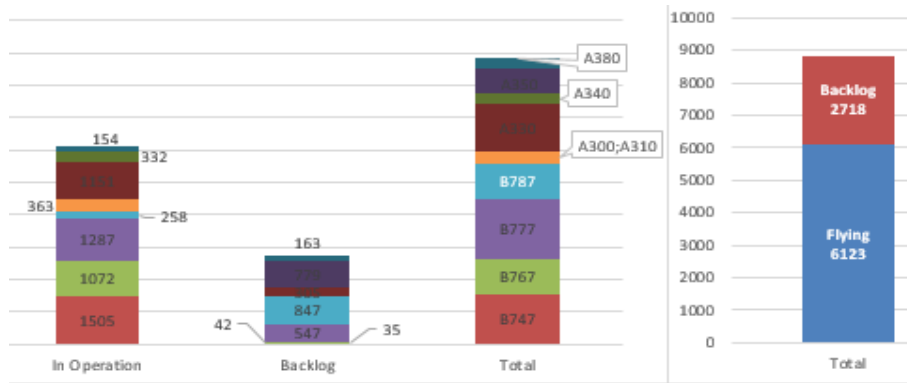
Source: (Flightglobal,, 2014), (World Airliner Census,, 2014) and Websites of (Embraer), (Bombardier), (ATR Aircraft)

Notes: (Shows commercial fleet status for March, 2015), (Other=1446 (ATR, Beechcraft, DeHavilland)+ 411 (Fokker, Bae RJ)), (Russian aircrafts Ilyushin and Tupolev are excluded)

Figure 5. World Regional Aircraft Fleet (2015)

There are 2 main manufacturers dominating the regional jet aircraft sector; Canadian Bombardier and Brazilian Embraer. Bombardier produces both turboprop model Q-Series/Dash 8 and jet aircraft model CRJ. 2161 of 2392 total Bombardier aircraft orders have been delivered and 231 will be manufactured. As a market leader in the business aircraft market Bombardier strives to pass commercial regional jet market leader, Embraer with its improved models of turboprop Q400 Nextgen and regional jet CRJ Nextgen series. (Embraer) is the world's largest manufacturer of commercial jets up to 130 seats with four main models (E170, E175, E190, E195). All four models had 2012 new orders and 1536 delivered. New orders are being added to 476 backlogs day by day. Another small but growing manufacturer in regional jet market is an Italian-Russian joint venture company (Sukhoi Inc). Its' commercial regional jet aircraft Superjet 100 has reached 182 orders from all over the world today.

Wide-Body (Twin Aisle) Fleet: In contrast to narrow-body worldwide fleet, there are several models in competition in wide-body fleet. In this category while Boeing has B747, B767 and B787 aircraft types; Airbus has A300, A310, A330, A340, A350, and A380 aircraft types. Main competition in wide-body global current fleet is between B777s and A330s with the numbers in operation as 1287 and 1151 in order, respectively. B777 has 547 new orders till March 2015 enhanced by new cost efficient model, B777X. A330 has 305 new orders in the same period, quite below from its competitor, but it is expected to increase to the same levels after new cost efficient model, called A330neo starts to have new orders.



Source: (CAPA, 2014), (Airbus) and (Boeing). (Shows commercial fleet status for March, 2015)

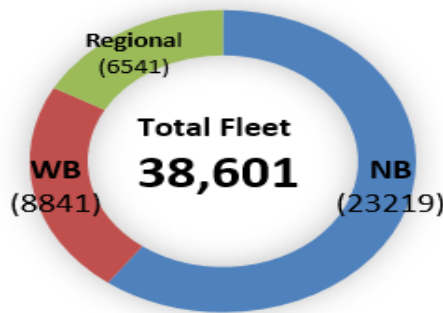
Figure 6. World Wide-Body Aircraft Fleet (2015)

A new airline business model approach come into consideration nowadays such as Long Haul Low Cost as a hybrid business model. Hybridization is accelerating as both LCCs and full service airlines look to adopt low cost models with full service profiles. (CAPA, 2014) This model previously started in Southeast Asia and was quickly adopted in the North Atlantic and Europe, as well. This new approach forces airlines to take new measures, for example to use more efficient crew usage aircrafts, like B787s or more capacity efficient aircrafts like A350s. The other two models that Airbus and Boeing compete with each other are B787s and A350s. There are 258 B787s in operation and 847 in backlog that add up to 1105 in total. A350 has only one delivered aircraft in 2014 with 779 aircraft in backlog, equals to 780. A300, A310 and A340 models of wide-body Airbus aircrafts are no longer manufactured and they will retire in a few years. On the other hand, Boeing has improved an old but reliable and long in service model aircraft B747 with B747-8 series. This improved model already has 87 deliveries and 35 new orders till 31 March 2015. Including old models, there are total 1505 B747s flying around the world. In addition, another successful Boeing aircraft called B767 has 1072 aircrafts in operation and 42 in backlog. (Figure 6)

Total Fleet: An aircraft will typically remain in service for around 20-25 years. This value is calculated historically and statistically by different consultancy companies. Average airframe retirement age was approximately 26 years in 2013 and average economic retirement age was 24 years. (ASCEND 2014). Specified years are expected to decrease in upcoming years due to potential increase of single aisle fleet retirement. Early retirements were dominated by regional jets until 2014, but most of the aging single aisle fleet like B737CL, MD80, early B737-NG series and early A320 series are expected to retire in very near future. Old design wide-bodies (e.g. B747-400, B767) will retire as well. Turboprop and regional jet retirements will continue as usual. Worldwide research and consultancy companies expect significant increase for retirement numbers. For example, (ICF SH&E 2014) projects more than 8,100 retirements through 2023, (ASCEND 2014) expects 10,000 jet retirements through 2023 which will drive nearly 50% of deliveries. We expect average retirement per year will increase from 600 to

over 1000 in the next 10 years and will rise up to 3.0 % of world fleet in 2023. Increasing volume of retirements will drive MRO opportunity all over the world, especially in North America and Western Europe according to high retirement rates.

