THE REPUBLIC OF TURKEY
BAHCESEHIR UNIVERSITY

# TECHNICIAN ASSIGNMENT FOR IFE LINE MAINTENANCE IN AVIATION MRO

**Master's Thesis**

**MUSTAFA İÇELOĞLU**

**ISTANBUL, 2018**

THE REPUBLIC OF TURKEY
BAHCESEHIR UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

INDUSTRIAL ENGINEERING

# TECHNICIAN ASSIGNMENT FOR IFE LINE MAINTENANCE IN AVIATION MRO

**Master's Thesis**

**MUSTAFA ICELOGLU**

**Assoc. Prof. BARIŞ SELÇUK**

**ISTANBUL, 2018**

**THE REPUPLIC OF TURKEY**
**BAHCESEHIR UNIVERSITY**

**GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES**

**INDUSTRIAL ENGINEERING**

Name of the thesis: Technician Assignment for IFE Line Maintenance in Aviation MRO

Name/Last Name of the Student: Mustafa İÇELOĞLU

Date of the Defense of Thesis: 27.01.2018

The thesis has been approved by the Graduate School of Natural and Applied Sciences.

Prof. Nafiz ARICA
Graduate School Director

I certify that this thesis meets all the requirements as a thesis for the degree of Master of Arts.

Assist. Prof. Adnan ÇORUM
Program Coordinator

This is to certify that we have read this thesis and we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Arts.

| Examining Committee Members | Signature |
|---|---|
| Thesis Supervisor<br>Assoc. Prof. Barış SELÇUK | ____________________ |
| Member<br>Assoc. Prof. Gülgün KAYAKUTLU | ____________________ |
| Member<br>Assist. Prof. Ethem ÇANAKOĞLU | ____________________ |

## ABSTRACT

TECHNICIAN ASSIGNMENT FOR IFE LINE MAINTENANCE IN AVIATION MRO

Mustafa İÇELOĞLU

Industrial Engineering

Thesis Supervisor: Assoc. Prof. PhD. Barış SELÇUK

January 2018, 71 Pages

All the Airway Companies around the world are buying and upgrading their services via equipping new products in order to compete each other. One of the most prominent product in this market is In Flight Entertainment Systems.

In Flight Entertainment Systems vary in terms of design, content and software. By the improving technology, the experience that these systems provide increases. Instead of Movies, Music, Games, now there are Internet and Live Tv services and special applications getting developed for the users. Because, the final researches and surveys show that In Flight Entertainment Systems have a great role for the Airline Companies in order to be selected by the passengers.

The Airline company which this study has taken place is one of the companies that has a lot of In Flight Entertainment System types on its fleet and follows all the new inventions in order to provide a high quality and pleasant experience to all of its passengers.

The aircraft which has an inoperative In Flight Entertainment system can be removed from the flight list. The subject Airline Company has been evaluated in terms of In Flight Entertainment Systems and has taken a place in the first five Airline Companies in the world. This Airline has more than 15 In Flight Entertainment System types and more than 20 system configurations in its fleet.

Therefore, this company gives a great importace to the maintenance of all these systems. The Line Maintenance activities are done meticiously by its own and subsidiary MRO Company. For only In Flight Entertainment Systems, a management having 200 technicians are working.

Since In Flight Entertainment Systems are electronical, they are a part of the Avionic Systems Group. The technicians working on these systems, must have Avionics capability. Also, it is an obligatory for an In Flight Entertainment technician to have the type certificate of the aircraft that he/she will be working on and B2 Type Aircraft Technician License for completing all the works on the aircraft perfectly. Also, since these systems are very special and vary too much, there is a need for In Flight Entertainment System Specific Certificate too.

Under all these limitations, it gets harder to maintain all the necessary activities of the In Flight Entertainment Systems of such a wide fleet. This study has been done in order to minimise the system based defects, technician costs, and maximize seat sales and user satisfaction. Because, in order to provide all of these, the maintenance activities must be improved. All the fleet and equipped In Flight Entertainment Systems require technician and type certificate in ratio with aircraft number. Via this study, the technicians and maintenance activities are classified and the needs are identified accordingly.

The purpose of this study is firstly to compare the aircrafts' ground time with In Flight Entertainment System based defects, statistically. And then, simulating the current situation via assigning the technicians whose capabilities are classified with the defects which are also classified.

Finally, statistical and simulation outputs are analysed and by considering the new aircraft types and their In Flight Entertainment Systems which will be delivered in the future, the technician planning is done by this study.

**Keywords:** Manpower Planning, Scheduling, Line Maintenance, Workforce Assignment, IFE, Aviation, MRO, Aircraft Technician

# ÖZET

MRO UÇAK BAKIMLARINDA TEKNİSYEN PLANLAMA

Mustafa İÇELOĞLU

Endüstri Mühendisliği

Tez Danışmanı: Doç. Dr. Barış SELÇUK

Ocak 2018, 71 Sayfa

Günümüz hava yolları rekabet edebilmek adına yolcularına sunabileceği hizmetleri geliştirmek adına sürekli yeni ürünler almakta ve geliştirmektedirler.

Bu yeni ürünlerden biri de Uçak İçi Eğlence sistemleridir. Uçak içi eğlence sistemleri birbirilerinden farklı dizaynlara sahip, yazılım ve içerik bakımından da çeşitli farklılıklar göstermektedir. Gelişen teknoloji ile birlikte bu sistemlerin sağladığı servislerde günden güne artmaktadır. Film, Müzik, Oyun dışında artık İnternet ve Canlı Tv hizmetleri de sağlanabilmekte yolculara özel uygulamalar geliştirilebilmektedir. Tüm bu hizmetlerin müşteri memnuniyetini göz önünde bulundurarak sürdürülmesi gerekmektedir. Bu yüzden Havayolu firmaları yolcuya direkt etkisi olan bu sistemlerin bakımlarına çok fazla önem vermektedir. Çünkü son zamanda yapılan araştırmalar ve anketler gösteriyor ki Havayolu müşterilerinin havayolu tercihlerinde Uçak içi eğlence sistemleri büyük bir öneme sahip.

Bu çalışmanın yapıldığı Havayolu firması da tüm bu gelişmeleri yakından takip ederek yolcularına kaliteli ve keyifli bir deneyim yaşatmak adına birçok uçak içi eğlence sistemine sahip ve konuya son derece önem göstermektedir. Uçak içi eğlence sistemi çalışmayan bir uçak seferden alınabilmektedir. Çalışmanın yapıldığı Havayolu uçak içi eğlence sistemleri değerlendirmelerinde ve anketlerinde dünyanın ilk 5 havayolu firmalarından biri olarak gösterilmektedir. Filosunda 15'ten fazla Uçak içi eğlence sistemi ve 20'den fazla da sistem konfigürasyonu bulunmaktadır.

Dolayısıyla tüm bu sistemlerin bakımına da önem vermek gerekmektedir. Havayolu firmasının hat bakım faaliyetleri gene kendi iştiraki olan MRO firması tarafından titizlikle yürütülmektedir. Sadece Uçak içi eğlence sistemleri için 200 Teknisyene sahip bir müdürlük bu iş için çalışmaktadır.

Uçak içi eğlence sistemleri elektronik sistemler olduğundan uçak bakım faaliyetleri açısından Aviyonik sistemler grubunda yer alırlar. Bu sistemler üzerinde çalışacak Teknisyenlerin Aviyonik özelliğe sahip olması gerekmektedir. Bir Teknisyenin Uçak içi eğlence bakım faaliyetlerini eksiksiz yürütebilmesi için çalışacağı uçağa ait bir uçak tip sertifikası ve B2 tip uçak teknisyenliği lisansına ihtiyacı vardır. Ayrıca bu sistemler çok özel olduğundan ve çeşitlilik gösterdiğinden uçak içi eğlence sistemine sahip bir sertfikaya da ayrıca gereksinim duyulmaktadır.

Tüm bu limitasyonlar altında bu ölçekteki uçak içi eğlence sistemlerinin bakım faaliyetlerini yürütmek zorlaşmaktadır. Uçak içi eğlence sistemleri kaynaklı arızaları ve

teknisyen maliyetlerini asgariye indirmek, maksimum koltuk satışı ve müşteri memnuniyeti sağlayabilmek adına bu çalışma yürütülmüştür. Çünkü tüm bunları yapabilmek için öncellikle bakım faaliyetlerinin geliştirilmesi sağlanmalıdır. Tüm filo ve sahip olduğu uçak içi eğlence sistemlerinin gerekli tip ve yeterlilikle teknisyen ihtiyacı bulunmalıdır. Bu çalışmada teknisyenler ve bakım faaliyetleri sınıflandırılmış ve buna göre ihtiyaçlar belirlenmiştir.

Bu çalışmanın amacı, öncelikle uçakların yerde kalış süreleri ve uçakların uçak içi eğlence sistemi kaynaklı arızalarının istatistiksel karşılaştırmasını yapmaktır.

Daha sonra yetkileri sınıflandırılmış teknisyenleri, sınıflandırılmış arızalara atayarak mevcut durumu simule etmektir.

Sonucunda istatistiksel ve simülasyon çıktılarını analizi etmek ve ileride filoya girecek uçak tipleri ve sahip oldukları uçak içi eğlence sistemlerinin sayısına göre teknisyen planlaması yapabilmektedir.

**Anahtar Kelimeler:** Havacılık, Bakım Faaliyetleri, Uçak İçi Eğlence Sistemleri, Teknisyen Planlama, Bakım Onarım Merkezi, Uçak Hat Bakım

## CONTENTS

## TABLES

# FIGURES

## ABBREVIATIONS

| | | |
|---|---|---|
| A/C | : | Aircraft |
| AD | : | Airworthiness Directive |
| AM | : | Aircraft Modification |
| AOG | : | Aircraft On Ground |
| APU | : | Auxiliary Power Unit |
| ATA | : | Air Transport Association |
| AV | : | Annual Visit |
| AWL | : | Air Worthiness Limitations |
| B777 | : | Boeing 777 Extended Range |
| BM | : | Base Maintenance |
| CMR | : | Certification Maintenance Requirements |
| CYC | : | Cycles |
| DDS | : | Dispatch Deviation Sheet |
| EASA | : | European Aviation Safety Agency |
| ETOPS | : | Extended Twin Operations |
| FAA | : | Federal Aviation Administration |
| FAR | : | Federal Aviation Regulation |
| FC | : | Flight Cycles |
| FH | : | Flight Hours |
| GCS | : | Global Communication Suite |
| HMx | : | Heavy Maintenance |
| HRS | : | Hours |
| ICAO | : | International Civil Aviation Organization |
| IFE | : | In Flight Entertainment |
| IST | : | Istanbul Ataturk Airport |
| JAA | : | Joint Aviation Authority |

| | | |
|---|---|---|
| JAR | : | Joint Aviation Regulation |
| LM | : | Line Maintenance |
| M | : | Mean |
| MEL | : | Minimum Equipment List |
| MRO | : | Maintenance Repair Overhaul |
| NB | : | Narrow body Aircrafts |
| RI | : | Repair Instruction |
| SB | : | Service Bulletin |
| SD | : | Standard Deviation |
| SL | : | Service Letter |
| SSI | : | Structural Significant Items |
| TK | : | Turkish Airlines |
| WB | : | Wide body Aircrafts |
| XSIT | : | Extended Sterile Insect Technique |

# 1. INTRODUCTION

This thesis includes a research project in order to optimize the man hour planning for IFE (In Flight Entertainment) and Connectivity Line Maintenance. It is carried out and assigned at IFE and Media Management department of Turkish Airlines Technic which is the top ten MRO (Maintenance Repair Overhaul) company in the world.

The definition of MRO is generally used in different types of industry. But it is especially used in the aviation industry. In order to be able to do the activities such as maintaining, repairing and overhauling in this industry, it is an obligatory to have the capability and necessary approvals from EASA or FAA. In the regulations of FAA, MRO is able to do maintenance, overhaul, repair and the replacement activities with the approval of authority. (FAA, 2012)

MRO is composed of three parts. These are base, line and shop (engine and component) maintenance.

While base, engine and component maintenances are simple and scheduled, line maintenance is generally complicated and may be unscheduled.

For 7 days and 24 hours, Line maintenance organizations are required to provide necessary support to all individual aircraft, on ground and during flight. This emphasizes that this is one the most major support that can ever be provided.

Line Maintenance means small, planned or unplanned maintenance (Williams, 2016). And it includes a lot of maintenance service types such as repetitive checks (Daily, weekly, Transit, A checks, ramp), troubleshooting, ground operations, cabin interior and in-flight entertainment services. The variety of the services keeps the aircraft schedule very busy fleet. Line maintenance must be perfectly organized to maintain the aircrafts reliable and safe for the operations and flights.

In this study, a specific service of line maintenance is addressed as a very new field in MRO industry which is In-Flight Entertainment services.

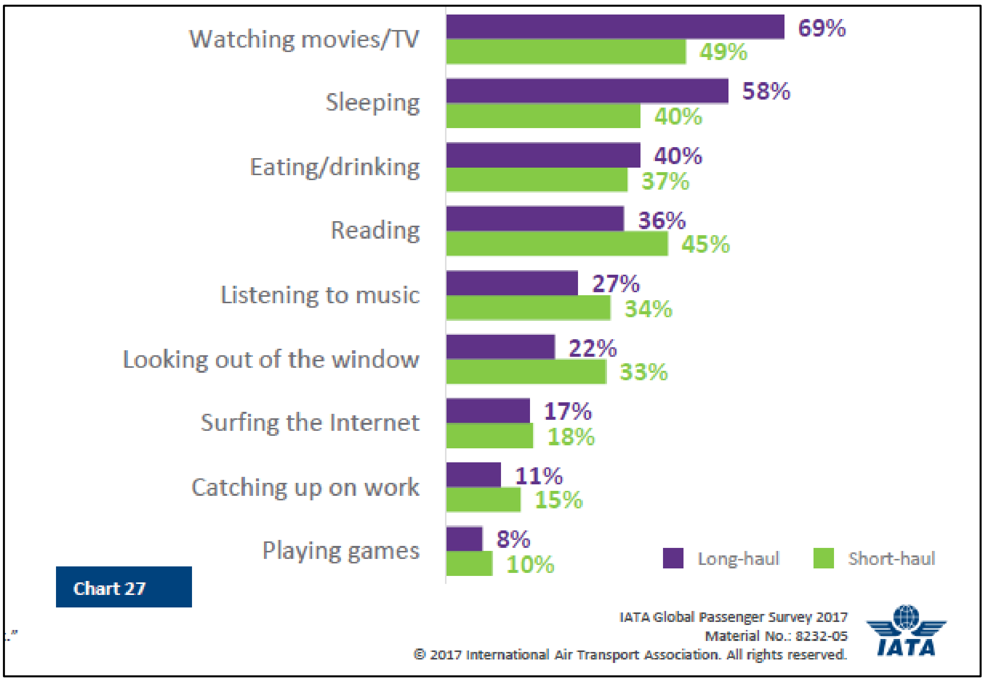
Today's premium airlines mostly focus on In-Flight Entertainment system which provides to passenger wide range of products from movies to Internet.

In our days in aviation industry, the competition amongst airlines has become stronger. This brings new improvements in airline products, especially in the in-flight entertainment services. While airlines spent $1.8 billion on IFE in 1998, in 2016 airlines spent more than $18 billion.

According to the statistics, IFE systems play an important role in Airline's revenue. Airlines make millions of dollars investment on IFE Systems in order to remain a competitive player in the aviation market.

In addition, the passenger surveys shows that one of the most influential factors affecting business passengers for preferring an airline is in-flight entertainment and connectivity systems. The result of the IATA Passenger journey shows that the favorite in-flight activity for both long-haul and short-haul flights is watching movies/TV. The in-flight activities percentage is seen in figure 1.1.

**Figure 1.1: IATA Passenger Survey: In-Flight**




*Source:* (International Air Transport Association, 2017)

According to the survey conducted by Inmarsat, %40 percent of passengers rank In-Flight entertainment and connectivity as a top 3 driver of airlines choice. %60 percent of passengers globally believe that inflight Wi-Fi is a necessity not a luxury. Global percentage is seen in the table 1.1

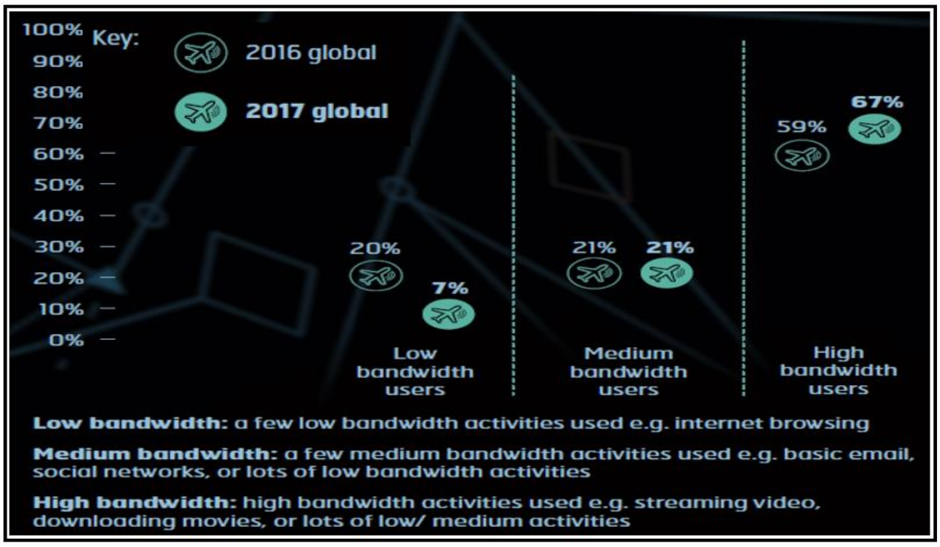
**Table 1.1: Wi-Fi is a necessity or not? (IFE Survey by Inmarsat)**

| | |
|---|---|
| **APAC** | **%62** |
| **U.S.** | **%61** |
| **EU** | **%56** |
| **MIDDLE EAST** | **%56** |
| **LATAM** | **%54** |

*Source:* (Inmarsat Aviation, 2017)

As a one of new feature of In-flight Entertainment system, connectivity has become more important and industry barometer. Inmarsat's annual Inflight Connectivity survey with more than 9000 passenger from 18 different countries across Europe, Asia Pasific, the Middle East and North and Latin America is very highlighting in order to see the usage level of connectivity also seen in figure 1.1. Accordingly, below figure 1.2 shows annual Inflight Connectivity Survey results of Inmarsat.

**Figure 1.2: Inmarsat's annual Inflight Connectivity Survey**




*Source:* (Inmarsat Aviation, 2017)

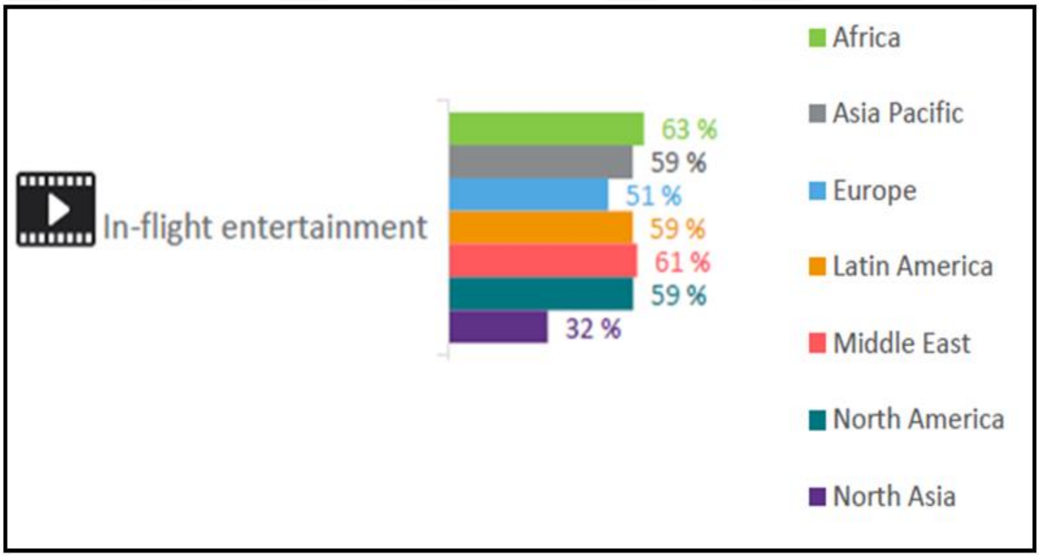
Therefore the quality of this service directly effects on customer loyalty and customer satisfaction. According to the same survey conducted by Inmarsat %39 percent of European passengers who have experienced high quality inflight Wi-Fi would stop using their preferred airline if it offered poor quality. The percentage of customer loyalty based to Country is seen in table 1.2 and the customer satisfaction is seen in figure 1.3

**Table 1.2: Customer Loyalty in European Passengers (IFE Survey by Inmarsat)**

| | |
|---|---|
| **ITALY** | **%62** |
| **FRANCE** | **%61** |
| **TURKEY** | **%56** |
| **UK** | **%56** |
| **GERMANY** | **%54** |

*Source:* (Inmarsat Aviation, 2017)

**Figure 1.3: IATA Passenger Survey: Customer Satisfaction**




*Source:* (International Air Transport Association, 2017)

A Premium IFE service provides to passenger movies, music, games, applications, internet, live TV, online shopping, magazines, on board social network, location services etc. and it is also enabling passenger to use their own devices. The typical IFE system features are seen in figure 1.4.