Finally, regarding the number of all commercial aircrafts flying today and ordered ones, we forecast 38,601 total commercial aircraft will be in air in 10 years, depending on manufacturer's capacity. Nearly 60% of total fleet will be narrow-body or single aisle with 130-250 seat capacity, 23% will be wide-body with over 200 seat capacity and 17% will be regional aircraft with up to 130 seat capacity equipped with turboprop or jet engines. (Figure 7)

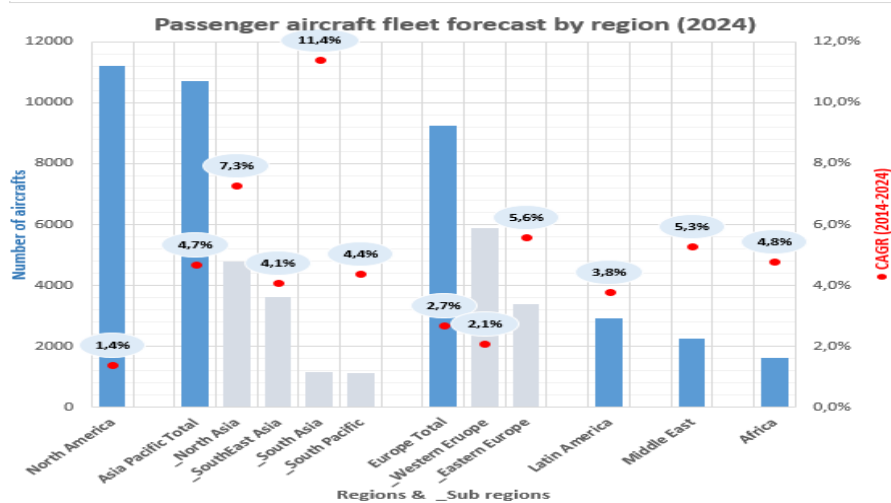


Source: (CAPA, 2014), (Flightglobal,, 2014), (World Airliner Census,, 2014) and Websites of (Airbus), (Boeing), (Embraer), (Bombardier) and (ATR Aircraft) (Net commercial aircraft orders before March, 2015) (WB=Wide-body; NB=Narrow-body)

Figure 7 World Total Fleet Forecast (2024).

2.3. Orders by Region

There is a significant discrepancy in the penetration of air transportation across the countries as well as regions. This situation depends on many internal and external factors. The largest external impact is fuel prices as nearly half of the airlines' total cost is fuel. Most of airline variable costs are beyond their control. Reducing staff costs, improving productivity or both are the most cost cutting strategies. Both of them differ across countries as well as regions. Air travel penetration in a region is highly correlated with GDP per capita. Air penetration can be increased by countries in a variety of ways like regulatory change (including liberalization of market access), infrastructure development and taxation policy.



Source: (CAPA, 2014), (ASCEND 2014) and aircraft manufacturers' declared orders.

Figure 8. Regional Commercial Aircraft Fleet Forecast and Annual Growth Rates From 2014 to 2024.

World aircraft fleet can be divided into 6 main regions: Latin America, North America, Africa, Middle East, Europe and Asia Pacific. Figure 8 shows regional forecast of world passenger aircraft fleet and compound annual growth rate (CAGR) from 2014 to 2024.

North America: There will be 11,220 aircrafts in 2024 with a yearly growth rate of 1.4% in North America with 167 airlines travelling to/from 866 commercial airports. The region will still hold the largest fleet but will have the lowest growth rate in the world. The reason of low growth rate is high values of fleet retirement.

Asia Pacific: Due to its fast growing economies Asia-Pacific region will continue its tremendous growth. The region has 906 commercial airports served by 355 airlines with 6809 aircrafts. The spectacular growth of Asia-Pacific aviation has been underpinned by progressive liberalization of air services. The number of aircrafts in the whole region will be over 10 thousand with a high annual growth rate of 4.7%.

Europe: With 6705 aircrafts in service, 387 airlines and 959 commercial airports Europe is the most congested region in terms of total commercial flights. Two thirds of the region fleet flies from Western European airports that have capacity constraints. Influenced by LCCs' new aircraft demands, Western Europe fleet will increase with a 2.1% annual growth rate while Eastern Europe will grow by 5.6%. The growth rate is lower than Eastern Europe due to higher retirement rates. However, Eastern part of the region has large air space areas and less number of countries which are not highly developed. Istanbul Ataturk airport is a candidate of world air traffic connection hub on East-West and North-South bound due to its geographical advantage and one of the fastest growing major carrier, Turkish Airlines. With its competitive advantages against powerful LCCs in Europe and flag carriers in Gulf and Asia, Turkish Airlines is set to become a new global

challenger in an increasing competitive landscape (Dursun, O'Connell, Lei, & Warnock-Smith, 40, 2014). It can serve more than 50 countries in Europe, Africa and near Asia only with narrow-body aircrafts and rest of the world with wide bodies.

Latin America: At the end of 2014, 2049 aircrafts were in service and 623 new orders were placed in the region including Caribbean for 177 airlines flying to/from 631 commercial airports. Its' fleet is growing with a value of 3.8%. **Hata! Başvuru kaynağı bulunamadı.** Brazil and Mexico are the largest markets of the region and emerging carriers like Gol, TAM and LAN airlines are hoping for improved economic conditions. Colombia continues to grow in domestic travel with its new LCC airlines. Chile, Columbia, Argentina and Peru have double digit domestic market growth at roughly 15% at 2014. (CAPA, 2014)

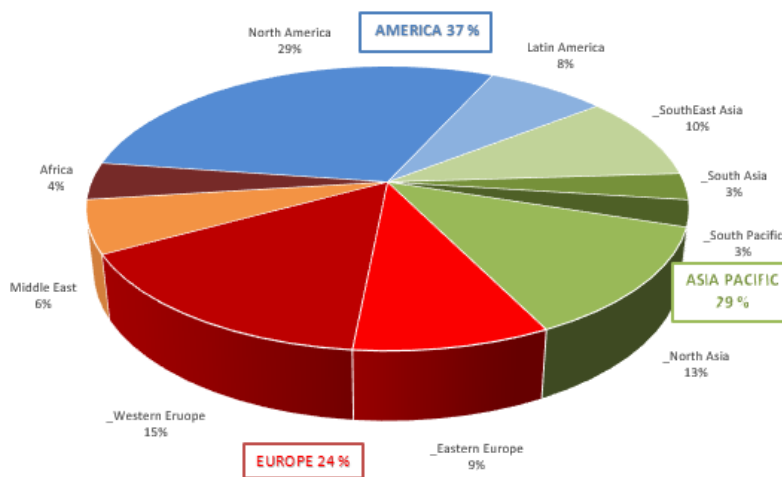
Middle East: Supported by government policies Middle East has become a global air traffic hub with its 131 commercial airports, 64 airlines and 1211 aircrafts dominated by wide-bodies. Worldwide, including the tourism impacts, Middle East accounts for 3% of the jobs and 4.5% of the GDP supported by the air transport industry. (ATAG, 2014). As a major hub Dubai has a natural geographical advantage which can serve more than 2/3 of the world's population within 8-hour flight.

Africa: Aviation is an excellent opportunity to support and accelerate the growth of Africa's weak but fast growing economy. Region has 371 commercial airports which serve 235 different airlines with 1282 African countries registered aircrafts. (ATAG, 2014) Emerging country carriers such as South African, Ethiopian and Kenya Airlines start to order more new aircrafts.

Figure 9 Source: (CAPA, 2014), (ASCEND 2014) and aircraft manufacturers' declared orders.

Figure 9. Commercial Aircraft Fleet Regional Market Share Forecast presents a brief summary of world passenger aircraft market share forecasts by region according to net orders as of 31 December 2014. The America region, particularly North America will still have the highest number of aircrafts (37% of the total). Asia Pacific region stands in the second lane but due to its fast growing economy and number of airlines it's likely to catch up America in terms of total fleet. Europe in total stands for third lane and Eastern Europe's fast and solid growth will boost total share rate in near future. Middle East and Africa will grow in particular with wide-body fleet as well. There will be stiff competition among Western Europe, Middle East and North Asia in capturing fleet market share in the near future to carry more passengers.

Every aircraft which is purchased, leased or owned by an operator requires some maintenance to stay airworthy and serviceable as long as it flies to transport passengers/cargos from one airport to another. Due to mandatory regulations, airworthiness requirements and common constraints, we think that maintenance organizations will determine the winners in this global fleet competition.



Source: (CAPA, 2014), (ASCEND 2014) and aircraft manufacturers' declared orders.

Figure 9. Commercial Aircraft Fleet Regional Market Share Forecast (2024)

3. Global MRO Outlook

Maintenance means the preservation, inspection, overhaul, and repair of aircraft, including the replacement of parts. Maintenance activities, personnel and organizations are highly regulated by the US, EU and national authorities.

Maintenance, repair, and overhaul are three terms commonly used to describe aircraft maintenance activity. An MRO (Maintenance, Repair and Overhaul) organization is thought to be a large company that holds numerous repair station authorizations from different aviation authorities around the world, and it accomplishes major maintenance on transport category aircraft that primarily belongs to airlines and leasing companies. The purpose of maintenance is to ensure that the aircraft remains airworthy throughout its operational life. All airlines are responsible for conducting required maintenance checks (either by themselves or through a qualified provider, MRO) in compliance with the aviation safety regulations of Federal Aviation Administration (FAA), the European Aviation Safety Administration (EASA), and/or national directorate general of civil aviation of their country.

Although maintenance requirements vary for different types of aircraft, experience shows that most aircrafts need some type of preventive maintenance every 25 hours or less of flying time, and minor maintenance at least every 100 hours. This is influenced by the kind of operation, climatic conditions, storage facilities, age, and construction of the aircraft. Most of the airlines in the world do minor maintenance checks and non-routine faults themselves with their line maintenance department. Minor checks can be done at any airport and generally do not require closed hangar area, but

major checks that take longer time and more comprehensive checks require a hangar area. Generally, large airlines that have more than 100 aircrafts have their own or subsidiary MRO facility at their base airports to do major checks. Most of the medium to small airlines outsource their major maintenance checks. An MRO company comprises of four main segments: (1) Airframe Maintenance, (2) Engine maintenance, (3) Component Maintenance and (4) Line Maintenance. (ARSA, 2014)