**Figure 1.4: Typical IFE System Features (Panasonic eX3 System)**


*Source:* (www.panasonic.aero, 2016)

In order to provide all these features for all flights, it is required to have a very good operation which has to include well organized maintenance and support structure. In addition, it is essential to communicate and coordinate with hardware manufacturers, satellite and internet service providers, software makers etc.

IFE systems may seem simple and easy to use for passenger; however, it is very hard to maintain all IFE activities in a limited ground time especially the premium airlines such as Turkish Airlines which is flying to more than three hundreds destinations with one thousand five hundreds flights per day.

Turkish Airlines is the biggest IFE collector in the world and has more than three hundreds aircraft suited with twenty-five different configurations of IFE systems. And one third of these aircraft provides Live TV and Internet Connectivity. The IFE diversity in Turkish airlines is seen in Table 1.3.

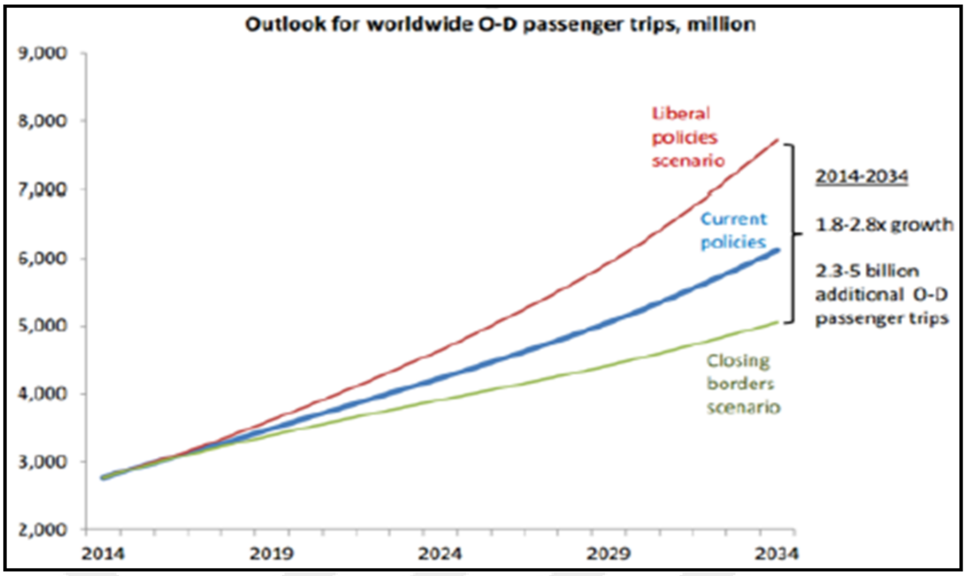
**Table 1.3: In-Flight Entertainment Type operated by Turkish Airlines**

| IFE SYSTEM | THE NUMBER OF IFE CONFIGURATION | TYPE OF IFE SYSTEM | A/C AISLE TYPE |
|---|---|---|---|
| Panasonic efX | 1 | AVOD-WIRED | NB |
| Panasonic eX1 | 2 | AVOD-WIRED | NB |
| Panasonic eX2 | 6 | AVOD-WIRED | WB |
| Panasonic eX3 | 3 | AVOD-WIRED | WB |
| Panasonic dMpes | 1 | BCAST-WIRED | NB |
| Panasonic Mpes | 1 | BCAST-WIRED | NB |
| Panasonic GCS | 3 | WIRELESS | WB,NB |
| Panasonic 3000i | 1 | AVOD-WIRED | WB |
| Thales i3000 | 1 | BCAST-WIRED | NB |
| Thales i4000 | 1 | AVOD-WIRED | NB |
| Thales i5000 | 2 | AVOD-WIRED | WB |
| Thales Avant | 1 | AVOD-WIRED | NB |
| Turkish/Havelsan WIFE | 1 | AVOD-WIRELESS | NB |
| Turkish/Havelsan Tablet | 1 | AVOD-TABLET | NB |
| | **25** | | |

The scope of the IFE Maintenance is increasing day by day with the new aircraft deliveries. In five years, more than 250 new aircraft will be joining for Turkish Airlines fleet.

According to recent net orders, it is forecasted that nearly 750 aircrafts will be inflight in five years and this value can reach over 1,000 with new orders in the next decade for Turkish Airlines operator. According to the statistics of International Air Transport Association (IATA), it is expected that over 3.5 billion people is in-flight all over the world in 2015. It is seen in figure 1.5.

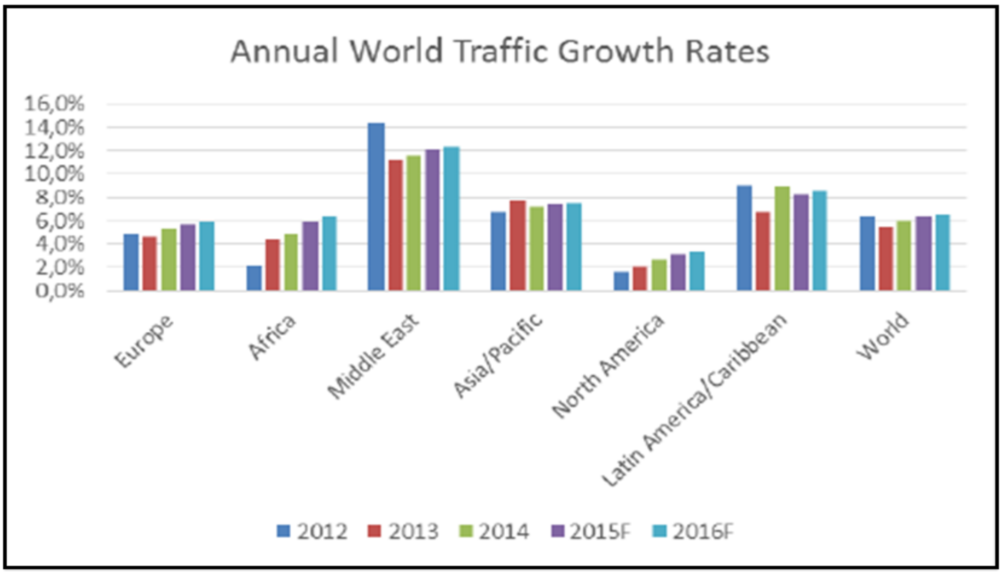
**Figure 1.5: IATA/Tourism Economics "Air Passenger Forecast"**




*Source:* (IATA-Tourism Economics, 2014)

With the growing demand, airlines have to provide additional services in order to be competitive. Especially, the growth rates in Middle East are charming and the reasonable to compete the rivals of Turkish Airlines such as Emirates and Qatar Airways. The annual world traffic growth rates are seen in figure 1.6.

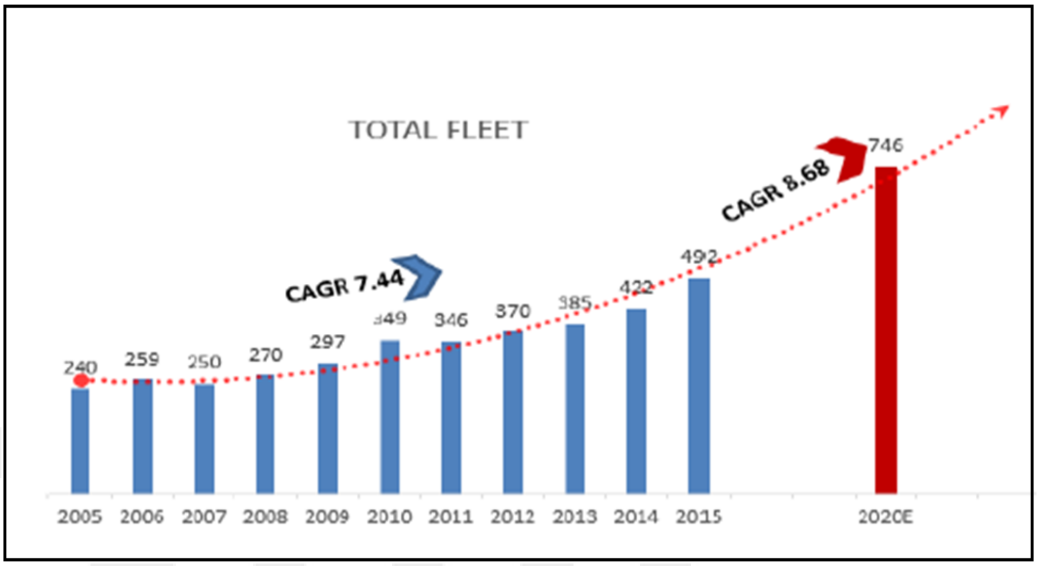
**Figure 1.6: Annual World traffic growth rates**




*Source:* (ICAO Annual Report of the Council, 2014)

Increase in the number of aircrafts in Turkey and nearby regions will influence demand for the national MROs. The increase of Total Fleet in Turkey is seen in figure 1.7.

**Figure 1.7: Annual World traffic growth rates**



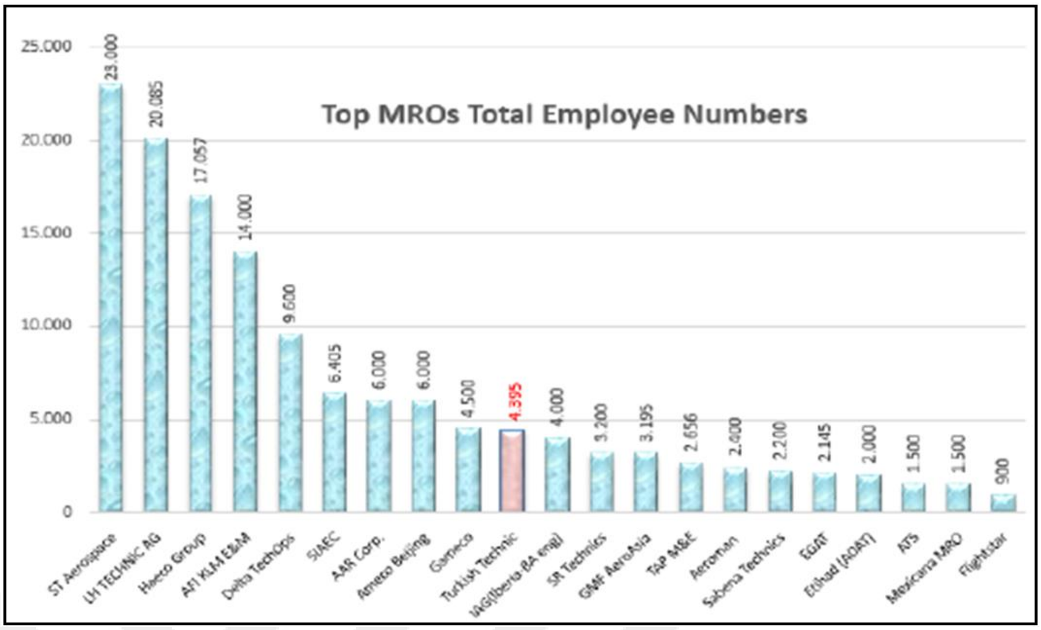

*Source:* (Aviation Magazine, 2015)

The MROs must have adequate infrastructure and skilled labor to sustain continuous growth. There are 7 MROs in Turkey and only 2 of them can provide full maintenance service with a limited capacity.

In parallel with traffic and fleet growth, maintenance repair stations in the country must grow at the same rate or faster to satisfy increasing demand of emerging nearby regions like Eastern Europe, Middle East and North Africa. In order to satisfy this huge demand, Turkish Technic should firstly find or create skilled aviation maintenance professionals in Turkey.

Turkish Technic has more than four thousand technicians. The number of IFE technician in IFE and Media Management is nearly two hundred. In figure 1.8, the employee numbers of the top MROs is seen.

**Figure 1.8: The Top MROs Total Employee Numbers**




*Source:* (Aviation Magazine, 2015)

From the IFE line maintenance perspective, it is really necessary to have and prepare specific maintenance teams which are certified and has good knowledge and enough experience about IFE systems. Every performed scheduled/unscheduled maintenance activity or rectified defect on an airframe, engine or component of an aircraft must be released to service by a certifying staff authorized for that specific maintenance.

Every certifying staff must have a valid maintenance license issued and continuously monitored by a competent authority like EASA, FAA or a national DGCA. Certifying staff specifications, training and experience requirements are described as a regulation of competent authorities similarly. (EASA , 2017) The sub-category and skills are seen in figure 1.9.

**Figure 1.9: AMP sub-categories and skills (red highlighted for LM skills)**

| | | | | |
|---|---|---|---|---|
| 1 | Aeronautics / Aerospace / System Engineer | Maintenance Planning System Engineering Continuing Airworthiness Management | AML not required | OFF WING |
| 2 | Aircraft Maintenance Engineer / Technician (base maintenance) | Scheduled Maintenance checks (Larger than A check) Heavy Maintenance | Category A/B1/B2/B3 or C type AML | ON WING |
| 3 | Aircraft Maintenance Engineer / Technician (line maintenance) | Defect rectification Unscheduled maintenance Troubleshooting Scheduled Maintenance (Up to A) | Category A/B1/B2 or B3 type AML | ON WING |
| 4 | Component Maintenance Engineer / Technician (base maintenance) | All shop level maintenance on a specific component | AML not required, | OFF WING |

*Source:* (EASA , 2017)

In addition, a strict labor and resource planning (material and consumables) is necessary for especially unscheduled faults, service requirements or mandatory checks in line maintenance while a 24-hour dynamic operation. Therefore, airlines generally do not outsource line maintenance and want to do itself at their hub station or stations to avoid long delays or to manage Aircraft On Ground (AOG) cases in the operation. Usually airlines contract with MROs or other airlines to receive line maintenance services at international stations they fly and in some stations they establish own departments to do line maintenance and no-go material storage. Because of these reasons, the study is only focused on Istanbul Hub Station of Turkish Airlines.

IFE and Media Management department of Turkish Airlines Technic is responsible to maintain all IFE activities in Turkish Airlines Fleet.

In this study, IFE and Media Management processes have been analyzed within this manner. The effective usage of its capacity directly effects on the customer satisfaction. According to the procedure of Turkish Airlines, no aircraft shall depart from main base (Istanbul) without operative IFE Systems. This private procedure created by the board of director of Turkish Airlines, is a pure evidence of the serious approach about In-Flight Entertainment.

In this study, it is focused on only the premium IFE systems which is commonly referred as AVOD (Audio/Video-On Demand) Systems which is enabling to individual passenger usage and command. The statistics for IFE system diversity through the world airlines are seen in the Appendix 1.

Typical wired premium IFE systems consist of three subsystems which are Head-End System, Cabin Distribution System and Seat-End System. In addition to this sub-system there is also fourth optional subsystem which is connectivity system. It provides wireless or broadband connectivity, mobile phone capability, and satellite television to passengers, crew members, and maintenance personnel. The maintenance processes of these subsystems are distributed into the main four categories in order to determine the capability of the IFE technicians.

In this study all maintenance processes have been analyzed with these subsystems in order to make deductive categorization for IFE defects.

IFE Head-End system includes major components such as servers, disk arrays, network controller, aircraft interface, and crew/maintenance terminal. Cabin Distribution system includes passive components such as area distribution boxes, floor disconnect boxes, master control units for the supply power and data connection of IFE system components. And Seat-End System consists of Seatback Monitors, Handset, and Remote Connection Ports which are used directly from passengers. An example of an IFE system structure has been seen in Appendix 2.

Categorization was made based on defect rectification time in IFE and Media Management department of Turkish Airlines Technic. It is separated into four main defect categories which are labeled as number from 1 to 4 for this study.

Defect category 1 refers a defect can be rectified in one hour ground time. It covers the defects that can be rectified with test & reset procedure or minor swap and replacement process. This defect category is mainly for the maintenance of Seat-End subsystem. The example of an IFE initialize procedure for a Boeing 777-300ER aircraft is seen in Appendix 3 according to the AMM (Aircraft Maintenance Manual) of Boeing 777-300R.

Defect category 2 refers a defect can be rectified in two hours ground time. It covers the defects that can be rectified with installation or removal procedure for Cabin Distribution systems or Seat-End system; minor software and content upgrade procedures for Head-End System. The example of an IFE installation or removal procedure of a component of Cabin Distribution systems for a Boeing 777-300ER aircraft is seen in Appendix 3 according to the AMM (Aircraft Maintenance Manual) of Boeing 777-300R.

Defect category 3 refers a defect can be rectified in four hours ground time. It covers the defects that can be rectified with installation or removal procedure for Head-End system. The example of an IFE installation or removal procedure for a component of Head-End system for Boeing 777-300ER aircraft is seen in Appendix 3 according to the AMM (Aircraft Maintenance Manual) of Boeing 777-300R.

Defect category 4 refers a defect can be rectified in more than four hours ground time. It covers the defects that can be rectified with advance troubleshooting which might be caused by wiring problem or core software corruption. According to the busy aircraft scheduling this defect category is most likely deferred within the day when the defect occurred and it is scheduled for available ground time.

The retroactive defect data has been exported from the database of MRO record systems for the dates between 1.1.2017 and 1.10.2017 and has been analyzed for this study. Approximately 50.000 defects have been analyzed and categorized from 1 to 4 as if mentioned before.

At the same time, the ground time data has been collected and separated based on the aircraft type for the same dates in order to determine the real capacity for rectification which made by IFE technicians of IFE and Media Management department.
The ground time is depending on the type of aircraft. Turkish Airlines fleet is composed of Airbus A320, A330 and A340 series and Boeing B737 and B777 series aircrafts which is fully maintainable by Turkish Airlines Technic with having the capability of all these aircraft types and more. The number of IFE suited aircrafts operated by Turkish Airlines is seen in table 1.4.

**Table 1.4: Aircraft Type and numbers operated by Turkish Airlines**

| Aircraft Type | A319 | A320 | A321 | A330 | A340 | B737 | B777 |
|---|---|---|---|---|---|---|---|
| The Number of Aircraft | 7 | 22 | 68 | 53 | 4 | 86 | 33 |
| Total Seat Number | 792 | 3657 | 11826 | 13846 | 1332 | 13469 | 11321 |
| The Average Age | 7 | 10 | 5 | 5 | 19 | 8 | 4 |

The capability list of Turkish Airlines Technic is also seen in the Appendix 4. In this study, the ground time of each aircraft type of Turkish airlines fleet has been examined and statistically analyzed according to the body type, IFE systems, and the flight hour of the aircraft in order to take the reliability of IFE systems into consideration and aim to find the rate of the defect factors.

In the time while the study has been conducting, the number of IFE technicians was one hundred eighty. The skills and experiences were differing from one to another.
The skills and abilities of an aircraft technician are limited with the certifications.

There are three type of IFE technician such as certifying staff (C/S), qualified (QMAVI) and candidate qualified (CQMAVI).

In the aviation, all maintenance activities are divided into the chapters which are seen in Appendix 5.

IFE is one of the Avionic Chapter and the chapter number of IFE is either 23 or 44. This number depends on the aircraft type; Boeing uses chapter 44, Airbus uses chapter 23 for IFE systems.

In order to be a certifying staff for IFE Systems, it is necessary to have B2 license and an aircraft type certificate. In order to be a qualified avionics, it is necessary to have IFE task certificate and minimum 18 months of IFE experience. In order to be a candidate qualified avionics, it is necessary to have at least one IFE task certificate. There are also additional requirements such as English proficiency and company training to work on the aircrafts. However, this study is focused on the skills of IFE technicians in order to assign different defect categories that have to suit with the skills.

It is required a C/S IFE Technician for rectifying and closing defects of the category 3 and category 4. It is also required a QMAVI IFE Technician for rectifying and closing defects of the category 2. And It is required a CQMAVI IFE Technician for rectifying and closing defects of the category 1.

**Table 1.5: Defect and Technician Category**

| **General IFE Operation** | **Defect Category** | **Technician Category** |
|---|---|---|
| Inspection/Check | 1 | CQMAVI |
| Cleaning/Painting | 1 | CQMAVI |
| Adjustment/Test | 2,3 | QMAVI |
| Removal/Installation | 2,3,4, | C/S, QMAVI |
| Servicing (Meet & Greet) | 1,2 | QMAVI, CQMAVI |
| Advance Troubleshooting | 4 | C/S |

The goal of this study is to analyze the process of IFE line maintenance for defect rectification and to use the defect database to optimize the man hour capacity of IFE and Media Management department of Turkish Airlines Technic.

There are also other process in the IFE Line maintenance such as media preparation and loading, meet &greet services and on call support. However, the major concern is in this study is defect rectification process and it is particularly analyzed in terms of ground time, defect category and technician skills. The defect rectification process is the most challenging part of IFE maintenance and it corresponds to 90 percent of the total work load of the IFE and Media Management department. It is very hard to follow and evaluate daily work load and priorities, and to assign technicians and resources to the related operations relying on technical experience. This way of works does not allow the upper management to acknowledge the real capacity since the optimum scheduling solution may not be recognized. In this problem there are many parameters to take into account such as workers' skill set, number of workers, necessary equipment number and most importantly the available ground time of the aircraft, etc.

For this study, it is important to evaluate current defect rectification process by statistically analyzing defect database and ground time capacity in the dates between 01.01.2017 and 01.10.2017, daily defect numbers and types, daily ground time of each type of aircraft, monthly maintenance numbers, start and completion times of maintenance task and the total man-hours for maintenance tasks. This analysis is a reference point for this study.

The current performance values and defect database, which were gathered by using statistical methods, has been evaluated in a computer program for this thesis. ANOVA, single factor, linear regression method have been used as inferential and descriptive statistics in order to analyze the relations between aircraft type, their ground time and defects and their significance firstly has been observed to feed the schedule with defects according to the aircraft type with related ground time. All these statistical outputs are given at chapter three.