Resource availability and management of technical requirements are very limited in some cases for an airline due to lack of resources such as facility, material or skilled technical staff. Growth rate of MRO industry is lower than airlines fleet or network growth rates. Currency fluctuations create another risk for the MRO industry. Moreover, the MRO industry is expected to face some serious constraints in the future. In the short term they must struggle to overcome OEM⁴ dominance, over capacity and adverse regulatory ruling limitations. Due to high costs in establishing maintenance shops and storing spare parts, OEMs dominate engine and component maintenance segments. Hence, the number of independent MROs' joint venture agreements with OEMs is expected to increase in short to medium term. Particularly, in Europe and Middle East regions some MROs face overcapacity issues due to limited demand, high labor rates and limited experienced staff which result in facilities underutilized. But overcapacity problem is likely to disappear in the very near future if MROs can change some opportunities to cover empty hangar slots. First, there are a lot of leased aircrafts flying within Europe and all around the world owned by European operators. They are aging and operators want to replace old ones with brand new aircrafts by the same leasing way. Therefore, especially in the Western Europe many lease returns are expected. New MROs from the Eastern European emerging countries that can be accessed from main European market with a few hours' flight might enter the market. On the other hand, overcapacity issue in the Middle East will be solved by the world emerging airlines' huge order deliveries each year. In the short to medium term MROs and their supply chain continue to consolidate in order to remain as competitive as possible. Supply of spare parts will increase in legacy fleets in line with increased number of aircrafts in operation and it is expected to drive prices down due to increased part outs. In the long term well financed new entrants can make immediate impact on the MRO industry. Another main constraint is aging work force with limited incentives for younger generations, leading to questions over qualifications to perform the necessary work. Also, strict regulatory limitations especially to achieve aircraft maintenance license have a negative impact on workforce availability. Lack of aviation maintenance professionals is a global issue in the mid and long term except North America for both the airlines and MROs.

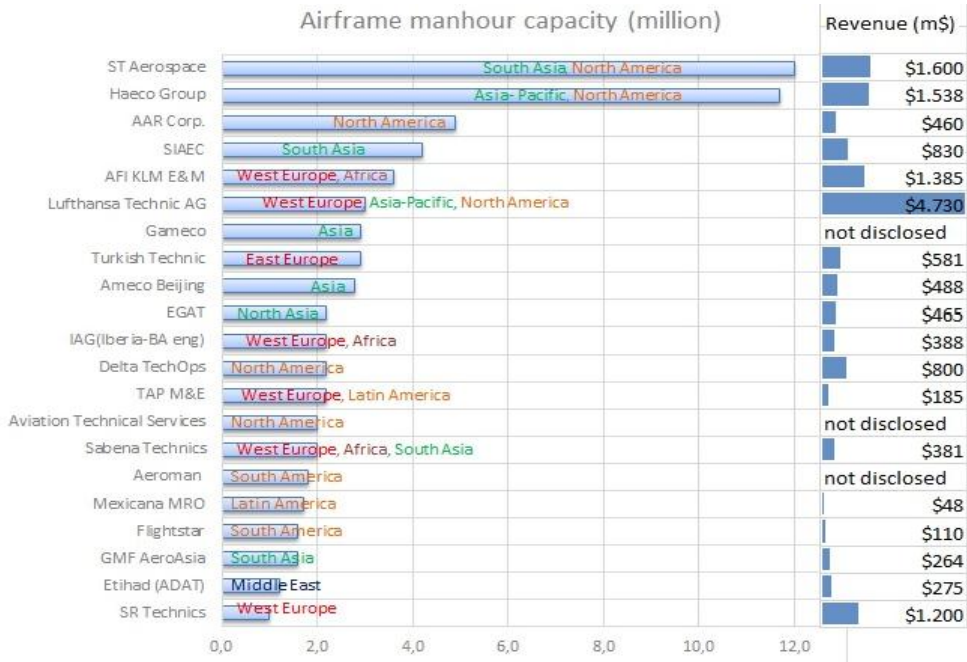
⁴ OEM: Original Equipment Manufacturer. (e.g. Airbus, Boeing, Rolls Royce, Honeywell)

3.1. Top MROs in the World

Airlines conduct line maintenance operations by themselves in their hub or domestic stations and contracts with other airlines for international stations' line maintenance requirements. Moreover, willingness to outsource airframe, component and engine maintenance to a proved nearby MRO is growing because of high and unstable costs, highly skilled labor shortage and material supply chain difficulties. Heavy maintenance visit (HMV) and modifications are considered as airframe or base maintenance as well.

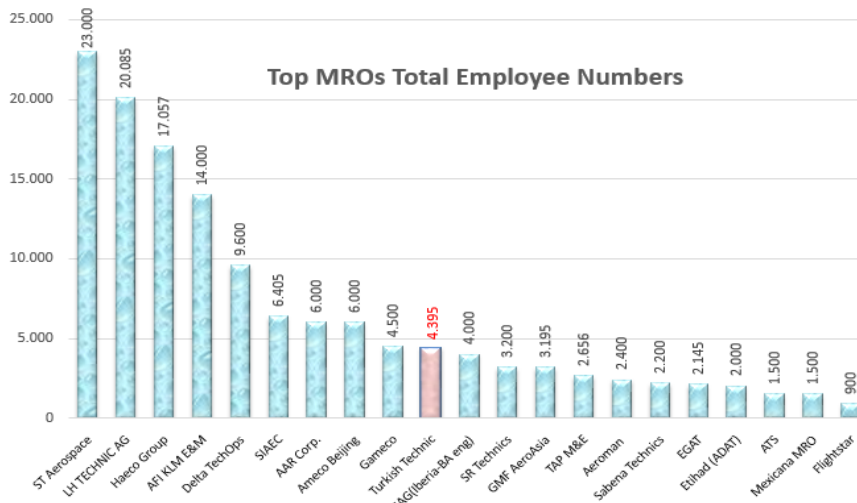
Airframe, engine or component maintenance can be provided in five different ways: (1) Airline undertakes it itself using own resources, labor and facility, (2) Airline third party undertakes related maintenance of another airline in a contracted time period (they can offer competitive prices), (3) Independent MRO does related maintenance of an airline in its' facility during a contracted period of time (they have lowest labor costs), (4) Joint Venture which is formed by gathering the resources of OEMs with in-country capabilities to build particular capacity, performs the related maintenance in a different facility, (5) OEM who is the manufacturer of airframe/component/engine and does it without using airline's resources.