The current defect rectification process is modeled via using ARENA program. For each process step, chronological statistical values are entered as inputs, in order to acknowledge times of processing. The real number of workers are entered to the program. The technician skills and ground time capacity constraints have also been reflected inside the model.

With the main process of IFE line maintenance, simulation model initially have “create” module which controls the defect entrance, which can send the defects randomly (means times between job entrances to workshop are close) or can send jobs with an incoming schedule based on seasonal factors and trend depending on the MRO database of Turkish Airlines Technic. In the real operation defects are created by crew member or technician. The defect created by Cabin Crew is recorded to the DCMS (Digital Cabin Management System) which is used instead of Cabin Maintenance Logbook in order to avoid to the huge paper usage and the defect created by technician is recorded to TRAX System which is the main MRO ERP system of Turkish Airlines Technic. Both of these systems are able to talk each other and keep the data in common database which is used for analyzing the data in this study.

After the defect created, target values was assigned to each defect by “assign” modules such as defect rectification times.

Because of having four main category types for defect rectification, these varieties have been established by “decide” module in ARENA simulation. According to the defect database, total defect numbers of each category was obtained and returned to a percentage of possibility value, and entered to decide module to determine each defect entered to the system belongs to which defect category.

Each defect process steps have been gathered and generated in simulation model with “process” modules. These modules have specific processing times, which were obtained by statistical analysis on past historical data.

Total processing times, total and individual waiting times, workers utilization, number of defect rectification and number of tardy and on-time completed defects and deferral have been explained as actual indicators of performance. A possible effect of each of variety has been analyzed in order to obtain adequate simulation outputs. In order to make a conclusion on the effects, real time scenario has been compared with the outputs of the simulation.

In order to reduce the costs for the maintenance and to increase capacity of the service, the output of this simulation will give additional methods in order to have a constant reorganization to maintain the IFE services on time. At this point, this research provides special view point of IFE maintenance for every MRO Company.

Even though very few studies concentrate on the MRO industry, most of the studies analyzed and explained in the technician assignment for base or shop maintenance.
So, the research is meant to be relevant as it explains and applies for IFE line maintenance man hour and improvement of capacity in MRO industry where no similar research has been performed by considering an internal industry vantage point. The research takes demonstration of a real case study in line maintenance organization into consideration with a data source which was obtained by MRO database of Turkish Airlines Technic.

**Null Hypothesis ($H_0$);** there will be no significant difference between ground time and defects rate according to the aircraft type in order to make efficient technician man-hour planning. It means that there will not be any significant improvement.

**Alternative Hypothesis ($H_a$);** there will be significant difference between ground time and defects rate according to the aircraft type in order to make efficient technician man-hour planning. It means that there will not be any significant improvement.

## 1.1 OPERATIONAL DEFINITIONS

The following terms and phrases will be explained in order to define the scope of work in line maintenance industry.

**Heavy (Base) Maintenance:** This means the maintenance activities mentioned under C and D checks (JAR-145 Section 2 paragraph 3.2.3), which requires the panel and access doors opening and disassembly, and eventually for deeper inspection and repairing. Base maintenance is generally characterized by long downtime periods and large maintenance packages, as it is quantified in terms of man-hours.

**Line Maintenance:** It is used to mention a short, planned or unplanned maintenance (Williams, 2016). Line Maintenance has a lot of maintenance services such as repetitive checks (daily, weekly, ramp, transit and A checks), cabin interior, servicing, troubleshooting, operations on ground, and in-flight entertainment services and more.

**Schedule Maintenance:** Maintenance is generally scheduled at pre-determined and intervals and corrective action items are taken to make sure the flight safety until the aircraft reaches to the next upcoming scheduled maintenance duration.

**Unscheduled Maintenance:** When a damage which threatens the safety happens, an unscheduled maintenance is planned.

**Pre-flight Check:** A routine check is applied before the flight in order to perform functional and visual inspection.

**A Check:** This check is made with a certain interval by taking the flight hour or the flight cycle into consideration of the aircraft. The duration of A check may vary according to the aircraft type. The first A check may take nearly 24 hour.

**Visual Check / Operational Check:** This check is made depending on the conditions. If there is a visual or technical problem, it is observed from pilot or technician, this check can be made via requested as well.

**Ramp Check:** This check is also made depending on the conditions. However, if there is a major or crucial problem which could make the aircraft inoperative, this check is requested. It may be planned or unplanned depends on the decision of airline operator.

**Transit Check:** Before and after each flight a transit check must be performed. It is an obligatory to do this item and walk around the aircraft for inspecting everything. If there becomes any necessity the related action item may take place.

**In Flight Entertainment:** It means the entertainment system that is equipped on the aircraft which will be served to the usage of the passengers. It offers music, games, movies, live tv, internet, and special applications, depending on the quality of service that an airline can offer.

**ETOPS**: It means Extended Range Operation with Two-Engine Airplanes also a standard defined by ICAO.

**AOG:** It means aircraft on ground. In order to enter an aircraft to the service, AOG team or group behaves like a help desk which is responsible to find a required component and spare parts for the aircrafts.

**Certifying Staff:** According to the EASA, an A/C certifying staff is authorized to release an A/C to service following minor scheduled line maintenance and simple defect rectification within the limits of tasks specifically endorsed on the EASA Part-145 C/S - S/S individual authorization. (EASA, 2015)

**B1 Certifying Staff:** are authorized to release an A/C to service following:

i. Maintenance performed on aircraft structure, power plant and mechanical and electrical systems;
ii. Works on avionic systems requiring only simple tests to prove their serviceability and not requiring troubleshooting

**B2 Certifying Staff:** are authorized to release an A/C to service following:

i. Maintenance performed on avionic and electrical systems, and
ii. Electrical and avionic tasks within power plant and mechanical systems, requiring only simple tests to prove their serviceability.

**Qualified Mechanics (QMAVI):** are authorized to close a task to service following:

i. Maintenance performed on avionic and electrical systems, and
ii. Electrical and avionic tasks within power plant and mechanical systems, requiring only simple tests to prove their serviceability.

**Candidate Qualified Mechanics:** are not authorized to close a task or release and A/C to service. They are only authorized to close minor defect item or open a defect.

**Ground Time:** is the time between the arrival and departure of an aircraft. It is mostly use as a service operation time for an aircraft.

**Aircraft Scheduling:** is a scheduling for the fleet in order to assign an aircraft for the routes and destinations.

**AMM:** Aircraft Maintenance Manual is a formal document which includes all maintenance tasks

**CML:** Cabin Maintenance Logbook is a logbook in which all cabin defects are recorded by cabin or maintenance crews.

**DCMS:** Digital Cabin Management System is digital platform as logbook of Turkish Airlines Fleet in order to avoid paper usage and record the all cabin defects to company database.

**TRAX:** Turkish Technic MRO ERP System

**IFE Head-End Distribution:** provides an interface for personnel to operate and control the system, interface the IFE system with crucial aircraft subsystems, it stores entertainment media for access by the passenger and IFE equipment operating files and data files. It performs real-time decoding of video and audio sources for distribution to the audio and video subsystems.

**IFE Seat-End Distribution:** routes media and data to and from the passenger seats.

**IFE Cabin Distribution:** includes the components for AVOD media storage and retrieval, Input of passenger requests for media or content, Media decoding at the passenger seat, Media playback to the passenger seat

**Ground Power:** unit may also be built into the jet way, making it even easier to supply electrical power to aircraft. Many aircraft require 28 V of direct current and 115 V 400 Hz of alternating current.

**Airworthiness:** Conformation to the regulations under which an aeronautical product is certified

**Maintenance Check:** A group of maintenance tasks that share the same maintenance interval, as defined in the OMP

**Maintenance Demand:** The total amount of man-hours required to perform all maintenance work due on an aircraft

**Maintenance Items:** A collection of Maintenance Task Packages and Maintenance Checks

**Maintenance Slot:** A specified amount within which an aircraft is withdrawn from operations for the purpose of maintenance

**Maintenance Task:** Unit task as defined in the MPD

**Maintenance Task Package:** A group of maintenance tasks that share the same setup activities, and have a common maintenance interval

# 2. LITERATURE REVIEW

The primary focus on the literature analysis tends to be centered on technician assignment and man hour planning for line maintenance in MRO industry.

Especially, because of the main research area of this study is a specific field in MRO industry, no similar research has been found in literature.

However, there have been useful approaches in the literature related with MRO industry.

On the contrary of manufacturing environment which has been mostly studied and researched in the literature, aviation MRO industry has much more complexities. Limited ground time, restriction of technician certification, fixed shift hours, safety regulations, and non-uniform job entrances creates new uncertainties and the scheduling and assignment problem become much harder.

Hölzel, Schröder, & Thomas Schilling (2012) has proposed an a method for optimization of aircraft maintenance task items in MRO. Prognostics and Health Management is used to reduce the operational interruptions and maintenance downtimes for maintenance of unscheduled and preventive conditions. The purpose of the work is to minimize aircraft maintenance costs and downtime for the change of aircraft scheduling and the labor.

Alafres (1999) has explained an aircraft maintenance labor scheduling style in order to reduce the costs. A new integer programming formulation version was shown in the study. A report for determining maintenance power has been described by (Bell & Stucker, A Technique for Determinig Maintenance Mapower Requirements for Aircrafts Units, 1971). Because of the limited data, the study was not enough in order to find a complete methodology, but was quite useful because of the several approaches which had been illustrated for expanding the basic methodology.

Muchiri, (2002) made a research in order to develop a cost-effective plan for maintenance. This work is well organized and has full of definition of maintenance. The execution of maintenance items were categorized as line maintenance and base maintenance which were deeply analyzed.

One study is inspiring reported by United States Air Force Project Rand; it was aiming to develop a technique for determining maintenance manpower requirements for aircraft units. In this research, it was primarily focused on the problem of setting maintenance assignment level with the effect of desired flight schedule. Then, the required information was basically listed such as required time for a team, team size and composition by skill level, skill types, completion time of process, and type of work, delays and the reasons of delays. Monte Carlo computer model was used for simulation of operational events. This simulation had been generated the same kinds of forms of historical data regarding manpower usage as an actual operating organization. (Bell & Stucker, 1971)

Another study deals with scheduling complex tasks with inhomogeneous set of resources. Problem is designed for technician assignment of multi-level skills and tasks. The similarity between the studies on scheduling of maintenance is very close. Increased importance of skill management is specialized in this study. It has been found out, study focus on France Telecom maintenance instance. In the problem Set of task and group of technician scheduled for workloads according to work sequence. Complex task and specialized technicians assignment formulized with mixed integer programming. In conclusion, solution methodology uses flexible matching models which were firstly proposed by Hurkens. (Fırat & Hurkens, 2011)

One study by Alfares about Aircraft Maintenance workforce scheduling describes to determine optimum an aircraft maintenance workforce labor scheduling. The study includes switch of shift times 5 days to 7 days workweek for aircrafts maintenance. Integer programming used to calculate 7 days suitable working Schedule with no increasing workforce size. This Project applied on Saudi Aramco in Dhahran and Saudi Arabia. This study shows opportunities to satisfy labor demands for each of the week and eliminate the overtime by using a unique integer programing without increase of number of workers. (Hemskam, 1999)

In the study of maintenance scheduling conducted by Noemi, principally mentioned on job scheduling process and problems for productions. Each machine, each worker and each process were shown engaged with work order to each other’s and it lets each job to connect each other with work order with maintenance worker. It seen described special situation of machine and process to avoid chancing, awaiting time, and cancelation, break down, randomness, pre-emption etc. and also described special requirements for maintenance and maintenance tasks. Journal also refers and address to Scheduling methods such as list scheduling, heuristic methods and artificial intelligence. (Paz, 1994)

In one of the study The University of Mississippi, researcher was made of mathematical models had been developed to solve Preventive Maintenance Problems. Also was referred among Gopala Krishnan, Ahire and Miller's developed adaptive integer programming model for PM scheduling problems. (Gao, 2007) Researcher was asserted four research questions to prove its dissertation hypothesis. Research questions were identified as craft combinations could be found , how could solve problem without crafts combinations , feasible solutions could be found quickly for PM and cross training was important for skilled workers. This study is beneficial for all group of service sector such as airlines, banking, railways, highways etc. Objective function was Schedule task and skilled limited workers in given time period. It has seen developed heuristic algorithms and integer programming models to solve Preventive Maintenance problems quickly.

A literature survey and computational study focus on travelling workforce scheduling is aimed to reduce significant travel times with scheduling. Study additionally was mixed vehicle routing problems and common employee Schedule problems together. In recent days, importance of this kind of scheduling increased because of mobile workforce. In the study, Researchers referred to workforce scheduling, manpower allocation, routing problems, and also reviewed solution techniques like heuristic, optimization hybrid approaches. (Castillo, Landa, & Qu, 2016)

The study especially is focused on technician scheduling for geographically different places. It was mainly included mixture of two approach which common mathematical modeling with allocation of technician and empowerment criteria. It is aimed to reduce travel cost and optimize empowerment scheduling. Empowerment scheduling is applied with criteria which are defined as simplicity, flexibility, fairness, providing a Win-Win approach. In conclusion empowerment concept defined and implementation which matches managerial literature was shown. It was formulated the empowerment concept in workforce field scheduling with an optimization problem. (Alsheddy & P.K.Tsang, 2011)

A case study is aimed to solve unscheduled maintenance problems during daily scheduled flight of military aircrafts. It is aimed to not fall behind flight Schedule of aircrafts because of unpredictable failures of components and systems. Problem have been seen formulated with time indexed mixed integer programming model to maximize military aircrafts fleet hours while lack of off wing and on wing limited skilled technician. (Safai, Banjevic, Jardine, & S, 2011)

In aviation Maintenance Repair and overhaul companies, all specific maintenance actions made by trained licensed technician. They are categorized according to their skills, mechanic, avionics and their trainings which include aircrafts type. Licensed technician who has this opportunity can apply its tasks according to qualifications. Study which applied in Chinese airline is showed optimization based approach to problem. Study is aimed to minimize costs with constraints of qualifications, skills, hangar space, shifts licenses, fairness etc. while allocation load to workers. Problem is developed with heuristic algorithms. (Chen, He, Leung, Lan, & Han, 2017)

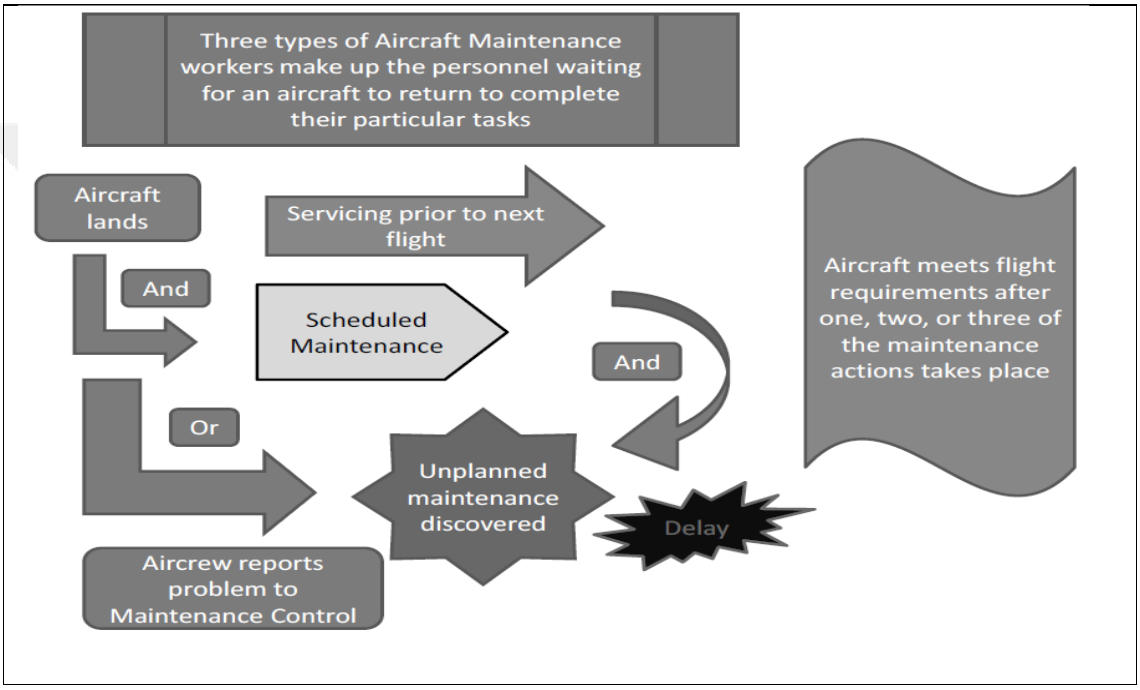
Scheduling and keep operational military aircrafts is so important for air forces. Maximize the usage of maintenance sources and aircraft availability is an effective scheduling way for air forces. In study, it is aimed to optimal maintenance Schedule with mathematical modeling. Mixed integer program model was used to optimize maintenance time and flight intervals. (Cho, 2011)

One thesis is aimed to reduce maintenance cost and increase aircraft availability for line. It is developing packaging methods and task scheduling which is prepared according to Boeing MSG philosophy. Thesis is included different perspective instead of our previously inspected thesis and journal. It is focus on whole maintenance tasks and packaging scheduling instead of workforce scheduling. It is aimed to distribute task work load with scheduling package to available grounding time. (Muchiri, 1997)

By taking the information in the database of Council of Higher Education of Republic of Turkey, between 2000 and 2014, the number of thesis about Airline is 242. 11 percent of this thesis have industrial engineering subject and 50 percent of these has been studied for airline fleet and crew scheduling, and 25 percent of airline revenue management. Also, there are 185 thesis about Aviation and just a 8 percent of them is about industrial engineering. Only one study was found in the subject database which was made by Yılmaz, (1998). The study defines the needs of approved maintenance organization and standards of aviation quality. A typical line maintenance model and organization chart in an MRO organization can be respectively seen in figure 2.1 and figure 2.2.

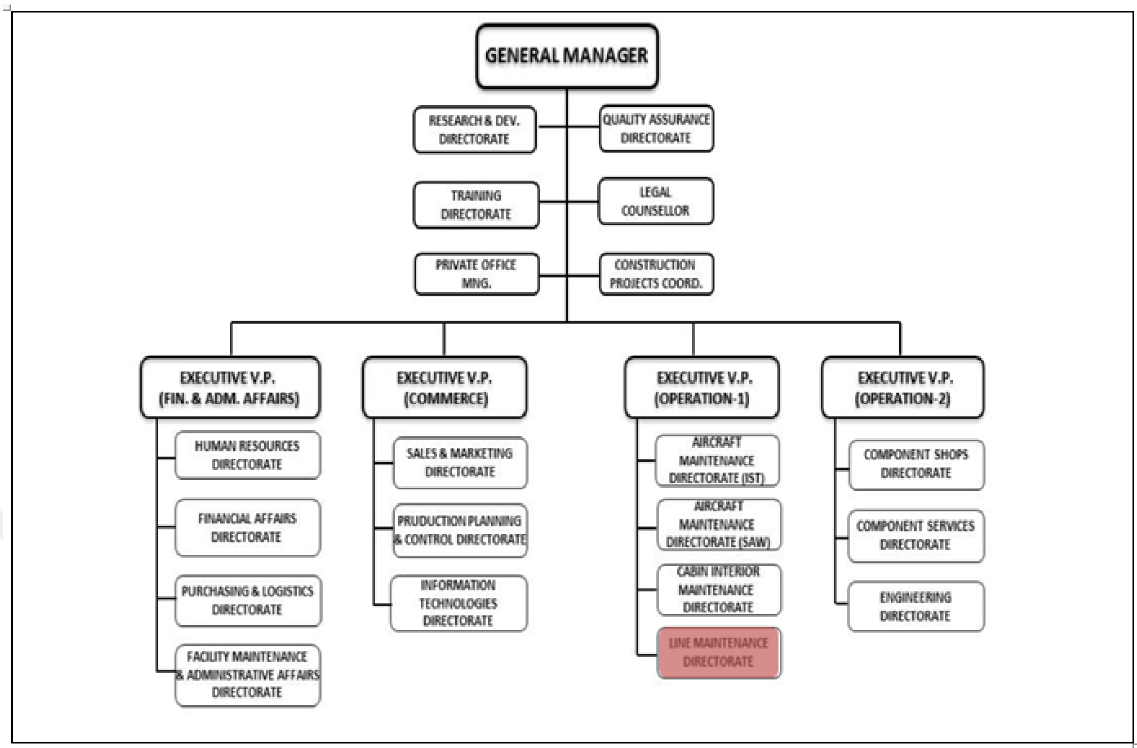
While working for the literature review, a lot of books and papers were reviewed. None of them were significantly definitive and supported with actual methodology.

**Figure 2.1: Line Maintenance Model**




*Source:* Aviation Maintenance Management, by H. A. Kinnison, 2004. New York: McGraw-Hill.

**Figure 2.2: An MRO Organization Chart**



# 3. METHODOLOGY

## 3.1 RESEARCH METHODOLOGY

The concepts of technician assignment and simulation theories are tried to be generated from data collection during this study. As a data gathering instrument, quantitative research method is used in terms of ground time and man hour, which is also used for rectify the defects.

The research was meant to be a creative task for the line maintenance area, where the people have been investigating the angles of each specific IFE task which they perform everyday. In order to collect numerical data and analyze the processes, questionnaires or databases were used. The actual info about the values, strategies and behaviors were obtained by each technician in the IFE and Media Management workshop.

As an addition, the ex-post facto design method was used in which technicians with capabilities that are already existing, that can be compared on some dependent variables. It is important to mention that the defect processes are not randomly assigned and every defect has been categorized under four main category group. In order to show the possible effects of an experience or process, simple ex post facto design may show a difference between the process for the actual and future states. Accordingly, the methodological selections are positivism from scientific perspective, deductive about scientific approaches, and quantitative research method in this study.

The aim of this study is mainly focused on the abilities from the authorization of the IFE technicians such as certifying staff, qualified mechanics and candidate mechanics. Each aircraft type has been individually researched due to the limitation of authorization.

The practice in this study was very useful to implement the data collection and simulation techniques which are helpful to identify every specification of defect process in order to determine the optimum technician assignment according to the each aircraft type in the organization.

## 3.2 SAMPLING AND POWER ANALYSIS

It is aimed to research the effects of the aircraft ground time on the technician assignment and to create an optimum defect rectification with the minimum number of authorized technician in Aviation MRO environment, especially for the IFE line maintenance which has very complex and independent process. The quantitative study is helpful for investigating the each process deeply for identifying the required man hour and understanding the value in service improvement by comparing and measuring all the data collected through this study.

The sample used in this research study was consisting of the aircraft ground time and defect numbers for nearly one year. The sampling size was divided into four aircraft types which are Airbus 320 Series, Airbus 330, Boeing 737 Series and Boeing 777 in order to make statistical analysis. There are 2 groups which are ground time and defect number and total eight independent variables in the study, so a one-way ANOVA statistical analysis model will be employed.

The main advantage of ANOVA is that it allows more than two independent variables. As stated by the power analysis, the alpha-level of significance is set to $\alpha=.05$.

The data is consisting of the annual ground time and failure number of the four fleets of Turkish Airlines. All Ground Time and number of Failures are given in Appendix 6 and Appendix 7.

## 3.3 INDEPENDENT AND DEPENDENT VARIABLES

The cause and effect relationships were investigated in the research study for finding the possible effects, the ground time and the number of defects according to the days of week by applying statistical methodology was defined as independent variables. There are two levels to this variable, namely ground time and defect number. The scale of measurement for the independent variable is nominal. And the dependent variable was a process which potentially influenced by these independent variables.

### 3.4 RESEARCH QUESTION AND HYPOTHESIS

How appropriate technician assignment is for IFE line maintenance improvement in MRO industry? And what are the most important factors to improve the multi-skill technician assignment for the multi-task IFE line maintenance operation?

**Null Hypothesis ($H_0$);** there will be no significant difference between ground time and defects rate according to the aircraft type in order to make efficient technician man-hour planning. It means that there will be no valuable improvement.

**Alternative Hypothesis ($H_a$);** there will be significant difference between ground time and defects rate according to the aircraft type in order to make efficient technician man-hour planning. It means that there will be no valuable improvement.

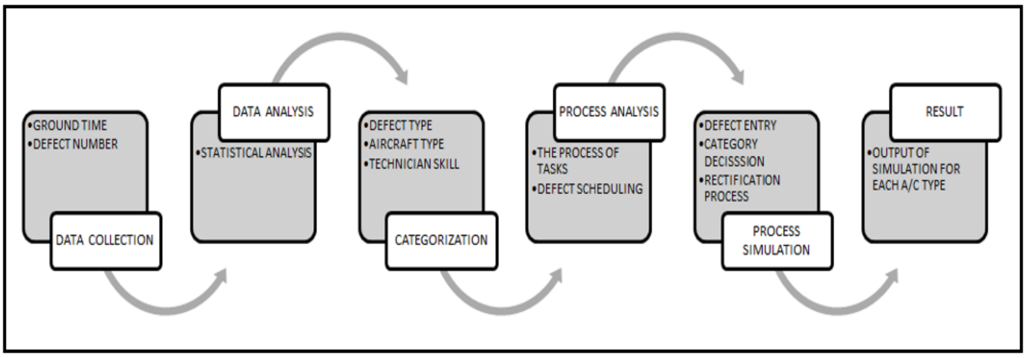
### 3.5 INFERENTIAL STATISTICS

In order to observe an improvement, an experimental study has been implemented. Process characterization and optimization, evaluation of material properties, service design and development have been simulated in Rockwell Collins ARENA software with the comparative experiment such as IFE workshop process. In order to use the historical data set of independent variables for the process simulation, all data has been statistically analyzed with excel solver. Based on the output of this statistical framework, schedules and capacities of the processes simulation have been created.

### 3.6 THEORITICAL FRAMEWORK

Firstly, the data has been collected from Company's MRO database which was firstly used to make general analysis of the current state and then provided to compose of the theoretical framework of this study. In order to draw a framework, the model in the figure 3.1 was created to summarize and conduct the study more comprehensive.

**Figure 3.1: Theoretical Framework**




In order to make a feasible technician assignment, it is first necessary to have a real data and real acknowledgement through the technicians of IFE line. Firstly, the experience and knowledge has to be shared between the technicians in order to determine the completion time of each IFE tasks which are used for defect rectification and also was used for process analysis in this study. The first step was to determine all the processes in the organization by the help of each technician.

In the aircraft maintenance, especially in line maintenance organization the selection of the service family refers to the choice of the line maintenance service that has complex design. A few of them is the same or similar and the method of maintaining the services is not identical. For this study, the defect rectification processes have been merely investigated because of being major part of IFE line maintenance.

Secondly, the historical data through the company database has been collected for nearly one year. This huge amount of data sets in excel format is one of the main sources of this study. It is seen in Appendix 6 and Appendix 7.

This historical data has been analyzed according to the ground time of each aircraft type and defect type which are the key factors in order to determine the constraints and capacity. All defects have been categorized into four main categories by assigning a time period for each of the category and technician skills such C/S, QM and CQM which were described in chapter one.

The result of statistical analysis gave a direction to this study and according to the result the process has been evaluated and simulated for each aircraft type. The defect rectification processes has been considered as banding together for minimizing the complexity for the simulation. The scheduled and unscheduled defect rectification process is seen in figure 3.2 and figure 3.3.

**Figure 3.2: The Scheduled Defect Rectification Process**

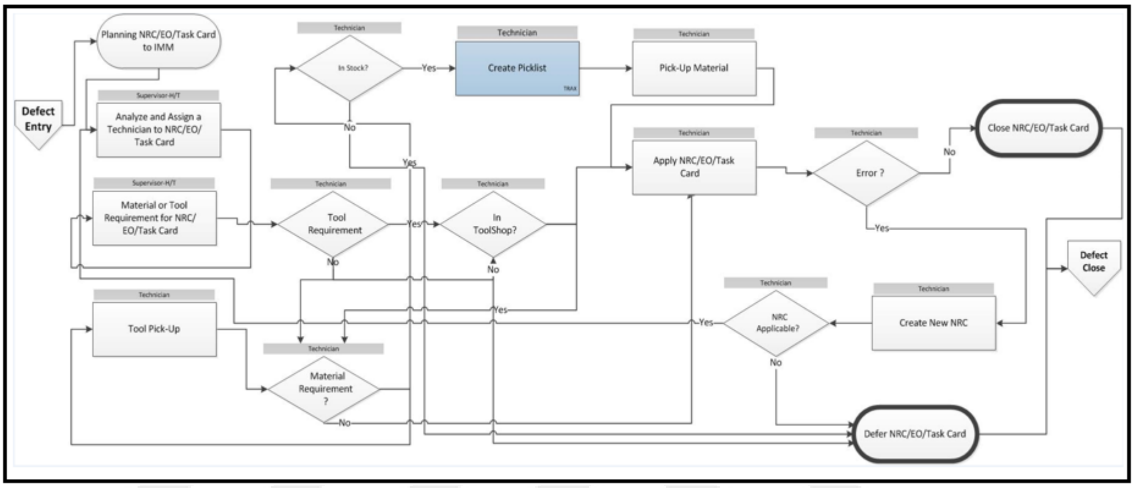
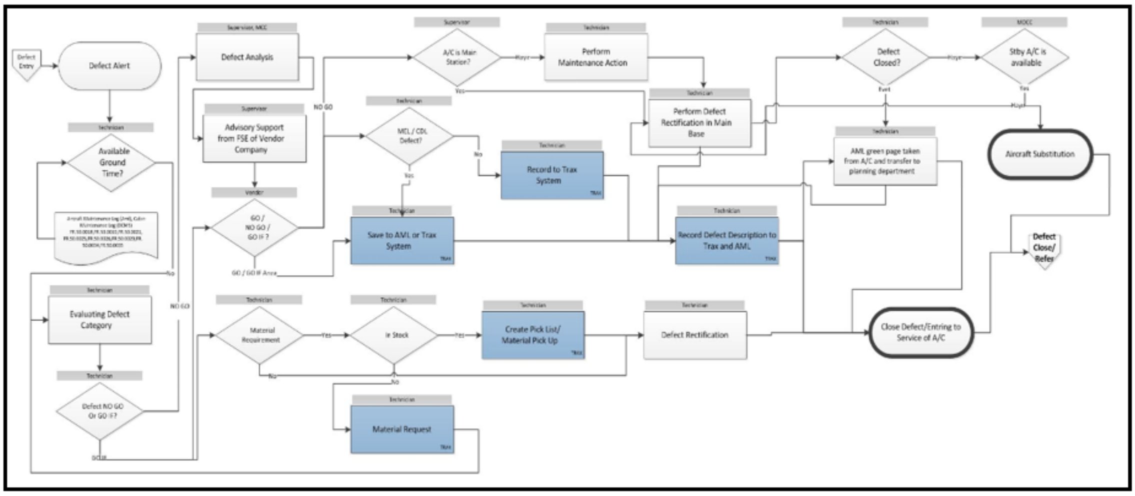



**Figure 3.3: The Unscheduled Defect Rectification Process**




The routine defect rectification process has a sequential diagram which starts with the defect entry. The defect entry is created by Cabin Crew or Maintenance Crew (IFE Technicians) as finding at flight phases or on ground (in the maintenance checks).

If the defect is recorded the system while passenger boarding, in flight or in a limited time, defect is planned for the first available ground time at Main Station which is

Istanbul. Otherwise, the first touch is made by IFE technician. According to the defect category and defect description; technician assignment is firstly made by IFE Supervisors. While investigating and working on defect, the material or tool requirements are checked by IFE Technicians and IFE supervisors are informed. If there is a material or tool requirement, the inventory stock level is questioned trough the Trax system. The required tool or material is sent to the Aircraft to perform defect rectification. If there is no material or available tool in Inventory, defect item is deferred from Trax System or AML if it is applicable and create a new order or follow up the order status for the required material. Once all tasks and steps are applied, the test process is performed for the related area, zone or seat which is affected by the defect. If the test is successful, the defect is closed. In this study these all processes have been simplified in order to focus on the skill of the IFE technician which is enabling to work on each different aircraft type for each different defect category.
Main 6 defect rectification steps are briefly described in following;

i. **Defect Entry:** There are three types defect entry; one of them is sweep finding which is created by cabin crew. This defect type is generally passenger origin and is recorded upon passenger complaints in-flights. The cabin crews use their Ipad in where DCMS software implemented in order to create or update a defect.
This software program talks with TRAX (Main MRO ERP System) in order to provide real time connection and share the common MRO ERP database.

   Second defect entry is created by IFE Technician during the meet & greets service, "A" checks or routine controls. IFE Technicians use their Ipad in where DCMS and TRAX software implemented in order to create, update or close a defect.

   Third defect entry is created by IFE Engineers as the result of field performance reports provided by IFE vendors and the outputs of IFE Health Monitoring Tools. Both of them are used as preventive maintenance activities for keeping the IFE system and its components more reliable and avoiding the fully in-operative IFE system situations. An advanced health monitoring tool provide detailed IFE system analytics such as Flight Sectors, LRU location summary with the real defect reason and advices, defect history, reboots and commands by cabin crew, connectivity time line, flight logs, parts and configuration and more. An example of how an IFE system is follow up with the health monitoring system is seen in Appendix 8.

ii. **Defect Analysis:** IFE System has four main subsystems which are described in chapter one. An IFE defect is evaluated based on its effect through the whole system. The possible effects of the defect are observed in individual seat, seat group, zonal seat class or entire seat class on the aircraft. According to this influence area, defect analysis is made by IFE supervisors. Each IFE system has own special system design which is the most challenging part of IFE Maintenance. Differences between IFE systems in Turkish Airlines fleet cause the complexity of IFE troubleshooting with regards the system design, software and material. It is necessary to have different skills in order to maintain many different systems

iii. **Technician Assignment:** Technician assignment is made by IFE supervisor according to the skill based on defect category. The defect and technician category is seen in Table 1.5. There are two type of technician assignment such as manual and automatically.

Manual assignment is usually used for unscheduled defect entries and automatic assignment is used for scheduled defect entries by the help of rostering software which is capable of assigning a technician for a defect. This planning tool is very helpful for assigning an available Technician with a defect/defects to aircraft during available ground time and it works flexible. However, it is not capable to differ the defect category for each technician skills.

iv. **Material or Tool Requirement:** IFE systems have many LRU's. In the Turkish Airlines Inventory, there are more than three thousands of IFE components which are expendable and repairable. IFE tools consist of classical and special hand tools, server duplicators, portable data loaders, power supply and computers etc.

v. **Defect Rectification:** Defect rectification in MRO Maintenance is well documented and reported by Aircraft Manufacturers and IFE Vendor Company. According to this maintenance documents such as AMM (Aircraft Maintenance Manual), FIM (Fault Isolation Manual), TSM (Troubleshooting Manual), WSM (Wiring Schematic Manual), each task has been safely performed. An example of AMM procedure is seen in Appendix 3. Defect Rectification consist of six main maintenance activities which are generally Inspection/Check, Cleaning/Painting, Adjustment/Test, Removal/Installation, Servicing (Meet & Greet), Advance Troubleshooting.

vi. **Report & Documentation:** Each defect is recorded to TRAX system from opening to closing. All processes is described and reported with detailed in the TRAX database. Each defect item has to have a reference with regards to related task in that document. A defect item example of TRAX system is seen in Appendix 9.

In order to perform all IFE Maintenance Tasks, the IFE workshop has 25 Certifying staff, 65 Qualified Mechanics and 110 Candidate Qualified Mechanics. This capacity is also limited by certification of Aircraft types. Each certifying staff has to have at least one aircraft type certificate with IFE system certification which is enabling to perform a related task for that aircraft. Therefore the limit of certification is a one of bottleneck for perfect allocation of staff. Skill matrix is seen in Table 3.1

**Table 3.1: The Skill Matrix of IFE C/S Technician**

| | Type Certification | | | | System Certification | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C/S # | *A320* | *A330/A340* | *B737* | *B777* | *Pac efX* | *Pac eX1* | *Pac eX2* | *Pac eX3* | *Pac dMpes* | *Pac Mpes* | *Pac GCS* | *Pac 3000i* | *Ths i3000* | *Ths i4000* | *Ths i5000* | *Ths Avant* | *WIFE* | *Tablet* |
| **1** | **X** | **X** | | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| **2** | **X** | **X** | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| **3** | **X** | | | | **X** | **X** | | | **X** | **X** | | | **X** | **X** | | **X** | **X** | **X** |
| **4** | **X** | | | | **X** | **X** | | | **X** | **X** | | | **X** | **X** | | **X** | **X** | **X** |
| **5** | **X** | **X** | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| **6** | **X** | | | | **X** | **X** | | | **X** | **X** | | | **X** | **X** | | **X** | **X** | **X** |
| **7** | **X** | **X** | | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| **8** | **X** | | | | **X** | **X** | | | **X** | **X** | | | **X** | **X** | | **X** | **X** | **X** |
| **9** | **X** | **X** | | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| **10** | **X** | | | | **X** | **X** | | | **X** | **X** | | | **X** | **X** | | **X** | **X** | **X** |
| **11** | | | **X** | | **X** | **X** | | | **X** | **X** | | | | | | **X** | **X** | **X** |
| **12** | **X** | **X** | **X** | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | | | **X** | **X** | **X** | **X** |
| **13** | | **X** | **X** | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | | | **X** | **X** | **X** | **X** |
| **14** | | | **X** | | **X** | **X** | | | **X** | **X** | | | | | | **X** | **X** | **X** |
| **15** | **X** | | **X** | | **X** | **X** | | | **X** | **X** | | | | | | **X** | **X** | **X** |
| **16** | | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | | | | | **X** | **X** | **X** |
| **17** | **X** | **X** | **X** | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | | | **X** | **X** | **X** | **X** |
| **18** | | | **X** | | **X** | **X** | | | **X** | **X** | | | | | | **X** | **X** | **X** |
| **19** | | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | | | | | **X** | **X** | **X** |
| **20** | | | **X** | | **X** | **X** | | | **X** | **X** | | | | | | **X** | **X** | **X** |
| **21** | **X** | **X** | **X** | | **X** | **X** | **X** | **X** | | | **X** | **X** | | | **X** | **X** | | |
| **22** | | | **X** | **X** | **X** | **X** | **X** | **X** | | | **X** | | | | | **X** | | |
| **23** | **X** | **X** | **X** | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | | | **X** | **X** | **X** | **X** |
| **24** | | | **X** | **X** | **X** | **X** | **X** | **X** | | | **X** | | | | | **X** | | |
| **25** | | | **X** | **X** | **X** | **X** | **X** | **X** | | | **X** | | | | | | | |

As it is seen from skill matrix a certifying staff can only perform a dedicated task within his capability which is limited by certification. According to the statistical analysis, process has been simulated according to the each aircraft type which means that the capacity in all IFE task is limited by these skill matrix. For example, IFE maintenance for an Airbus 320 type aircraft suited with a kind of IFE system can be performed with only 12 C/S technicians.

With the help of these all capacity constraint and demand which comes from the historical data as a future forecast, the simulation model has been created by ARENA Simulation Software (Student Trial).

The work model of IFE Workshop is created for only defect rectification process in order to estimate the man power requirement for different skills and tasks and analyze the processing time, waiting time, utilization of technician capacity and bottlenecks etc. While modeling and creating a defect rectification process in ARENA, some modules have been used such as Create Module, Process Module, Decide Module, Assign Module and Record Module. These modules are briefly described as below;

Besides, dispatching rules and scheduling have been used in order to feed these modules. The combination of two dispatching rules has been used such as FIFO (First In First Out) and LRTJF (Last Remaining Time Job First). In order to create schedule for the defect entry to workshop, the historical data has been used. As an important factor, scheduling is highly affected in order to get the optimum results from the simulation.

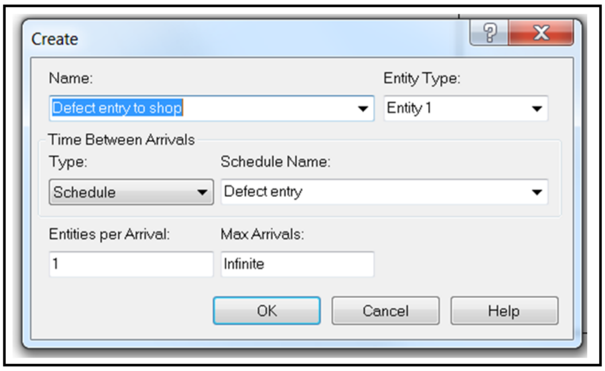
i. Create Module:

It explains the starting point for entities at the simulation model. Entities are created using a schedule. They also can be created as based on a time between the arrivals. After that the entities leave the module to start the processing through the whole system. The type of entity is explained in this module.

"Defect entry to shop" is a "Create" module of Arena simulation. This module creates the defects in given time intervals and sends back to system, randomly. This time intervals can be specified by the user as well. Constant time intervals or randomly selected intervals can be selected. Also, an expressions which include different types of distributions which may be entered to the create module too. Time units may be selected as days, hour and minutes, etc. As an option, the number of objects that will be created per arrival can be specified and maximum number of arrivals can be limited. In order to express an alternate method, a work load schedule can be supplied and simulated via this model.

In this study, randomly selected time intervals have been used based on the historical data of defects. And entities have been created according to the defect entry schedule which was created to feed the system.
A dialog box view is seen in figure 3.4.

**Figure 3.4: The Create Module View**



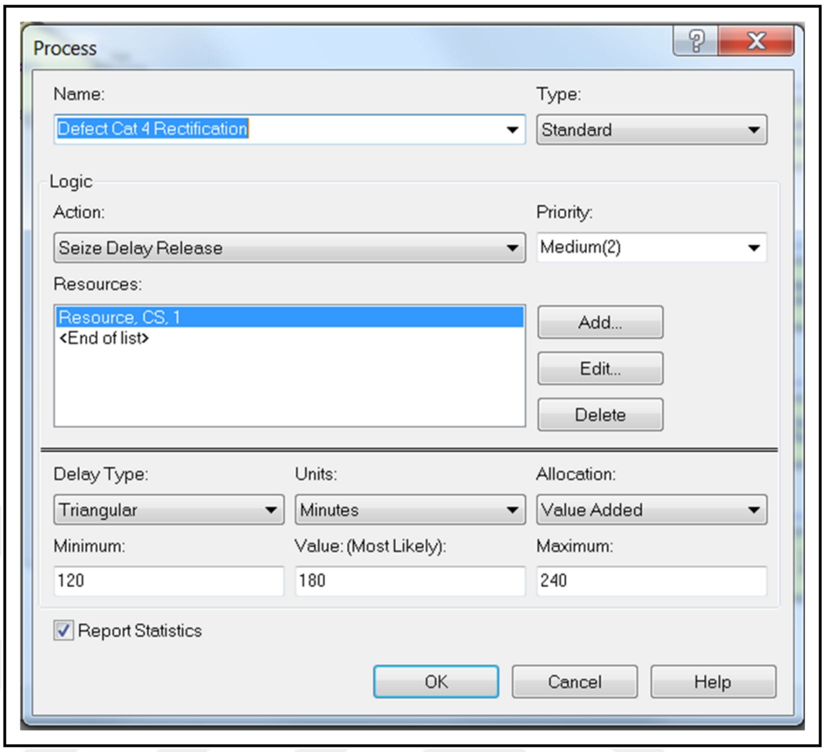

ii. Process Module:

It is used as the method of main processing. Options for releasing and seizing resource constraints are available at this module. As an addition, there is an option to use a "sub-model" and express hierarchical user-defined logic. The process time is allocated to the entity and may be considered to be value added, non-value added, transfer, wait or other. The associated cost might be added to the suitable category.