OEM provided maintenance is growing fast in recent years but it is still negligible given the size of the whole maintenance market. Therefore, OEM provided maintenance figures are excluded in this study. Moreover, maintenance that is provided by airline itself with no third party service is also excluded, since it has no commercial effect to the global marketplace. We investigate maintenance subsidiaries of airlines which perform third party maintenance, independent MROs and joint venture MROs which are able to produce over one million airframe man-hours to determine top MROs in the world. We analyze global MROs which meet above criteria in four dimensions as follows: Figure 10 presents (1) annual airframe man-hour capacity, (2) regions that served by related MRO and (3) annual revenue earned from aeronautical services. Figure 11 presents (4) total full time employees.



Source: Man-hour values are obtained from (AAR Corporate), (AEROMAN), (AMECO), (ATS), (EVERGREEN AVIATION TECHNOLOGIES CORP.), (Flightstar), (GAMECO), (GARUDA INDONESIA GROUP), (HAECO), (Iberia Maintenance), (MEXICANA MRO Services), (SABENA TECHNICS), (SIA Engineering Company), (SR Technics), (ST Engineering), (TAP Maintenance & Engineering), (TURKISH TECHNIC), (The National Business) company annual reports and formal websites

Figure 10. World's Top MROs According to Annual Man-Hour



Capacity, Revenue and Served Regions (2015)

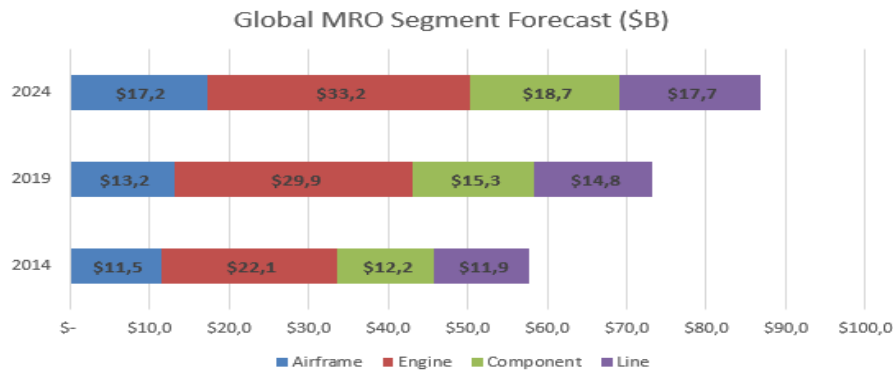
Source: All MRO's published 2014 annual reports.

Figure 11. World's Top MROs According To Full Time Employee Numbers (2015)

3.2. World MRO Forecast (2014-2024)

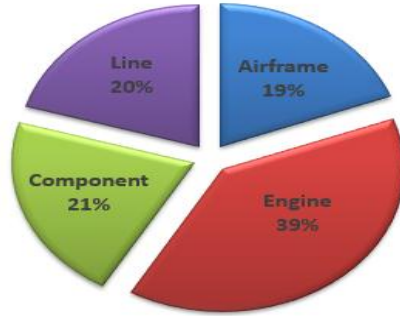
In line with the global growing fleet, demand for maintenance is increasing and the number of repair stations or MROs is growing as well. Last year's global MRO market revenue was almost \$58 billion from commercial aircraft maintenance. (TeamSai, 2014) expects this value to increase over \$70 billion in 2019 and nearly \$90 billion in 2024. Calculated compound annual growth rate (CAGR) from this forecast is a positive value of %4.20. Figure 12 shows current and forecasted annual MRO total and main segment revenues. MRO revenues are forecasted to increase in a smooth and balanced way in near future. Hence, we expect that revenue distribution rates between MRO sub segments will not change as much. Similar to recent years, consultancy companies forecast nearly the same percentage values at least until 2024. As of now, engine maintenance/overhaul revenues will be the largest MRO revenue segment with a value of 39%, remaining revenue will be shared about 20% between component maintenance, line maintenance and airframe-base- maintenance. (Figure 13)

Moreover, if we look at MRO revenue distribution forecast by aircraft type we see a different scenario to analyze. We expect a smooth annual increase in narrow-body and wide-body jet commercial aircraft maintenance. Although wide-bodies stay longer times in hangar for maintenance because of high narrow-body fleet size and shorter maintenance intervals according to higher Flight Cycle values, high lease returns and retirements, narrow body maintenance revenue is higher. Turboprop and regional jet market will remain at nearly same values. (Figure 14)