All processes of Defect rectification have been gathered into one process module such as defect rectification, defect analysis and material/tool requirements in this study.

"Seize, delay, release" options were used for the required action logic. When a defect comes to process unit, this function makes the necessary resources work and puts other defects in queue. After completion of each task, it releases resources for other queue of defect. Delay type, since it determines the duration of the process is a very critical parameter for process module, the subject duration can be entered to the process module in different types of ways via delay type area. A constant value or a distribution can be selected. In this subject new model, based on historical data, maximum, minimum and most likely process duration has been entered in order to process all the modules. As time unit, "hours" was selected; because the actual historical data was consist of man-hour values. A dialog box view of process module is seen in figure 3.5.

**Figure 3.5: The Process Module View**




iii. Decision Module:

This module is used for decision-making for the system. It includes options in order to be able to make the necessary decisions based on one or maybe more conditions (e.g., if entity type is Gold Card) or based on one or maybe more probabilities (e.g., 75% true; 25% false). Conditions can be based on attribute values (e.g., Priority), variable values (e.g., Number Denied), the entity type, or an expression.

There are two exit points out of the Decide module when its specified type is either 2-way chance or 2-way condition. There is one exit point for "true" entities and one for "false" entities. When the n-way chance or condition type is specified, multiple exit points are shown for each condition or probability and a single "else" exit. The number of entities that exit from each type (true / false) is displayed for 2-way chance or condition modules only. Examples are respectively seen in figure 3.6.

**Figure 3.6: Decide Module-Examples**

**Example 1—2-way by Chance**

| Prompt | Entry |
|---|---|
| Name | Satisfied Customers |
| Type | 2-way by Chance |
| Percent True | 90 |

**Example 2—2-way by Condition—Variable**

| Prompt | Entry |
|---|---|
| Name | Choose Wait Room |
| Type | 2-way by Condition |
| If | Variable |
| Named | Prod Maintenance Flag |
| Is | == |
| Value | 0 |

**Example 3—N-way by Condition—Entity Type**

| Prompt | Entry |
|---|---|
| Name | To ICU |
| Type | By Condition |
| If | Entity Type |
| Named | Critical Patient |
| If | Entity Type |
| Named | Stable Patient |

**Example 4—2-way by Condition—Expression**

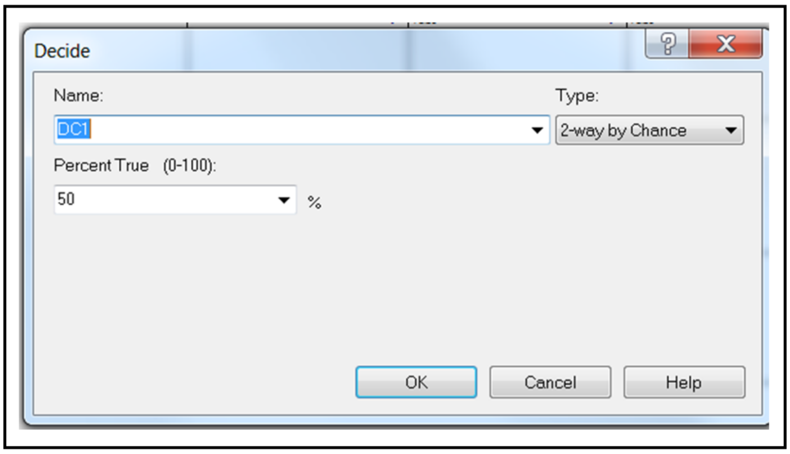
| Prompt | Entry |
|---|---|
| Name | Checkout Line |
| Type | By Condition |
| If | Expression |
| Expression | NQ(Line 1.Queue).LE.2 |

There are four types of Decide modules: 2-way by Chance, 2-way by Condition, N-way by Chance, N-way by Condition

The Decide module's default type **is 2-way by Chance**. There are two exit areas associated with this module type. Entities that meet the True condition exit from the right side of the module, while entities that meet the false condition exit from the bottom of the module. The exit behavior is the same for Decide modules with type 2-way by Condition.

In this study this module type has been used for determining the condition of defect categories with the possibilities according to the defect rate in the historical data. A dialog box view of decide module is seen in figure 3.7.

**Figure 3.7: The Decide Module View**



For a type defined as N-way by Chance or N-way by Condition, the exit point to the right of the module is a repeatable exit point, which consists of an exit for each of the conditions or probabilities specified. The exit point at the bottom of the module is defined to cover any Else conditions.

All exit points must be connected to other modules to run the simulation. Multiple exit points can be connected to the same module, if desired.

When using a Condition type of module, if all specified conditions are false, the entity will automatically exit from the False or Else exit at the bottom of the module. When using a Chance type of module, a random sample is generated when an entity arrives at the module. If the random sample falls outside the percent true ranges specified, the entity will automatically exit from the False or Else exit at the bottom of the module.

When entering values for by Chance decisions, enter the value as a number, not as a percentage. For example, to specify a true condition of 87%, enter 87, not .87. If you are loading variable values from a spreadsheet, make sure the percentage values in the spreadsheet are expressed as whole numbers, not decimal values.

If you use an Expression for a Condition type Decide module, the expression can be as simple as: TNOW > 300

iv. Assign Module:
It is used for assigning new values to variables, and attributes of entity. Also for entity types, pictures or for different system variables.

It is important to mention that multiple assignments may be made via a single Assign module.

**Figure 3.8: The Decide Module View**

| Example1—Attribute Value | | Example 2—Animation Picture | | Example 3—Other | |
|---|---|---|---|---|---|
| **Prompt** | **Entry** | **Prompt** | **Entry** | **Prompt** | **Entry** |
| Name | Time Stamp | Name | Complete Assembly | Name | Stop Simulation |
| Type | Attribute | Type | Entity Picture | Type | Other |
| Attribute Name | Registration Time | Entity Picture | Picture.Boat | Other | TFIN |
| New Value | TNOW | | | New Value | TNOW |

Model status variables, such as entity cost and time attributes or process cost and times, may not be assigned a value with the Assign module.

Multiple assignments are made in the order in which they are displayed within the Assignments repeat group. If an entity type is reassigned, the number of "incoming entity type" entities out of the system is increased, while the number of "incoming entity type" entities currently processing in the system is decreased. Then, the number of "outgoing entity type" entities in the system is increased and the number of "outgoing entity type" entities currently processing in the system is increased. If entity statistics of "incoming entity type" are desired before changing entity types, a Record module to collect entity statistics should be used prior to the Assign module.

When making an entity type assignment, the new entity type will automatically generate the specified entity type in the Entity spreadsheet, using default values for entity picture and costing information. The default values may be changed by clicking on the Entity module and modifying the specified entity type.

When making a variable assignment, the variable specified will be automatically added to the Variable spreadsheet if it has not already been defined. This includes variable arrays. However, the row and column dimensions of a variable array must be specified in the Variable spreadsheet before running the simulation.

v. Record Module: It is used to collect all the statistics required in the simulation model. A lot of types of observational statistics are available, and they include time between exits through the whole module and also entity statistics, observations, and the interval statistics. It is obligatory to mention that a count type of statistic is available too. Tally and Counter sets are able to be specified.

# 4. DISCUSSION

## 4.1 RESEARCH TOOL

The primary research tool in this study is a Defect Database of IFE Workshop which has been created by the cabin crews, maintenance crews and engineers. The first objective was to collect the historical data for ground time and defects. Then this data has been statistically analyzed and the current defect process of IFE line maintenance operations has been generated with this perspective.

In order to show all activities in one process, tasks have been initially grouped into four categories such as Category 1, Category 2, Category 3 and Category 4. Also, the IFE Technicians have been categorized according to their skills which are enabling to perform tasks in these categories.

Besides, every specific member of IFE Workshop defined the action taken in the process and every action has been demonstrated in one process. The processes were separately listed into four different aircraft type. In order to focus on skills and categories, the processes have been eliminated to make more simplified process map with this perspective. In order to simulate the processes, the ARENA Software program has been used with the standard simulation modules.

## 4.2 ANALYSIS

In order to assess statistically the difference between the ground time and defect rates of aircraft type, descriptive statistic has been performed. (See Table 4.1 and Table 4.2)

**Table 4.1: Descriptive Statistic of Ground Time**

| | *A320 GT* | *B737 GT* | *B777 GT* | *A330 GT* |
|---|---|---|---|---|
| ***Mean*** | 571,4127723 | 490,5810561 | 162,6774587 | 281,379538 |
| ***Standard Error*** | 4,303011472 | 3,565500179 | 1,503838254 | 3,051690726 |
| ***Median*** | 568,9 | 487,32 | 159,71 | 282,29 |
| ***Mode*** | #N/A | #N/A | 156,5 | 313,63 |
| ***Standard Deviation*** | 74,90206968 | 62,0642879 | 26,17715487 | 53,1204606 |
| ***Sample Variance*** | 5610,320043 | 3851,975833 | 685,2434369 | 2821,783334 |
| ***Kurtosis*** | 3,65356112 | 3,62936755 | 3,011807351 | 0,700776776 |
| ***Skewness*** | -0,442174169 | -0,431366267 | 0,560611971 | 0,045226664 |
| ***Range*** | 672,28 | 557,6 | 243,11 | 344,37 |
| ***Minimum*** | 135,67 | 139,99 | 46,61 | 119,53 |
| ***Maximum*** | 807,95 | 697,59 | 289,72 | 463,9 |
| ***Sum*** | 173138,07 | 148646,06 | 49291,27 | 85258 |
| ***Count*** | 303 | 303 | 303 | 303 |

**Table 4.2: Descriptive Statistic of Defect**

| | *A320 D* | *B737 D* | *B777 D* | *A330 D* |
|---|---|---|---|---|
| ***Mean*** | 71,31023102 | 44,99009901 | 36,0990099 | 48,59405941 |
| ***Standard Error*** | 0,962597117 | 0,831463403 | 0,719577312 | 1,231019733 |
| ***Median*** | 70 | 44 | 35 | 44 |
| ***Mode*** | 62 | 48 | 30 | 42 |
| ***Standard Deviation*** | 16,75582713 | 14,47319632 | 12,52560684 | 21,42823146 |
| ***Sample Variance*** | 280,7577427 | 209,4734116 | 156,8908268 | 459,1691037 |
| ***Kurtosis*** | 0,514878587 | 21,0963712 | 1,305852508 | 1,667506264 |
| ***Skewness*** | 0,27222457 | 2,719502788 | 0,779671376 | 0,994933968 |
| ***Range*** | 114 | 161 | 87 | 132 |
| ***Minimum*** | 9 | 14 | 5 | 9 |
| ***Maximum*** | 123 | 175 | 92 | 141 |
| ***Sum*** | 21607 | 13632 | 10938 | 14724 |
| ***Count*** | 303 | 303 | 303 | 303 |

In order to test the significance between the ground time and defects for each aircraft type Single factor ANOVA has been performed based on the values of skewness in the Table 4.2 and 4.1. The skewness values are slightly negative or positive which means that the ANOVA could be performed.

It is seen that there is a significant result $F_{GT}$ (3, 1208) =3294, 889>*Fcritic;* $F_{D}$ (3, 1208) =246, 20>*Fcritic* between the ground times and defects of each aircraft type according to ANOVA Outputs. (p<0,01)

It is seen below in Table 4.3 and Table 4.4.

**Table 4.3: Anova: Single Factor for Ground Time**

**SUMMARY**

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| *A320 GT* | 303 | 173138,1 | 571,4128 | 5610,32 |
| *B737 GT* | 303 | 148646,1 | 490,5811 | 3851,976 |
| *B777 GT* | 303 | 49291,27 | 162,6775 | 685,2434 |
| *A330 GT* | 303 | 85258 | 281,3795 | 2821,783 |

**ANOVA**

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F critic* |
|---|---|---|---|---|---|---|
| *Between Groups* | *32049357* | *3* | *10683119* | *3294,889* | *0* | *2,612269* |
| *Within Groups* | *3916735* | *1208* | *3242,331* | | | |
| *Total* | *35966093* | *1211* | | | | |

**Table 4.4: Anova: Single Factor for Defects**

**SUMMARY**

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| *A320 A* | 303 | 21607 | 71,31023 | 280,7577 |
| *B737 A* | 303 | 13632 | 44,9901 | 209,4734 |
| *B777 A* | 303 | 10938 | 36,09901 | 156,8908 |
| *A330 A* | 303 | 14724 | 48,59406 | 459,1691 |

**ANOVA**

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F critic* |
|---|---|---|---|---|---|---|
| *Between Groups* | 204280,3 | 3 | 68093,45 | 246,2044 | 1,2E-124 | 2,612269 |

| | | | | |
|---|---|---|---|---|
| ***Within Groups*** | 334099,9 | 1208 | 276,5728 | |
| ***Total*** | 538380,2 | 1211 | | |

When the correlation between the ground time and defects was analyzed, the person values are seen as low, the highest value is 0,36. It is seen in Table 4.5

**Table 4.5: Correlation Matrix**

| | *A320 GT* | *B737 GT* | *B777 GT* | *A330 GT* | *A320 D* | *B737 D* | *B777 D* | *A330 D* |
|---|---|---|---|---|---|---|---|---|
| ***A320 GT*** | 1 | | | | | | | |
| ***B737 GT*** | 0,630011 | 1 | | | | | | |
| ***B777 GT*** | 0,454435 | 0,339881 | 1 | | | | | |
| ***A330 GT*** | -0,03052 | 0,093955 | 0,07542 | 1 | | | | |
| ***A320 D*** | 0,0515 | 0,015168 | -0,21904 | 0,037295 | 1 | | | |
| ***B737 D*** | 0,055493 | 0,113233 | -0,04378 | -0,07611 | 0,209289 | 1 | | |
| ***B777 D*** | -0,06331 | -0,01858 | -0,13272 | 0,155367 | 0,198882 | 0,138713 | 1 | |
| ***A330 D*** | -0,23581 | -0,1949 | -0,22304 | 0,363485 | 0,2066 | 0,054044 | 0,271156 | 1 |

In addition to these statistical outputs, linear regression test has been performed in order to investigate the relationship between the dependent and independent variables to make fit modelling for the simulation. Because regression analysis also allows comparing the effects of ground time for each aircraft types or defect rate of each aircraft type.

According to the output of this regression analysis, the simulation model has been generated for each process of defect rectification of each aircraft type. Regression analysis is beneficial to eliminate and evaluate the best set of variables to be used for building predictive models.

The outputs of regression analysis for Boeing 737 aircraft are seen in Table 4.6, figure 4.1, figure 4.2 and figure 4.3.

**Table 4.6: Regression Summary for Boeing 737**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0,113232597 |
| R Square | 0,012821621 |
| Adjusted R Square | 0,009541959 |
| Standard Error | 61,76747072 |
| Observations | 303 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 14915,34934 | 14915,34934 | 3,909433 | 0,048927968 |
| Residual | 301 | 1148381,352 | 3815,220439 | | |
| Total | 302 | 1163296,701 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95,0%* | *Upper 95,0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 468,7353675 | 11,60447945 | 40,39262333 | 1,4E-123 | 445,8991847 | 491,5715502 | 445,8991847 | 491,5715502 |
| B737 A | 0,485566583 | 0,245579377 | 1,97722866 | 0,048928 | 0,00229669 | 0,968836476 | 0,00229669 | 0,968836476 |

**Figure 4.1: The Residual Plot of Defect Rates of Boeing 737**

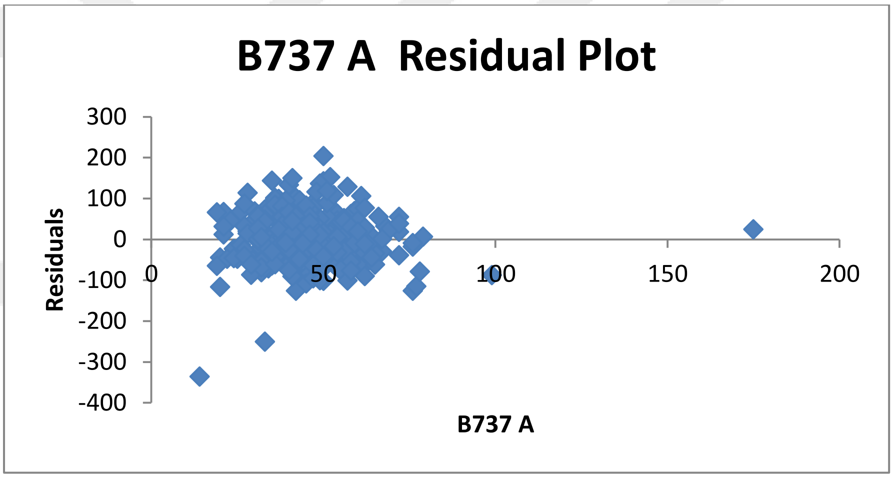



**Figure 4.2: The Line Fit Plot of Defect Rates of Boeing 737**

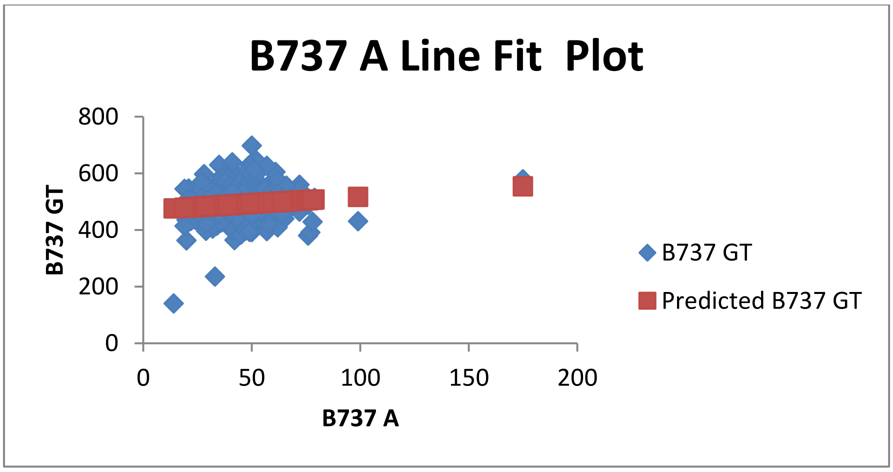
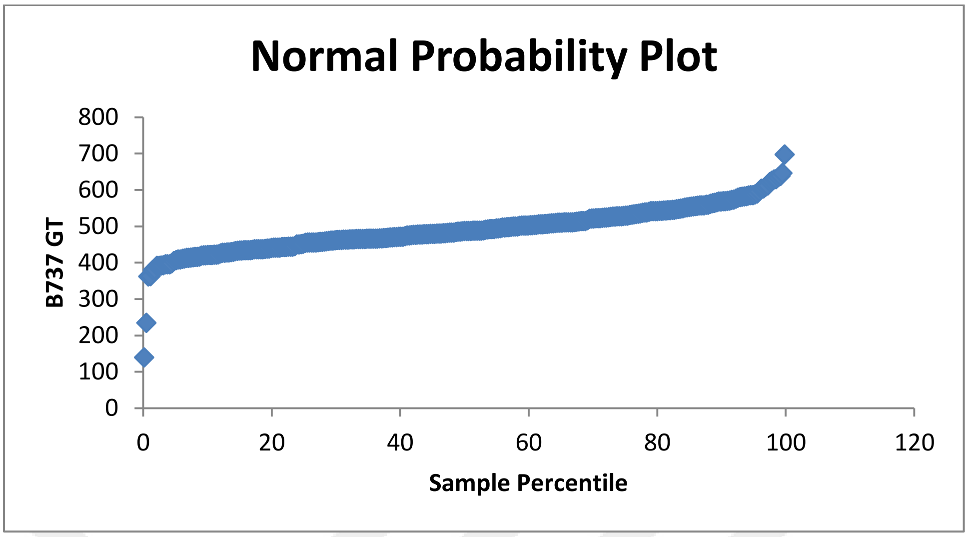


**Figure 4.3: The Normal Probability Plot of Defect Rates of Boeing 737**




According to the outputs of regression analysis for the defect and ground time of Boeing 737 Fleet, the linear regression relation is significant as p=0,0489 in spite of the fact that the RSquare is 0,01. It can be commented that every 1 percent of increment in the change of ground time can be explained with the defect rate of Boeing 737.

The outputs of regression analysis for Airbus 320 Series aircraft are seen in Table 4.7, Figure 4.3, Figure 4.4 and Figure 4.5.