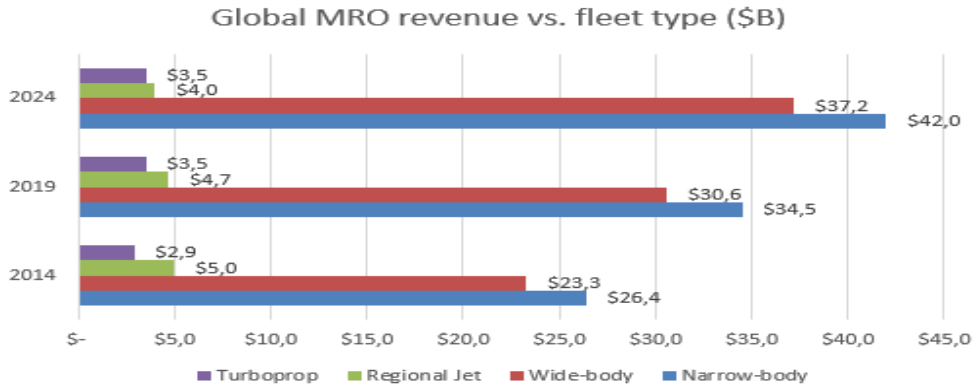
Source: (TeamSai, MRO Asia Conference Report, 2014)

Figure 12. World MRO Revenue Forecast with Main Segment Distributions (2014-2024)



Source: (TeamSai, MRO Asia Conference Report, 2014)

Figure 13. World MRO Revenue Segment Percentage (2014-2024)



Source: (ARSA, Aeronautical Repair Station Association Report, 2014)

Figure 14. World MRO Revenue Distribution Forecast by Aircraft Fleet (2014-2024)

3.3. MROs by Region

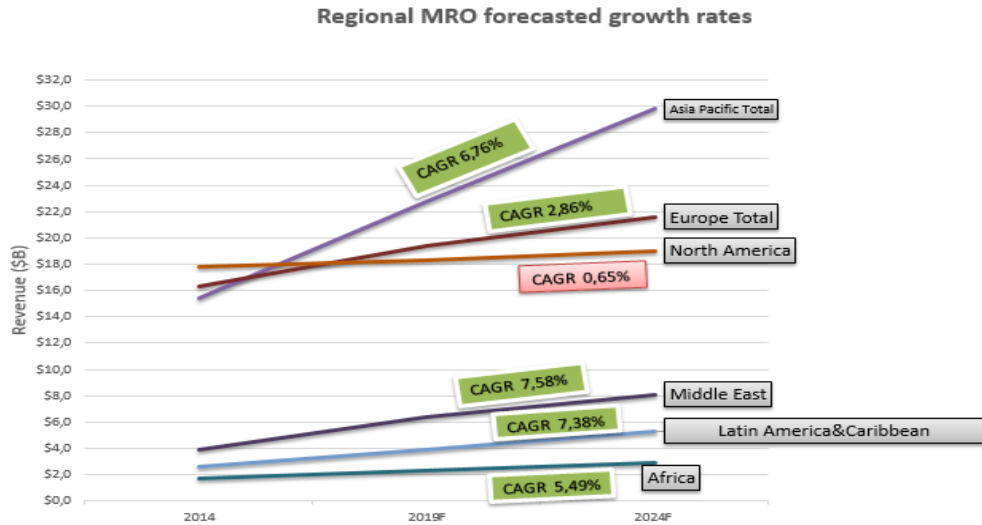
High capacity MROs are organized in regions where large number of aircrafts are operated. Similar to current fleet figures, the world MRO market is dominated by North America (17,8 \$B), Europe (16,3\$B) and Asia-Pacific (15,5\$B). These three regions are able to control nearly 86% of total MRO market. We think that North America, which has the highest MRO market share today, will be surpassed by both Europe and Asia-Pacific in 2019 according to expected growth rates. Boosted by enormous fleet increase of China and India and highly growing investments to meet demand, we expect that Asia-Pacific region will be the worlds' highest capacity provider and revenue earning area in 2024 with a value of 29,8\$B. This value corresponds 34% of 2024 world total MRO revenue forecast of 86.8\$B. The second leading region is Europe, particularly Western Europe with a total expected revenue of 21,6\$B. This situation tells us that more maintenance work will be outsourced from America to probably somewhere in Asia and Europe in the near future. Table 1 shows global MRO market regional revenue distribution and forecast.

Table 1. Global MRO Market Regional Revenue Distribution and Forecast (2014-2024)

Region	MRO MARKET SHARE BY REGION (\$B)		
	TOTAL MRO REVENUE (\$B)		
	2014	2019F	2024F
China	4,05	6,8	10,27
India	0,80	01,31	2,32
Other Asia & Pacific	10,60	14,7	17,21
Asia Pacific Total	15,45	22,81	29,80
Eastern Europe	2,40	3,33	4,27
Western Europe	13,90	16,11	17,31
Europe Total	16,30	19,44	21,58
North America	17,80	18,3	19,01
Middle East	3,90	6,43	8,11
Latin America & Caribbean	2,60	3,90	5,31
Africa	1,70	2,30	2,94
WORLD TOTAL	57,75	73,18	86,75

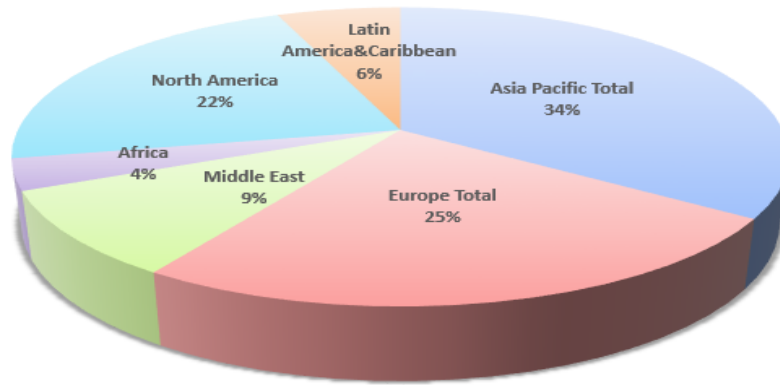
Source: (ARSA, Aeronautical Repair Station Association Report, 2014)

Compound Annual Growth Rate (CAGR) of each major region is calculated using regional revenue distribution data and is presented in Figure 15. Asia Pacific will continue to its enormous growth with a 6.76% CAGR resulting to be the largest MRO market with a significant revenue difference with the remaining regions. Europe will continue its smooth growth by a value of CAGR 2.86%. North America which has the largest passenger aircraft fleet in the world will not show the same success in MRO industry with a low CAGR value of 0.65%. Emerging air traffic and fleet markets such as Middle East, Latin America & Caribbean and Africa will grow with high CAGR values but impact of these markets to the global MRO industry will be limited due to low total revenue earnings. Emerging regions including India except Middle East, will not be able to fulfill the MRO demand due to facility and labor constraints even it is forecasted that overall India MRO market growth will be over 10% and Africa's growth nearly 6% in all maintenance dimensions. On the contrary, Middle East is expected to meet demand with over 7.0% growth rate in airframe, engine and line maintenance plus 6.6% in line maintenance resulting 7.58% average in all maintenance dimensions.



Source: (ARSA, Aeronautical Repair Station Association Report, 2014)

Figure 15. World Major Regions' Yearly Average Growth Rates Forecast (2014 – 2024)



Source: (ARSA, Aeronautical Repair Station Association Report, 2014)

Figure 16. World MRO Regional Market Share Forecast (2024)

As a summary, an airline's annual maintenance cost relative to the total annual cost will fluctuate over the years based on the timing of major maintenance visits, fleet age/size/mix and the price of fuel. MRO cost of an airline is generally between 10%-20% of the total costs with a typical breakdown of nearly 40% of engine maintenance and 20% of component, airframe and line maintenance each. Airline spent nearly 60 B\$ to MROs for maintaining aircrafts airworthy and serviceable in 2014. They will continue to spend more money for maintenance since they order new aircrafts or continue to fly existing ones. This value will be nearly \$90 billion in 2024. All regions in the world will continue their growth to be able to meet maintenance demand of new delivery aircrafts and existing aging fleets. Figure 16 presents the regional market share picture forecast in 2024.

CONCLUSION

This paper investigates the current situation and produces some realistic forecasts for the global and regional development of the air transport industry in three essential dimensions: air traffic, fleet and maintenance. Presenting a critical overview of the recent and future outlook of these three subsectors and their interactions, this paper provides an important insight to the aviation community. Aviation industry is always very sensitive to the global economic and social events. A war (Gulf), a terrorist attack (9/11), an epidemic event (SARS) and a financial crisis took place for the ten years duration until 2010 in the world. Air transport and all of its sub-industries were highly negatively affected by these major events. After ten devastative years air transport industry recovered its' losses until 2014. All indicators suggest that air traffic will globally grow at unprecedented high rates until 2024.

As air traffic increases with a highest growth rate for the last ten years globally, there are significant regional differences. Asia, Europe and Middle East are the emerging regions with double digit rates. China, USA and UAE are the main drivers if we consider additional passenger number size instead of growth rates. We expect that air traffic will continue to grow and double in the next ten years. The more people travel via air the more aircrafts will be required to fly. Therefore, airlines need to buy or lease additional aircrafts according to their network structure. This compels manufacturers to build more airframes, engines and components. World fleet will reach over 38 thousand aircrafts in ten years and be dominated by North America (39%), Asia Pacific (29%) and Europe (24%). There will be a stiff competition of market share mostly between Western Europe, Middle East and North Asia in terms of ordered aircrafts as well as passengers. On the other hand, every ordered aircraft will need additional maintenance capacity for an airline when delivered. Maintenance repair stations or MROs will play major roles in airlines' competitions due to high costs. Maintenance service capacity of the regions has to increase in line with fleet enlargement due to regulatory requirements. MROs in Asia Pacific (34%), Europe (25%) and North America (22%) will share the most of maintenance revenue of total \$90B in 2024. Middle East, Latin America and Asia Pacific will be the main drivers of MRO annual growth over 7%. While multi regional MROs in South Asia

and North America dominate global MRO market in terms of capacity, there will be crucial opportunities for other MROs particularly in emerging regions.