**Table 4.7: Regression Summary for Airbus 320**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0,051500467 |
| R Square | 0,002652298 |
| Adjusted R Square | -0,000661149 |
| Standard Error | 74,92682632 |
| Observations | 303 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 4493,832808 | 4493,832808 | 0,800465 | 0,371669295 |
| Residual | 301 | 1689822,82 | 5614,029303 | | |
| Total | 302 | 1694316,653 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95,0%* | *Upper 95,0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 554,9958797 | 18,84742643 | 29,44677257 | 1,24E-90 | 517,9064716 | 592,0852879 | 517,9064716 | 592,0852879 |
| A320 A | 0,230217913 | 0,257316713 | 0,894686981 | 0,371669 | -0,276149608 | 0,736585434 | -0,276149608 | 0,736585434 |

Figure 4.4: The Residual Plot of Defect Rates of Airbus 320

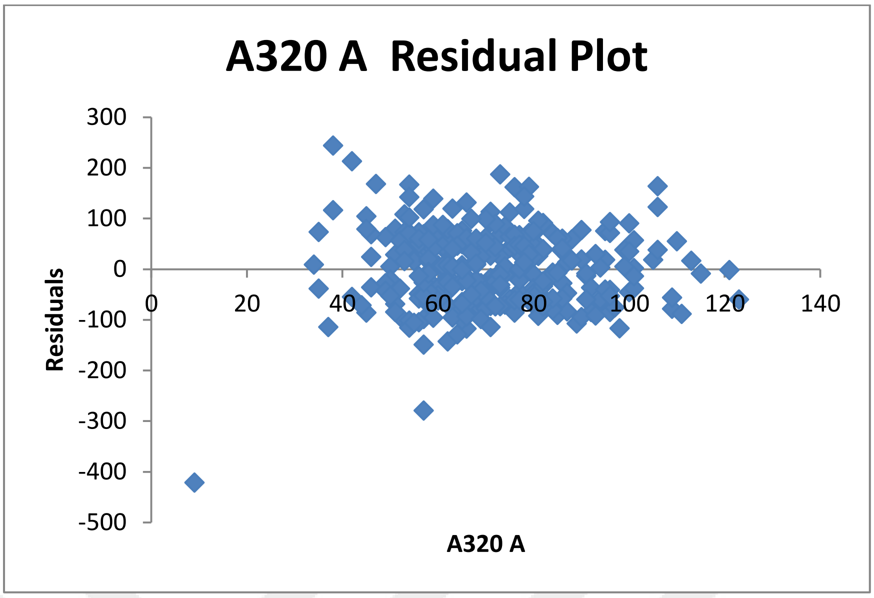



Figure 4.5: The Line Fit Plot of Defect Rates of Airbus 320

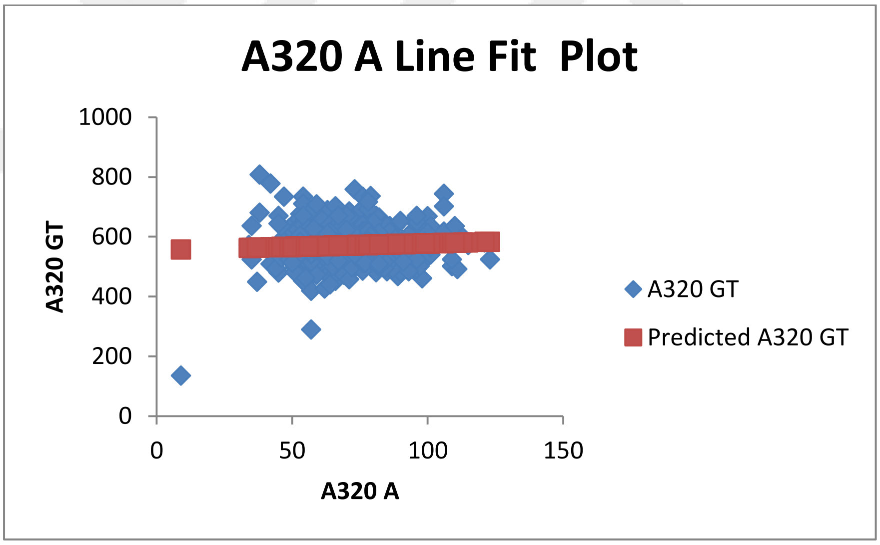
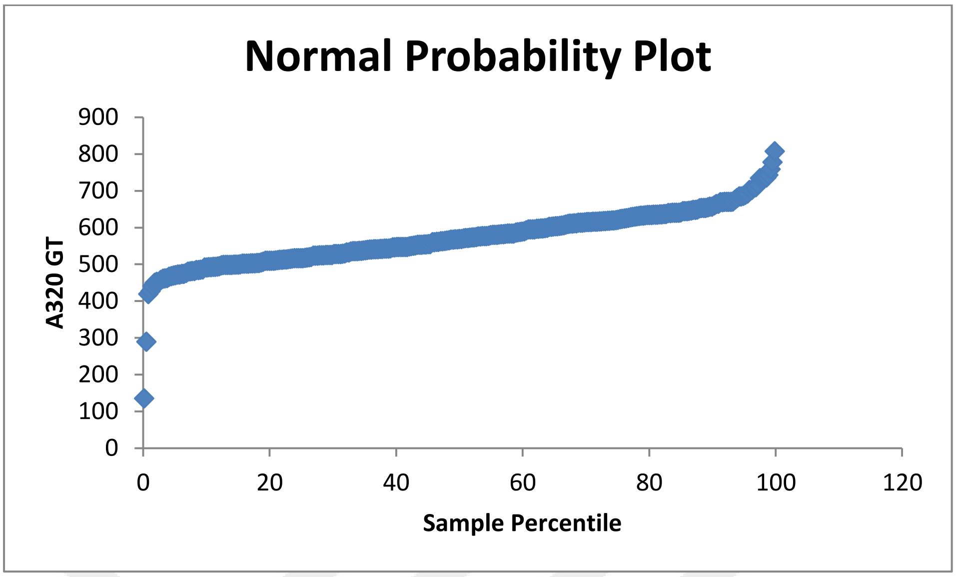


**Figure 4.6: The Normal Probability Plot of Defect Rates of Airbus 320**




According to the outputs of regression analysis for the defect and ground time of Airbus 320 Fleet, the linear regression relation is not significant as p=0,37 and also the RSquare is less than 0,01. It can be explained that there is no statistical relationship between the defect rate of and ground time of Airbus 320.

The outputs of regression analysis for Boeing 777 aircraft are seen in Table 4.8, Figure 4.6, Figure 4.7 and Figure 4.8.

**Table 4.8: Regression Summary for Boeing 777**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0,132721119 |
| R Square | 0,017614895 |
| Adjusted R Square | 0,014351158 |
| Standard Error | 25,98863983 |
| Observations | 303 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 3645,288437 | 3645,288437 | 5,397154 | 0,020835834 |
| Residual | 301 | 203298,2295 | 675,4094004 | | |
| Total | 302 | 206943,5179 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95,0%* | *Upper 95,0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 172,6903383 | 4,56126255 | 37,86020568 | 1,7E-116 | 163,7143368 | 181,6663398 | 163,7143368 | 181,6663398 |
| B777 A | -0,277372692 | 0,11939367 | -2,32317753 | 0,020836 | -0,512324694 | -0,04242069 | -0,512324694 | -0,04242069 |

**Figure 4.7: The Residual Plot of Defect Rates of Boeing 777**

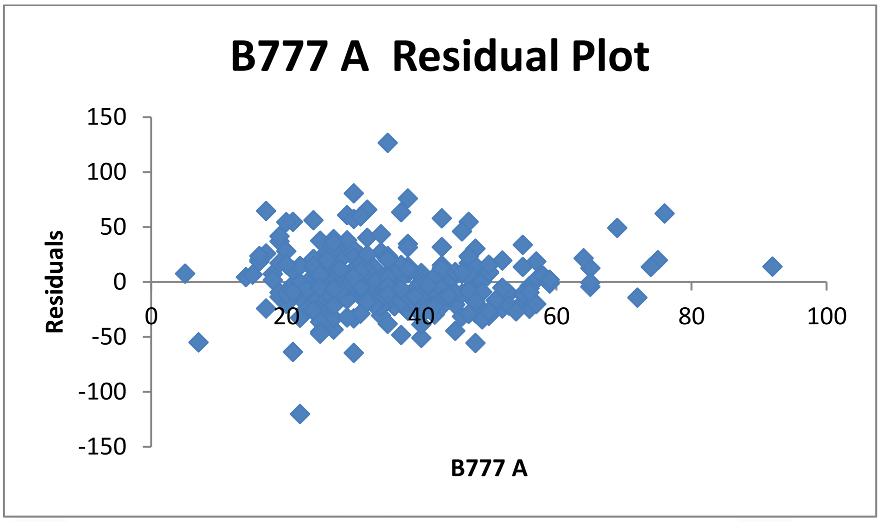



**Figure 4.8: The Line Fit Plot of Defect Rates of Boeing 777**

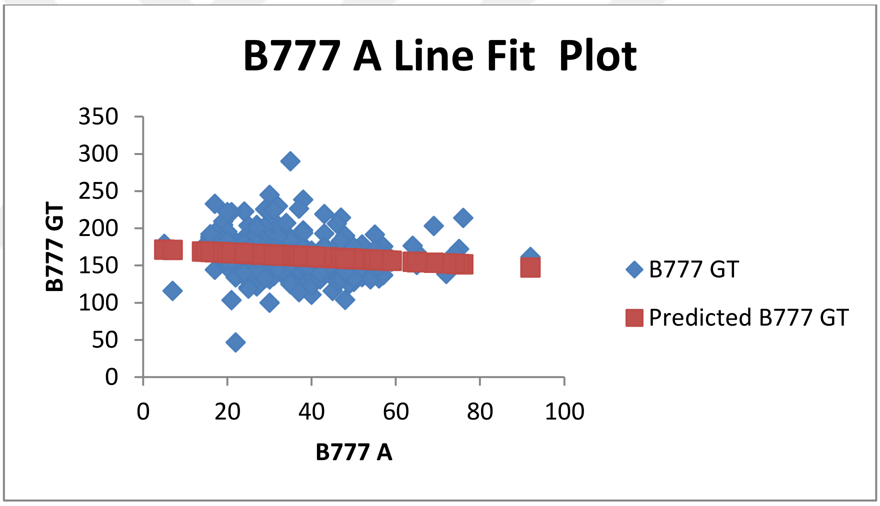
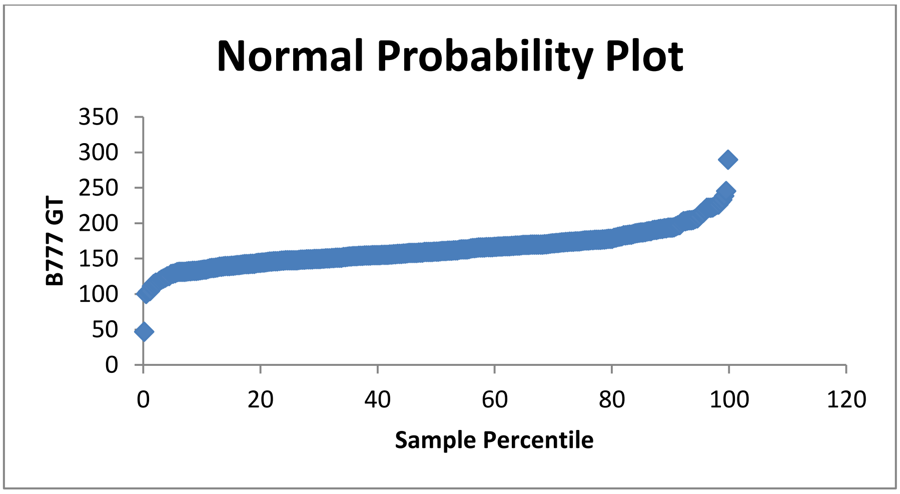



**Figure 4.9: The Normal Probability Plot of Defect Rates of Boeing 777**



According to the outputs of regression analysis for the defect and ground time of Boeing 777 Fleet, the linear regression relation is significant as p=0,02 in spite of the fact that the RSquare is 0,02. It can be commented that every 2 percent of increment in the change of ground time can be explained with the defect rate of Boeing 777.

The outputs of regression analysis for Airbus 330 aircraft are seen in Table 4.9, Figure 4.9, Figure 4.10 and Figure 4.11.

**Table 4.9: Regression Summary for Airbus 330**

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0,363484906 |
| R Square | 0,132121277 |
| Adjusted R Square | 0,129237959 |
| Standard Error | 49,56916194 |
| Observations | 303 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 112590,9204 | 112590,9204 | 45,82265158 | 6,77548E-11 |
| Residual | 301 | 739587,6465 | 2457,101816 | | |
| Total | 302 | 852178,5669 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95,0%* |
|---|---|---|---|---|---|---|---|
| Intercept | 237,5925507 | 7,067602414 | 33,61713588 | 6,4354E-104 | 223,6843818 | 251,5007196 | 223,6843818 |
| A330 A | 0,901076958 | 0,1331134 | 6,769243058 | 6,77548E-11 | 0,639126223 | 1,163027694 | 0,639126223 |

**Figure 4.10: The Residual Plot of Defect Rates of Airbus 330**

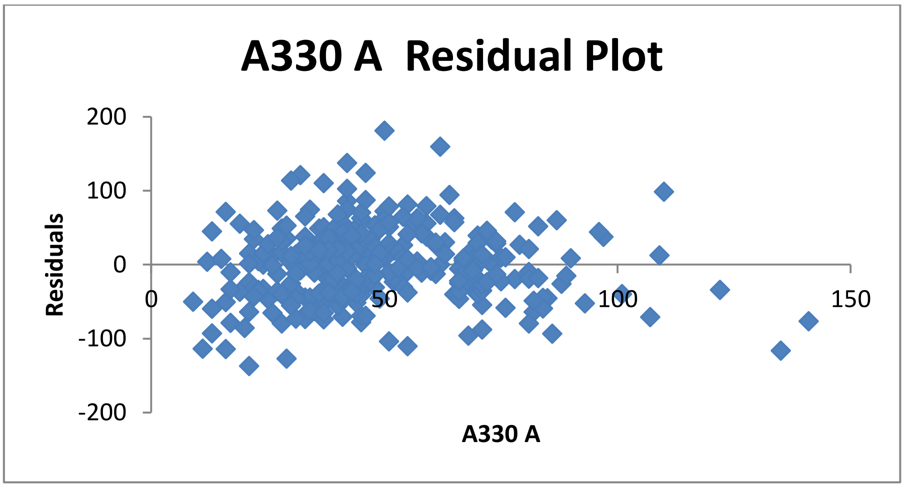


**Figure 4.11: The Line Fit Plot of Defect Rates of Airbus 330**

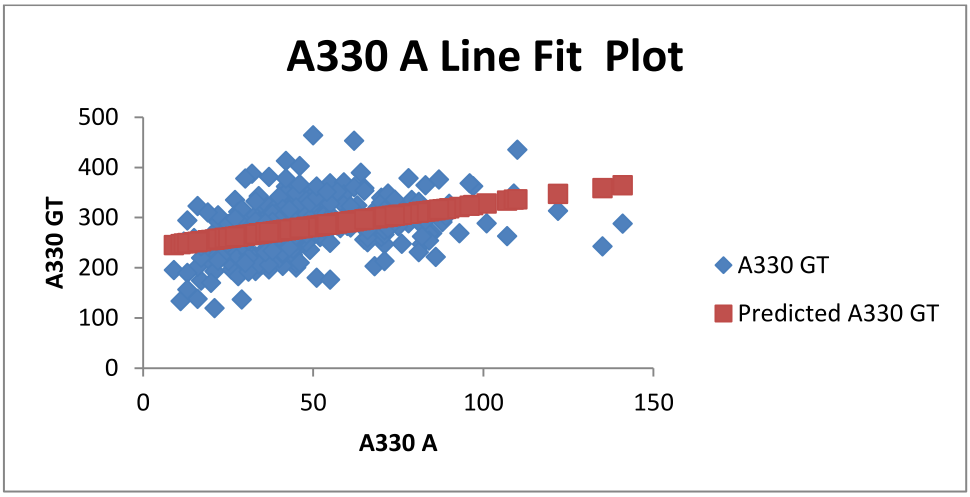
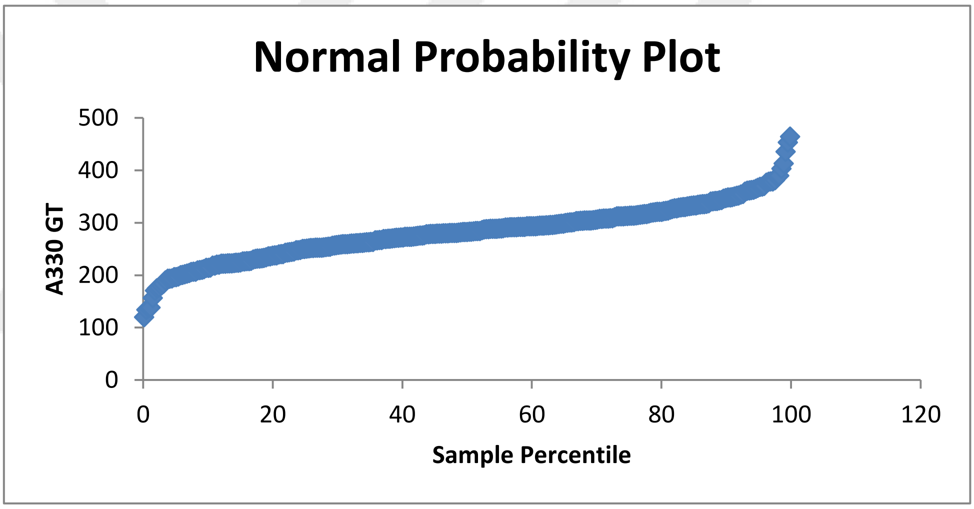



**Figure 4.12: The Normal Probability Plot of Defect Rates of Airbus 330**

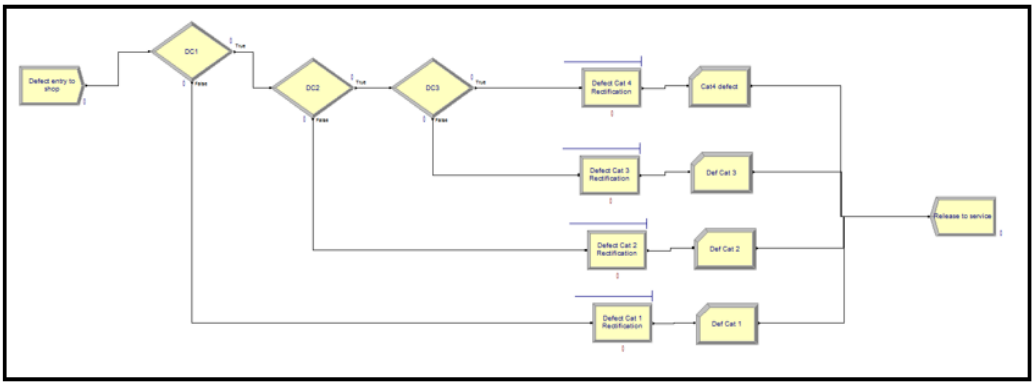



According to the outputs of regression analysis for the defect and ground time of Airbus 330 Fleet, the linear regression relation is significant as $p<0,01$ in spite of the fact that the RSquare is 0,13. It can be commented that every 13 percent of increment in the change of ground time can be explained with the defect rate of Airbus 330

## 4.3 THE OUTPUT OF SIMULATION

The outputs of the simulation model consist of processing and waiting time analysis, total numbers of input and outputs and resource utilization analysis. Current process model is seen in Figure 4.13. In this simulation, the process has been used for all aircraft type with different schedule and capacity. All time values are given in minutes. This replication can be seen as near future performance of IFE Workshop, because the sampling size is nearly one year. Due to the limitations of ARENA software program, the replication could not been performed as the real sampling size.

**Figure 4.13: The Simplified Defect Rectification Process in ARENA**




### 4.3.1 Time Outputs of Boeing 737 in ARENA Simulation

Simulation model including significant time outputs are maximum value of total time and maximum value of waiting times. According to the figure 4.14, maximum total time of process is 230 minutes for the defect rectification of a Boeing 737 Aircraft and maximum waiting time of a defect rectification is 44.31 minutes.

**Figure 4.14: Time Outputs of Boeing 737 ARENA Simulation**

**Time**

| VA Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 75.6732 | 1,53 | 73.7774 | 78.2595 | 0.00 | 230.82 |
| **NVA Time** | **Average** | **Half Width** | **Minimum Average** | **Maximum Average** | **Minimum Value** | **Maximum Value** |
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Wait Time** | **Average** | **Half Width** | **Minimum Average** | **Maximum Average** | **Minimum Value** | **Maximum Value** |
| Entity 1 | 0.3112 | 0,32 | 0.00 | 1.0033 | 0.00 | 44.3192 |
| **Transfer Time** | **Average** | **Half Width** | **Minimum Average** | **Maximum Average** | **Minimum Value** | **Maximum Value** |
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Other Time** | **Average** | **Half Width** | **Minimum Average** | **Maximum Average** | **Minimum Value** | **Maximum Value** |
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total Time** | **Average** | **Half Width** | **Minimum Average** | **Maximum Average** | **Minimum Value** | **Maximum Value** |
| Entity 1 | 79.1760 | 2,39 | 76.6965 | 83.9537 | 30.4012 | 230.82 |

### 4.3.2 Throughput Outputs of Boeing 737 ARENA Simulation

When looking at number of outputs, averagely 512 defects has been entered to process for the specified time period and 487 of defects have been rectified. WIP, which means

Average Work in Process, is an important and significant parameter that is used for evaluating the process performance. In any moment, there have been 27 defects occurred in the process. It is seen in figure 4.15.

In addition, the queue of each defect rectification process is seen in figure 4.16. The most important bottleneck can be seen in defect category 3 and defect category 4 whose waiting time is respectively 44.3 minutes and 32.8 minutes. The defect number waiting in queue for category 3 defect rectifications is 6 at maximum, 2 for category 4 defect rectification. Other two categories in process have no queue.

**Figure 4.15: Throughput Outputs of Boeing 737 ARENA Simulation**

| Number In | Average | Half Width | Minimum Average | Maximum Average |
|---|---|---|---|---|
| Entity 1 | 512.71 | 27,68 | 464.00 | 554.00 |

| Number Out | Average | Half Width | Minimum Average | Maximum Average |
|---|---|---|---|---|
| Entity 1 | 486.57 | 28,10 | 439.00 | 529.00 |

| WIP | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 27.0895 | 1,52 | 24.3278 | 28.8989 | 0.00 | 46.0000 |

**Figure 4.16: Queue Outputs of Boeing 737 ARENA Simulation**

## Queue

### Time

| Waiting Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Defect Cat 1 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 2 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 3 Rectification.Queue | 1.6567 | 1,53 | 0.00 | 4.5044 | 0.00 | 44.3192 |
| Defect Cat 4 Rectification.Queue | 1.7579 | 1,97 | 0.00 | 5.6555 | 0.00 | 32.8799 |

### Other

| Number Waiting | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Defect Cat 1 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 2 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 3 Rectification.Queue | 0.1153 | 0,11 | 0.00 | 0.3253 | 0.00 | 6.0000 |
| Defect Cat 4 Rectification.Queue | 0.01118362 | 0,01 | 0.00 | 0.03141971 | 0.00 | 2.0000 |

### 4.3.3 Resource Utilization of Boeing 737 ARENA Simulation

Resource utilization outputs are also enlightening in order to measure the performance of the type of technician required for the defect rectification process.

According to the simulation outputs, there are three types of technicians such as CQM, QM and CS.

Mostly utilized worker type is CS, which has been schedules as 15 and the maximum value in Number Busy is also 15. However, the allocation of this type of technician is still in the workshop limit.(15<25). With the same manner, CQM and QM numbers are respectively 18 and 20 within possibility of workshop technician size.

In the figure 4.17, it is easily seen that the maximum value.

**Figure 4.17: Resource Outputs of Boeing 737 ARENA Simulation**

**Resource**

**Usage**

| Instantaneous Utilization | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 0.07128504 | 0,00 | 0.06483247 | 0.07717975 | 0.00 | 0.1636 |
| CS | 0.6562 | 0,06 | 0.5832 | 0.7395 | 0.00 | 1.0000 |
| QM | 0.1427 | 0,01 | 0.1260 | 0.1596 | 0.00 | 0.3077 |

| Number Busy | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 7.8414 | 0,47 | 7.1316 | 8.4898 | 0.00 | 18.0000 |
| CS | 9.8433 | 0,84 | 8.7480 | 11.0926 | 0.00 | 15.0000 |
| QM | 9.2783 | 0,76 | 8.1913 | 10.3750 | 0.00 | 20.0000 |

| Number Scheduled | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 110.00 | 0,00 | 110.00 | 110.00 | 110.00 | 110.00 |
| CS | 15.0000 | 0,00 | 15.0000 | 15.0000 | 15.0000 | 15.0000 |
| QM | 65.0000 | 0,00 | 65.0000 | 65.0000 | 65.0000 | 65.0000 |

| Scheduled Utilization | Average | Half Width | Minimum Average | Maximum Average |
|---|---|---|---|---|
| CQM | 0.07128504 | 0,00 | 0.06483247 | 0.07717975 |
| CS | 0.6562 | 0,06 | 0.5832 | 0.7395 |
| QM | 0.1427 | 0,01 | 0.1260 | 0.1596 |

### 4.3.4 Time Outputs of Airbus 320 ARENA Simulation

Most significant time outputs of simulation model are maximum value of total time and maximum value of times of waiting. According to the figure 4.18, maximum total time of process is 511 minutes for the defect rectification of an Airbus 320 Aircraft and maximum waiting time of a defect rectification is 364 minutes.

**Figure 4.18: Time Outputs of Airbus 320 ARENA Simulation**

**Time**

| VA Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 73.3828 | 0,41 | 72.4860 | 74.5750 | 0.00 | 230.77 |

| NVA Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Wait Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 18.5006 | 4,37 | 6.6435 | 32.3986 | 0.00 | 364.17 |

| Transfer Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Other Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Total Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 96.2857 | 4,70 | 83.1345 | 109.53 | 30.2725 | 511.16 |

### 4.3.5 Throughput Outputs of Airbus 320 ARENA Simulation

When looking at number of outputs, averagely 914 defects has been entered to process for the specified time period and 835 of defects have been rectified. WIP, which means Average Work in Process, is an important and significant parameter that is used for evaluating the process performance. In any moment, there have been 61 defects occurred in the process. It is seen in Figure 4.19.

In addition, the queue of each defect rectification process is seen in figure 4.20.
The most important bottleneck can be seen in defect category 3 and defect category 4 whose waiting time is respectively 377 minutes and 340 minutes. The defect number waiting in queue for category 3 defect rectifications is 50 at maximum, 7 for category 4 defect rectification. Other two categories in process have no queue.

**Figure 4.19: Throughput Outputs of Airbus 320 ARENA Simulation**

| Number In | Average | Half Width | Minimum Average | Maximum Average |
|---|---|---|---|---|
| Entity 1 | 913.83 | 17,67 | 873.00 | 966.00 |

| Number Out | Average | Half Width | Minimum Average | Maximum Average |
|---|---|---|---|---|
| Entity 1 | 835.92 | 14,43 | 797.00 | 865.00 |

| WIP | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 61.4766 | 4,19 | 51.8263 | 75.2517 | 0.00 | 106.00 |

**Figure 4.20: Queue Outputs of Airbus 320 ARENA Simulation**

**Queue**

**Time**

| Waiting Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Defect Cat 1 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 2 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 3 Rectification Queue | 128.91 | 28,60 | 50.6174 | 219.26 | 0.00 | 377.17 |
| Defect Cat 4 Rectification Queue | 118.26 | 23,84 | 57.8266 | 198.30 | 0.00 | 340.20 |

**Other**

| Number Waiting | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Defect Cat 1 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 2 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 3 Rectification Queue | 15.1424 | 3,73 | 6.7348 | 27.7254 | 0.00 | 50.0000 |
| Defect Cat 4 Rectification Queue | 1.5685 | 0,42 | 0.5302 | 2.7353 | 0.00 | 7.0000 |

### 4.3.6 Resource Utilization of Airbus 320 ARENA Simulation

Resource utilization outputs are also enlightening in order to measure the performance of the type of technician required for the defect rectification process.

According to the simulation outputs, there are three types of technicians such as CQM, QM and CS.

Mostly utilized worker type is CS, which has been schedules as 15 and the maximum value in Number Busy is also 15. However, the allocation of this type of technician is still in the workshop limit (15<25). With the same manner, CQM and QM numbers are respectively 30 and 30 within possibility of workshop technician size.
In the Figure 4.21, it is easily seen that the maximum value

**Figure 4.21: Resource Outputs of Airbus 320 ARENA Simulation**

**Resource**

**Usage**

| Instantaneous Utilization | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 0.1277 | 0,00 | 0.1183 | 0.1350 | 0.00 | 0.2727 |
| CS | 0.9482 | 0,01 | 0.9299 | 0.9740 | 0.00 | 1.0000 |
| QM | 0.2537 | 0,01 | 0.2379 | 0.2771 | 0.00 | 0.4615 |

| Number Busy | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 14.0493 | 0,42 | 13.0176 | 14.8489 | 0.00 | 30.0000 |
| CS | 14.2232 | 0,13 | 13.9480 | 14.6095 | 0.00 | 15.0000 |
| QM | 16.4932 | 0,56 | 15.4654 | 18.0137 | 0.00 | 30.0000 |

| Number Scheduled | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 110.00 | 0,00 | 110.00 | 110.00 | 110.00 | 110.00 |
| CS | 15.0000 | 0,00 | 15.0000 | 15.0000 | 15.0000 | 15.0000 |
| QM | 65.0000 | 0,00 | 65.0000 | 65.0000 | 65.0000 | 65.0000 |

| Scheduled Utilization | Average | Half Width | Minimum Average | Maximum Average |
|---|---|---|---|---|
| CQM | 0.1277 | 0,00 | 0.1183 | 0.1350 |
| CS | 0.9482 | 0,01 | 0.9299 | 0.9740 |
| QM | 0.2537 | 0,01 | 0.2379 | 0.2771 |

### 4.3.7 Time Outputs of Airbus 330 ARENA Simulation

Most significant time outputs of simulation model are maximum value of total time and maximum value of waiting times. As seen in the figure 4.22, maximum total time of process is 221 minutes for the defect rectification of an Airbus 330 Aircraft and maximum waiting time of a defect rectification is 45 minutes.

**Figure 4.22: Time Outputs of Airbus 330 ARENA Simulation**

**Time**

| VA Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 76.2036 | 1,54 | 71.4311 | 79.7947 | 0.00 | 221.06 |

| NVA Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Wait Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 0.07119083 | 0,15 | 0.00 | 0.8300 | 0.00 | 44.9905 |

| Transfer Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Other Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Total Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Entity 1 | 79.7890 | 1,74 | 75.2927 | 83.6606 | 30.4012 | 221.06 |

### 4.3.8 Throughput Outputs of Airbus 330 ARENA Simulation

When looking at number of outputs, averagely 224 defects has been entered to process for the specified time period and 212 of defects have been rectified. WIP, which means Average Work in Process, is an important and significant parameter that is used for evaluating the process performance. In any moment, there have been 12 defects occurred in the process. It is seen in figure 4.23.

In addition, the queue of each defect rectification process is seen in figure 4.24. The most important bottleneck can be seen in only defect category 3 whose waiting time is respectively 45 minutes. The defect number waiting in queue for category 3 defect rectifications is 4 at maximum. Other three categories in process have no queue.

**Figure 4.23: Throughput Outputs of Airbus 330 ARENA Simulation**

| Number In | Average | Half Width | Minimum Average | Maximum Average | | |
|---|---|---|---|---|---|---|
| Entity 1 | 224.50 | 11,98 | 192.00 | 255.00 | | |
| **Number Out** | **Average** | **Half Width** | **Minimum Average** | **Maximum Average** | | |
| Entity 1 | 212.42 | 12,06 | 183.00 | 243.00 | | |
| **WIP** | **Average** | **Half Width** | **Minimum Average** | **Maximum Average** | **Minimum Value** | **Maximum Value** |
| Entity 1 | 11.8418 | 0,59 | 10.3574 | 13.0573 | 0.00 | 28.0000 |

**Figure 4.24: Queue Outputs of Airbus 330 ARENA Simulation**

**Queue**

**Time**

| Waiting Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Defect Cat 1 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 2 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 3 Rectification Queue | 0.4421 | 0,69 | 0.00 | 3.7681 | 0.00 | 44.9905 |
| Defect Cat 4 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Other**

| Number Waiting | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Defect Cat 1 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 2 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 3 Rectification Queue | 0.01472296 | 0,02 | 0.00 | 0.1308 | 0.00 | 4.0000 |
| Defect Cat 4 Rectification Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

### 4.3.9 Resource Utilization of Airbus 330 ARENA Simulation

Resource utilization outputs are also enlightening in order to measure the performance of the type of technician required for the defect rectification process. According to the simulation outputs, there are three types of technicians such as CQM, QM and CS.

Mostly utilized worker type is CS, which has been schedules as 10 and the maximum value in Number Busy is also 10. However, the allocation of this type of technician is still in the workshop limit (10<25). With the same manner, CQM and QM numbers are respectively 12 and 10 within possibility of workshop technician size. In the figure 4.25, it is easily seen that the maximum value.

**Figure 4.25: Resource Outputs of Airbus 330 ARENA Simulation**

**Resource**

**Usage**

| Instantaneous Utilization | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 0.03067070 | 0,00 | 0.02673638 | 0.03848773 | 0.00 | 0.1091 |
| CS | 0.4245 | 0,03 | 0.3493 | 0.5109 | 0.00 | 1.0000 |
| QM | 0.06474022 | 0,01 | 0.04879594 | 0.07948345 | 0.00 | 0.1692 |

| Number Busy | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 3.3738 | 0,24 | 2.9410 | 4.2337 | 0.00 | 12.0000 |
| CS | 4.2452 | 0,28 | 3.4927 | 5.1087 | 0.00 | 10.0000 |
| QM | 4.2081 | 0,38 | 3.1717 | 5.1664 | 0.00 | 11.0000 |

| Number Scheduled | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 110.00 | 0,00 | 110.00 | 110.00 | 110.00 | 110.00 |
| CS | 10.0000 | 0,00 | 10.0000 | 10.0000 | 10.0000 | 10.0000 |
| QM | 65.0000 | 0,00 | 65.0000 | 65.0000 | 65.0000 | 65.0000 |

| Scheduled Utilization | Average | Half Width | Minimum Average | Maximum Average |
|---|---|---|---|---|
| CQM | 0.03067070 | 0,00 | 0.02673638 | 0.03848773 |
| CS | 0.4245 | 0,03 | 0.3493 | 0.5109 |
| QM | 0.06474022 | 0,01 | 0.04879594 | 0.07948345 |

### 4.3.10 Time Outputs of Boeing 777 ARENA Simulation

Most important and significant time outputs of the subject simulation model are maximum value of the total time and maximum value of waiting times. According to the figure 4.26, maximum total time of process is 223 minutes for the defect rectification of a Boeing 777 Aircraft and maximum waiting time of a defect rectification is 65 minutes.

**Figure 4.26: Time Outputs of Boeing 777 ARENA Simulation**

| Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| VA Time | | | | | | |
| Entity 1 | 75.6434 | 2,99 | 67.8600 | 85.2428 | 0.00 | 221.06 |
| NVA Time | | | | | | |
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Wait Time | | | | | | |
| Entity 1 | 0.1448 | 0,24 | 0.00 | 1.2535 | 0.00 | 65.3187 |
| Transfer Time | | | | | | |
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other Time | | | | | | |
| Entity 1 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total Time | | | | | | |
| Entity 1 | 79.0303 | 3,34 | 72.7421 | 91.4111 | 30.4073 | 223.11 |

### 4.3.11 Throughput Outputs of Boeing 777 ARENA Simulation

When looking at number of outputs, averagely 124 defects has been entered to process for the specified time period and 115 of defects have been rectified. WIP, which means Average Work in Process, is an important and significant parameter that is used for evaluating the process performance. In any moment, there have been 7 defects occurred in the process. It is seen in figure 4.27.

In addition, the queue of each defect rectification process is seen in figure 4.28. The most important bottleneck can be seen in only defect category 3 whose waiting time is respectively 65 minutes. The defect number waiting in queue for category 3 defect rectifications is 2 at maximum. Other three categories in process have no queue.

**Figure 4.27: Throughput Outputs of Boeing 777 ARENA Simulation**

| | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Number In | | | | | | |
| Entity 1 | 123.83 | 8,46 | 101.00 | 150.00 | | |
| Number Out | | | | | | |
| Entity 1 | 115.42 | 7,89 | 95.0000 | 139.00 | | |
| WIP | | | | | | |
| Entity 1 | 6.5340 | 0,53 | 5.3249 | 7.7852 | 0.00 | 17.0000 |

**Figure 4.28: Queue Outputs of Boeing 777 ARENA Simulation**

**Queue**

**Time**

| Waiting Time | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Defect Cat 1 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 2 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 3 Rectification.Queue | 0.5654 | 0,92 | 0.00 | 4.7861 | 0.00 | 65.3187 |
| Defect Cat 4 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Other**

| Number Waiting | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| Defect Cat 1 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 2 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Defect Cat 3 Rectification.Queue | 0.01272650 | 0,02 | 0.00 | 0.1097 | 0.00 | 2.0000 |
| Defect Cat 4 Rectification.Queue | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 |

### 4.3.12 Resource Utilization of Boeing 777 ARENA Simulation

Resource utilization outputs are also enlightening in order to measure the performance of the type of technician required for the defect rectification process.

According to the simulation outputs, there are three types of technicians such as CQM, QM and CS.

Mostly utilized worker type is CS, which has been schedules as 7 and the maximum value in Number Busy is also 7. However, the allocation of this type of technician is still in the workshop limit (7<25). With the same manner, CQM and QM numbers are respectively 7 and 8 within possibility of workshop technician size. In the figure 4.29, it is easily seen that the maximum value.

**Figure 4.29: Resource Outputs of Boeing 777 ARENA Simulation**

**Resource**

**Usage**

| Instantaneous Utilization | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 0.01655860 | 0,00 | 0.01339753 | 0.02139017 | 0.00 | 0.06363636 |
| CS | 0.3307 | 0,05 | 0.2499 | 0.5185 | 0.00 | 1.0000 |
| QM | 0.03669606 | 0,00 | 0.02469683 | 0.05117342 | 0.00 | 0.1231 |

| Number Busy | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 1.8214 | 0,17 | 1.4737 | 2.3529 | 0.00 | 7.0000 |
| CS | 2.3146 | 0,37 | 1.7495 | 3.6297 | 0.00 | 7.0000 |
| QM | 2.3852 | 0,29 | 1.6053 | 3.3263 | 0.00 | 8.0000 |

| Number Scheduled | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 110.00 | 0,00 | 110.00 | 110.00 | 110.00 | 110.00 |
| CS | 7.0000 | 0,00 | 7.0000 | 7.0000 | 7.0000 | 7.0000 |
| QM | 65.0000 | 0,00 | 65.0000 | 65.0000 | 65.0000 | 65.0000 |

| Scheduled Utilization | Average | Half Width | Minimum Average | Maximum Average |
|---|---|---|---|---|
| CQM | 0.01655860 | 0,00 | 0.01339753 | 0.02139017 |
| CS | 0.3307 | 0,05 | 0.2499 | 0.5185 |
| QM | 0.03669606 | 0,00 | 0.02469683 | 0.05117342 |

**Table 4.10: Resource Outputs of each Aircraft Types**

| Technician Type | Boeing 737 Series | Airbus 320 Series | Airbus 330 | Boeing 777 | Total |
|---|---|---|---|---|---|
| **CS** | 15 | 15 | 10 | 7 | **47** |
| **QM** | 20 | 30 | 11 | 8 | **69** |
| **CQM** | 18 | 30 | 12 | 7 | **67** |

According to the outputs of each process simulation for every aircraft type, the resource table is given above in Table 4.10. The number of CS is actually equal to the number of aircraft type certificate. One Certifying Staff (CS) can attain more than one type certificate, however in this study each defect rectification process of an aircraft type has been evaluated individually. Each technician has been assigned to a task in that process and this situations limits the flexible workload for CS. The demand is higher than the current capacity of the IFE Workshop.

In this study, the run setup of simulation has been made with the replication parameters as weekly and monthly. In order to have realistic outputs, all historical defect data has been entered to schedule module as 303 days row. Replication time units has been selected as days, base time has been selected as minutes. Different replication lengths have been selected to run the simulation. It hasn't been observed any substantial differences between the outputs.

Another key factor is the process waiting time for each defect rectification process seen in Table 4.11.

**Table 4.11: Resource Outputs of each Aircraft Types**

| ***Maximum Waiting Times, (minutes)*** | **Boeing 737 Series** | **Airbus 320 Series** | **Airbus 330** | **Boeing 777** |
|---|---|---|---|---|
| ***Defect Category 1*** | 0 | 0 | 0 | 0 |
| ***Defect Category 2*** | 0 | 0 | 0 | 0 |
| ***Defect Category 3*** | **44** | **377** | **45** | **65** |
| ***Defect Category 4*** | 33 | 340 | 0 | 0 |

It is seen that Defect Category 3 is a bottleneck of the defect rectification process for every aircraft type. This result is very important from the skills-perspective. Especially, the waiting time of the defect rectification process on Airbus 320 Series for Defect Category 3 is remarkable as 377 minutes which is nearly nine times higher than other waiting times in defect category 3. By taking into account the age and the size of Airbus 320 Series aircraft fleet, the result has to be discussed. However, if the age and size of Airbus 320 fleet is compared with the Boeing 737 fleet, there is no such difference. The numbers are seen in Table 1.4 in Chapter one.

Therefore, the findings should be taken into account both for theoretical and practical point of views. In order to have better explanation about how this subject study relate to improvement in IFE Technician Assignment or how could be applied into simulation model, it is essential to create a compact process simulation with the real data for each defect category created by the member of IFE workshop.

IFE line maintenance comprises different types of services in both hangar and apron areas. The problem is to maintain each services and process them perfectly in a complicated and at the same time in a restricted environment. Aviation has its own strict rules for providing the safety and quality all the time. Keeping every aircraft in airworthy is the most important challenge during the operations. By the necessity of the aviation industry, scheduling changes every second, and because of never ending flight scheduling, uncertainty does not let operations to make successful plans for future. Hence, there are too many special problems such as high variability, limited work scope and material requirements, unpredictable response times from support, quick operations in a short time, difficulties in managing shared resources, and physical restrictions on movement of maintenance. These all cause complex and unpredictable flow paths which is a little bit far away from this study which is focused on only defect rectification process with avoiding the other constraints. So, this work allows the ways to adapt a simulation model for the IFE defect rectification processes for finding the optimum solution for resource allocation.

In the inspected literature, there is lots of technician assignment adopted by several MRO companies which had limitedly used to improve their processes for only their heavy maintenance, component repair and engine overhauls. But none of them has real data and specific categorization for defect process which is nearly span the 75% percent of workload of IFE Workshop in Turkish Technic.

#### 4.3.13 Sensitivity Analysis

Real data was used during the analysis. In case any increase happens in the number of aircraft or number of defects, there a sensitivity analysis has also been made. By the sensitivity study, it was aimed that the differences in terms needs were meant to be highlighted. In the future works, especially at MRO Establishments, by the sensitivity analysis, it will be easier to find the required skilled technicians according to the defects. Also with this analysis, while considering the changing requirement statuses, the required number of technicians will be calculated dynamically via the Arena program. The sensitivity analysis is made by taking B777 fleet’s defects into consideration. The number of defects were multiplied by four. Related details are seen on the below figure 4.30.