REFERENCES

- AAR Corporate. *Annual reports* . 2014. <http://phx.corporate-ir.net>, 15.05.2015
- AEROMAN. *Company*. 2015. <http://www.aeroman.com.sv>, 15.05.2015
- Airbus. *"Orders & deliveries"*. <http://www.airbus.com>, 15.05.2015.
- AirFranceKLM. *Our Ambitions, annual report 2014*. <http://www.airfranceklm.com>, 20.05.2015.
- AMECO. *Company Index*. 2015. <http://www.ameco.com.cn>, 01.06.2015
- ARSA. *Aeronautical Repair Station Association Report, Global MRO Market, Economic Assessment, Air Transport*. 2014.
- ASCEND. *Flight Global Consultancy, Changing Fleets & Impact on MRO Demand*. 28 October 2014.
- ATAG. *Air Transport Action Group, Aviation Benefits Beyond Borders*. Geneva, April 2014.
- ATR Aircraft. <http://www.atraircraft.com>, 21.01.2015
- ATR. Bombardier Inc, *Profile, Strategy and Market*. February 2015. <http://ir.bombardier.com>, 20.05.2015
- AVIATION TECHNICAL SERVICES. *About ATS*. 2015. <http://atsmro.com/about-ats/>, 01.06.2015
- Aviation Week Network. *Aviation Week Announces Top 10 Airframe MRO Providers*. Lee Ann Shay. 2015.
- Boeing. *"The Boeing Company"*. *Active.boeing.com*. 2015. <http://www.boeing.com/commercial/#/orders-deliveries>.
- Bombardier Commercial Aircraft. *Market Forecast 2014-2033*. <http://www.bombardier.com>, 05.06.2015
- Bombardier. *Profile, strategy and market* . <http://ir.bombardier.com>, 01.02.2015
- CAPA . *Aviation Awards for Excellence*. 2014. <http://centreforaviation.com/about-capa/awards/>.
- CAPA. *Centre For Aviation, World Aviation Yearbook*. CAPA, 2014.
- CAPA, Centre For Aviation. *CAPA > Aviation Analysis > Airbus and Boeing 2014*, January 2014.
- CFR 14 Chapter I Subchapter A Part 1.1 General definitions.
- DELTA AIR LINES INC . *FORM 10-K/A Amended Annual Report*. 2014.

- Dursun, Mehmet Erkan, John F. O'Connell, Zheng Lei, and David Warnock-Smith. "The transformation of a legacy carrier - A case study of Turkish Airlines." *Journal of Air Transport Management* (Elsevier), 40. 2014: 106-118.
- EASA Part-145 AMC 145.A.10 Scope (a)(c).
- Embraer. *Press and events*. <http://www.embraerexecutivejets.com>, 11.06.2015
- EU COMMISSION REGULATION (EC) No 2042/2003, Annex 1, Part M.
- EVERGREEN AVIATION TECHNOLOGIES CORP. *mediafile*. 2014. <http://www.casid.org.tw> and <http://www.evaair.com>, 01.06.2015.
- Federal Aviation Administration (FAA), Electronic Code Of Federal Regulations (e-CFR). U.S. Government Publishing Office (GPO), n.d.
- Flightglobal . *ANALYSIS: The changing size and shape of the world airliner fleet*. <http://www.flightglobal.com>, 22.08.2014.
- Flightstar. *Company Overview*. 2015. <http://www.flightstarjax.com>, 01.05.2015.
- GAMECO. *News&Events, Our Services*. <http://www.gameco.com.cn/>, 03.06.2015.
- GARUDA INDONESIA GROUP. *GMF AeroAsia, Annual report*. 2014. <http://www.gmf-aeroasia.co.id>, 05.05.2015.
- HAECO. *Annual reports*. 2014. <http://www.haeco.com>, 07.06.2015.
- IATA. *International Air Transport Association, Annual Review 2014*. 2015.
- . «Pearce, Brian, The shape of air travel markets over the next 20 years.» www.iata.org. 2014. <http://www.iata.org/publications/Pages/20-passenger-forecast.aspx>.
- IATA-Tourism Economics. *20-year passenger forecast*. IATA, 2014.
- Iberia Maintenance. *Facts & Figures*. 2014. <http://www.iberiamaintenance.com>, 07.06.2015
- ICAO . *Annual Report of the Council-2013*. 2014.
- ICAO. *International Civil Aviation Organisation, Manual on the Regulation of International Air Transport (Doc 9626, Part 4)*.
- ICF SH&E. "MRO Market Overview & Trends." *2014 Snnusl Transportation Review Board Meeting*. Washington, DC: ICF International, 2014.

- MEXICANA MRO Services. *Resources*. 2015.
<http://www.mexicanamro.com>, 03.06.2015.
- SABENA TECHNICS. *Facts & Figures*. 2014.
<http://www.sabenatechnics.com>, 08.06.2015.
- SIA Engineering Company. *FY2014/15 Performance Review*. 2015.
<http://www.siaec.com.sg>, 19.06.2015.
- SR Technics. *Facts & Figures* . 2014. <http://www.srtechnics.com>,
19.06.2015.
- ST Engineering. *2014 financial statements*. <http://www.stengg.com>,
11.06.2015.
- Sukhoi Inc. *Superjet International*.
<http://www.superjetinternational.com>, 10.06.2015.
- TAP Maintenance & Engineering. *Technical Sheet*. 2015.
<http://www.tapme.com.br>, 03.06.2015.
- TeamSai. «2014-2024 Global MRO Forecast.» *MRO America Conference*. April 2014.
- TeamSai. «MRO Asia Conference Report, 2014-2024 Global MRO Forecast.» 2014.
- TeamSai, David Hygate, MRO Europe Conference, The challenging landscape of engine MRO. 2013.
- The National Business. *Etihad Airways acquires aircraft maintenance provider from Mubadala*. 2014. <http://www.thenational.ae>,
12.06.2015.
- Turkish Aviation General Directorate of State Airports Authority (DHMI). <http://www.dhmi.gov.tr>, 12.06.2015
- TURKISH TECHNIC. *Financial Statements*. 2014.
<http://www.thytechnik.com>, 17.06.2015
- World Airliner Census. *Special Report*. Flight International, 2014.