**Figure 4.30: Sensitivity Analysis Outputs of Boeing 777 ARENA Simulation**

**Resource**

**Usage**

| Instantaneous Utilization | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 0.06625766 | 0,00 | 0.05994330 | 0.07621546 | 0.00 | 0.2000 |
| CS | 0.9459 | 0,01 | 0.9054 | 0.9735 | 0.00 | 1.0000 |
| QM | 0.1341 | 0,01 | 0.1098 | 0.1564 | 0.00 | 0.3077 |

| Number Busy | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 7.2883 | 0,39 | 6.5938 | 8.3837 | 0.00 | 22.0000 |
| CS | 6.6215 | 0,09 | 6.3378 | 6.8147 | 0.00 | 7.0000 |
| QM | 8.7183 | 0,58 | 7.1355 | 10.1645 | 0.00 | 20.0000 |

| Number Scheduled | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| CQM | 110.00 | 0,00 | 110.00 | 110.00 | 110.00 | 110.00 |
| CS | 7.0000 | 0,00 | 7.0000 | 7.0000 | 7.0000 | 7.0000 |
| QM | 65.0000 | 0,00 | 65.0000 | 65.0000 | 65.0000 | 65.0000 |

| Scheduled Utilization | Average | Half Width | Minimum Average | Maximum Average |
|---|---|---|---|---|
| CQM | 0.06625766 | 0,00 | 0.05994330 | 0.07621546 |
| CS | 0.9459 | 0,01 | 0.9054 | 0.9735 |
| QM | 0.1341 | 0,01 | 0.1098 | 0.1564 |

According the analysis, when the number of defects were increased 4 times than the original data, it was observed that there is no change at the maximum CS number, also found out that the QM and CQM numbers were nearly increased three times more than the original data values.

# 5. CONCLUSION

First of all, the null hypothesis has been rejected based on the statistical tests which were performed with the historical data collected from Company Database. Therefore, it means that there will be valuable improvements via this study. According to this statistical results and the analysis of processes, the simulation model has been created.

Final outputs of this study show that the technician assignment based on specific IFE skills for every defect category is appropriate and provide a real approach to see the important factors in the defect rectification process of IFE Line Maintenance.

***"Null Hypothesis ($H_0$);*** *there will be no significant difference between ground time and defects rate according to the aircraft type in order to make efficient technician man-hour planning."*

This study has been only focused on IFE defect rectification process in a MRO environment. In order to catch a real aspect, historical data has been used to analyze both ground time and defect rate. Every process has been grouped into four main categories and the process completion time of each has been calculated with the current database. The whole data collected from the database of Company consist of the months between January 2017 and October 2017 which is equal to 303 days.

All inputs and outputs that are obtained from statistical analysis have been examined with current IFE Workshop workers who consist of supervisors, technicians and engineer. Every elimination of process has been made by these team members which performs the real tasks of IFE maintenance.

ARENA Simulation program has been used for analyzing the technician capacity and the defect rectification process with actual processing times based on statistical analysis on historical data. Three or more replications had been run to see the difference between them. There were not significant differences on process waiting times and total process completion time accordingly.

Secondly, the effect of defect entry schedules has been tested in simulation model for weekly and monthly. The all defect data has been used as the real data sets in order to create the arrival schedule. When the defect entries increase as twice as the used data, the waiting times and total process completion time also increased. The effects can be easily seen in the outputs of ARENA simulation.

In this study, in order to gain experimental data and information, an IFE workshop was performed with the standard defect rectification procedures, such as the procedures of other chapter's task in the literature of MRO. While adapting the IFE related defect rectification process to this study, some considerations have been observed. The complexity and limitations in the line maintenance makes difficult to find improvement opportunities. The IFE rectification processes in the line maintenance operation are independent and not in order and one piece flow.

Because of these various reasons, it is very hard to implement a standard process without considering to develop a modification for line maintenance.

Another important matter is to describe whole scope; it is an obligation to have technicians from each department to define the effects of other department's process on IFE process. For instance, there are many other departments such as handling teams, cabin crews, dispatchers, and controllers etc. in apron environment which cause some preliminary work to perform an IFE task on aircraft.

Besides, the empirical data which is collected after the IFE workshop from the team members are not precise. They depend on individuals' experiences that makes us gather the main source of information which has to be recorded in Company database. Mostly, this data has not been recorded with whole detail. Every company has to create awareness about the missing data. This uncertainty could cause miss and contaminated data which is used for real analysis. However, it is nearly impossible to reflect the data in practice to the companies' database %100 percent. Increasing the number of technicians for getting experimental data in this complex process may only make sense, if the number of Defect rectification process is replicated for each task of IFE line maintenance.

In the IFE workshop, in order to fit both scheduled and unscheduled process to one flow for making easy simulation is another consideration. The forecast of unscheduled jobs is unpredictable. Therefore, the real data has been used instead of this unpredictable data. In the study, the categorization of the defect rectification process was the most challenging part, so that the each defect data has been analyzed and the completion time of each has been obtained by the technicians who rectified these defects.

Another consideration is technician shift. Due to the lack of the time of the defect recorded by the technicians to the Company's system, technician assignment has not been performed based on shifting working style. However, there is only one type of shift system for line maintenance technician in the company due to the restrictions of labour union. Because of this reason, the numbers of technicians in shifts are equally distributed. This most important factor as finding shift demand has been eliminated from this study just because of the missing data which cause the weakness in improvements.

Eventhough some obligatory elimination, the study has been reached the goal. While this research does have its limitations and the uncertainty in the study area, it offers a resource which could be used as a basis for further scientific research.

Thanks to the historical and experimental data collection, it has been performed statistical and simulation analysis which summarize the needs of technician assignment. The results provide future actions to IFE workshop such as forecasting the demand from new aircraft deliveries and new IFE systems. The skill based results provide a preparation in order to take training actions to have required IFE system skills, aircraft type certification and aircraft technician license.

Despite the fact that, there are many considerations and limitations in the utility of IFE line maintenance operation, the result of the study was nearly satisfying and encouraging to develop a modified method for the future research.

If the data entry is developed and reflect the real world numbers with improved data entering computer based application in the company, new avenues for future research could be created, both inside and outside the MRO industry. The study helps in understanding the effects of technician assignment on the complex and specific service area such as IFE line maintenance operation.

## *REFERENCES*

***Books***


Bicheno, J. (2008). *The Lean Toolbox: The Essential Guide to Lean Transformation.* Picsie Books.

Dailey, K. W. (2003). *Tle Lean Manufacturing Pocket Handbook.*

James P.Womack, D. T. (2003). *Lean Thinking.* Free Pres.

Liker, J. K. (2004). *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer* . New York: McGraw-Hill.

Monden, Y. (1998). *Toyota Production System: An Integrated Approach to Just-in-time.* London: Chapman & Hall.

Rother, M., & Shook, J. (1999). *Learning to see: Value stream mapping to create value and eliminate muda.* Lean Enterprise Institute.

Womack, J. P., T.Jones, D., & Roos, D. (1990). *The Machine That Changed the World* . New York: Macmillan Publishing Company.

***Periodicals***


Alafres, H. K. (1999). Aircraft maintenance workforce scheduling. *Journal of Quality in Maintenance*.

Alafres, H. K. (1999). Aircraft maintenance workforce scheduling. *Journal of Quality in Maintenance*.

Alsheddy, A., & P.K.Tsang. (2011). Empowerment Scheduling For a Field Workforce . *Journal of Scheduling*.

Aviation Magazine. (2015).

Aviation Maintenance. (2017). *Aviation Maintenance.* https://www.aviationmaintenancejobs.aero/aircraft-ata-chapters-list adresinden alınmıştır

Ayeni, P., Ball, P., & Baines, T. (2016). Towards the strategic adoption of Lean in aviation Maintenance Repair and Overhaul (MRO) industry: An empirical study into the industry's Lean status. *Journal of Manufacturing Technology Management*.

Bell, C. F., & Stucker, J. P. (1971). *A Technique for Determinig Maintenance Mapower Requirements for Aircrafts Units.* California: The Rand Corporation.

Bell, C. F., & Stucker, J. P. (1971). A Technique for Determining Maintenance Manpower Requirements for Aircraft Units.

Boeing. (2017). 777-AMM THY D633W101-THY. Boeing. içinde

Bojic, Z. (2015). *systemico.ca.* www.systemico.ca: http://www.systemico.ca/wp-content/uploads/2015/04/VSM-Process-e1433078651392.png adresinden alınmıştır

Brinkman, K. (2015). *Luchtvaartfeiten.* Luchtvaartfeiten: ww.luchtvaartfeiten.nl adresinden alınmıştır

Business, A. (1999). Airlines Business. *Airlines Business*.

Castillo, A., Landa, D., & Qu, R. (2016). *Annals ofOperations Research*.

Chen, G., He, W., Leung, L. C., Lan, T., & Han, Y. (2017). Assigned licenced technician to maintenance tasks at aircraft maintenance base. *International Journal of Production Research*.

Chen, K. M. (2011). The development of an nn-line RFID-based facility performance monitoring system.

Chen, L., & Shady. (2010). From value stream mapping toward a lean/sigma. *An industrial case study. "International Journal of*, An industrial case study. "International Journal of.

Cho, P. Y. (2011). *Optimal Scheduling of Fighter Aircraft Maintenance.*

Dailey, K. W. (2003). *Tle Lean Manufacturing Pocket Handbook.*

Doan, C. (2015). *2015-2025 Global MRO Market Forecast.* Oliver Wyman.

EASA . (2017).

EASA. (2015). *Foreign Part-145.* European Aviation Safety Agency.

FAA. (1985). *FAR PART 1.* Seattle: FAA.

FAA. (2012). *Fderal Acquisition Regulatin.* FAA.

Fırat, M., & Hurkens, C. (2011). *An improved MIP-BASED approach for a multi-skill workforce scheduling problem ;.*

Gao, H. (2007). *Preventive Maintenance Scheduling with Multi Skilled Workforce Constraints; Models, Algoritms and Applications* .

Hemskam, A. (1999). Aircraft Maintenance Workforce Scheduling. *Journal of quality Maintenance Engineering*.

Hines, P. H. (2004). 'Learning to evolve: A review of. *International Journal of Operations & Production*.

Hölzel, N. B., Schröder, C., & Thomas Schilling, V. G. (2012). A Maintenance Packaging and Scheduling Optimization Method for Future Aircraft.

IATA-Tourism Economics. (2014).

ICAO Annual Report of the Council. (2014).

IMDC. (2017). *http://www.geemedia.com/services/research-consultancy#.*

IMDC. (2017). *http://www.geemedia.com/services/research-consultancy#.*

Inmarsat Aviation. (2017). *Inmarsat Aviation.*

International Air Transport Association. (2017). *IATA Global Passenger Survey.*

James P.Womack, D. T. (2003). *Lean Thinking.* Free Pres.

Kodali, R., & Jasti, N. V. (2014). *Lean production: literature review and trends*.

Liker, J. K. (2004). *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer* . New York: McGraw-Hill.

Linton, I. (2015). *Chron.* smallbusiness.chron.com: http://smallbusiness.chron.com/five-differences-between-service-manufacturing-organizations-19073.html adresinden alınmıştır

McManus, D. H. (2005). *Product Development Value Stream.* Massachusetts: Center for Technology, Policy, and Industrial Development.

Monden, Y. (1998). *Toyota Production System: An Integrated Approach to Just-in-time.* London: Chapman & Hall.

Muchiri, A. K. (1997). *Maintenance Planning Optimisation for the Boeing 737 Next Generation.*

Muchiri, A. K. (2002). *Maintenance Planning Optimisation for the Boeing 737 Next Generation*.

Nanova, G., Dimitrov, L., Neshkov, T., C.Apostolopoulos, & P.Savvopoulos. (2012). *Lean Manufacturing Approach in Aircraft MRO*.

P.Hines, Holweg, M., & Rich., N. (2004). Learning to Evolve: A Review of Contemporary Lean Thinking. *International Journal*.

Panasonic Avionics Corporation. (2015). *Aircraft Maintenance Manual Supplement.*

Papadopoulou, T., & Özbayrak, M. (2005). Leanness: experiences from the journey to date. *Journal of Manufacturing Technology Management*.

Paz, N. (1994). Maintenance Scheduling. *Leigh, William International Journal of operation and production management*.

Rother, M., & Shook, J. (1999). *Learning to see: Value stream mapping to create value and eliminate muda.* Lean Enterprise Institute.

S.Tiwari, Dubey, R., & Tripathi, N. (2012). *The Journey of Lean*.

Safai, N., Banjevic, D., Jardine, A. K., & S. (2011). *Workforce-constrained Maintenance Scheduling for Military Aircraft.*

Smith, R., & Hawkings, B. (2004). *Lean Maintenance: Reduce Costs, Improve Quality, and Increase Market Share.*

Stall, S. (2010). Making the business case for MRO.

Stone, K. B. (2012). *A systematic literature review. "International Journal of Lean Six Sigma*.

Sullivan, W. G., McDonald, T. N., & VanAken, E. M. (2002). *Equipment replacement decisions and lean manufacturing.* Pergamon.

Thiruvengadam, A. (2004). *A Practical Method For Assesing Maintenance Factors Using VSM*.

Turkish Technic. (2017). *www.turkishtechnic.com.*

Turkish Technic Maintenance Software-TRAX. (2017).

Williams, S. (2016). aviationglossary: http://aviationglossary.com/ adresinden alınmıştır

Womack, J. P., T.Jones, D., & Roos, D. (1990). *The Machine That Changed the World* . New York: Macmillan Publishing Company.

*www.panasonic.aero.* (2016). Panasonic Aviation. adresinden alınmıştır

Yılmaz, O. (1998). *Quality & JAR 145 Approved Maintenance Organisation in Aviation*.

York, K. (2016). *sustainametrics.com.* 2013 tarihinde sustainametrics.com: http://sustainametrics.com/index.php/page/display/lean_green adresinden alındı

Zhu, Z., & Meredith, P. H. (1995). *Defining Critical Elements in JIT Implementation*.

***Other Resources***

Bojic, Z. (2015). *systemico.ca.* www.systemico.ca: http://www.systemico.ca/wp-content/uploads/2015/04/VSM-Process-e1433078651392.png

Brinkman, K. (2015). *Luchtvaartfeiten.* Luchtvaartfeiten: ww.luchtvaartfeiten.nl adresinden alınmıştır

FAA. (1985). *FAR PART 1.* Seattle: FAA.

FAA. (2012). *Fderal Acquisition Regulatin.* FAA.

Linton, I. (2015). *Chron. smallbusiness.chron.com: http://smallbusiness.chron.com/five-differences-between-service-manufacturing-organizations-19073.html*

Williams, S. (2016). *aviationglossary: http://aviationglossary.com/*

York, K. (2016). *sustainametrics.com. 2013 sustainametrics.com: http://sustainametrics.com/index.php/page/display/lean_green*

# APPENDICES

**Appendix A.1 The Statistics For IFE System**

**Figure 1.1:** Wireless IFE Market share Charts for Connected Aircrafts

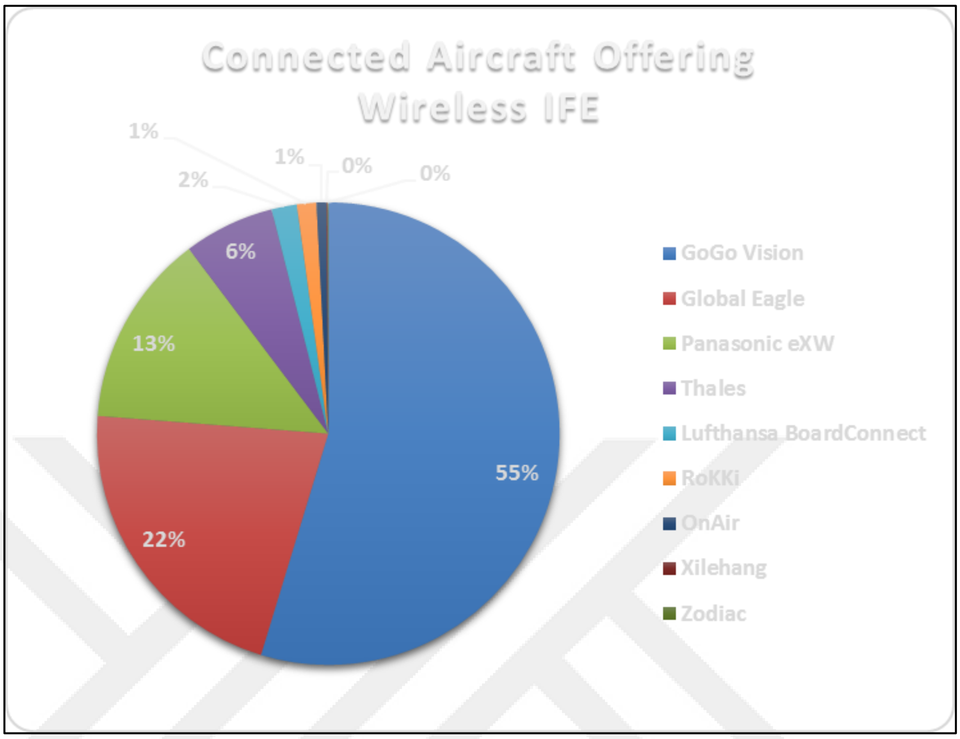
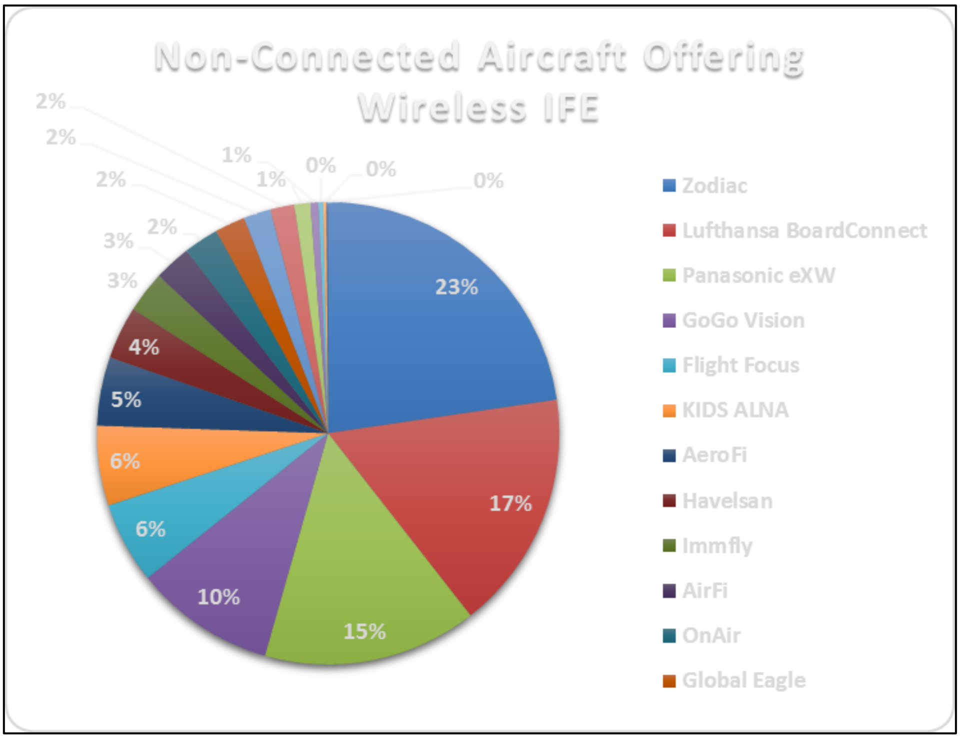



**Figure 1.2:** Wireless IFE Market share Charts for Non-Connected Aircraft




*Source:* (http://www.geemedia.com/services/research-consultancy#, 2017).

**Figure 1.3:** Market Share by Installed Aircraft

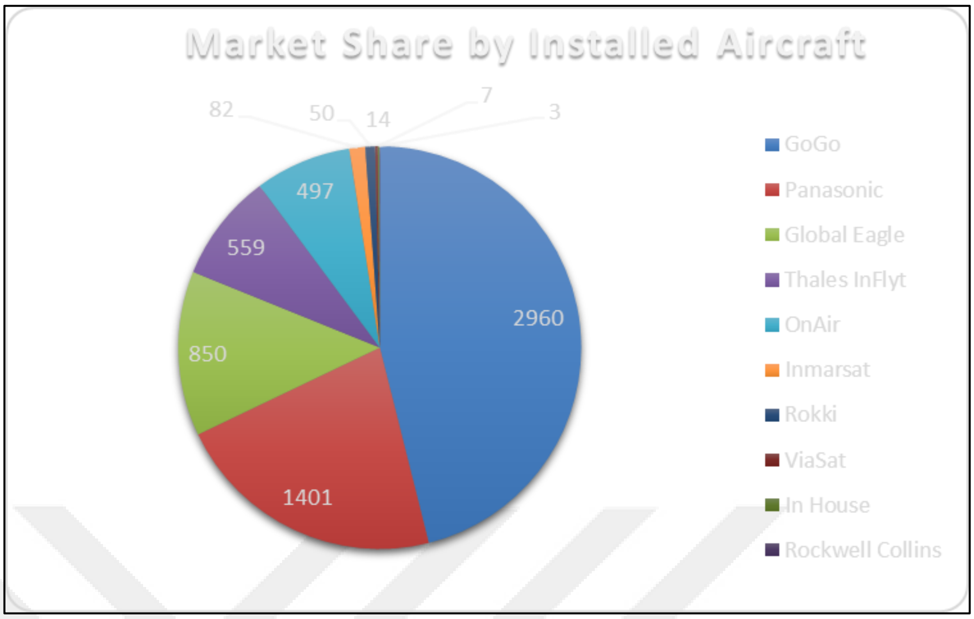
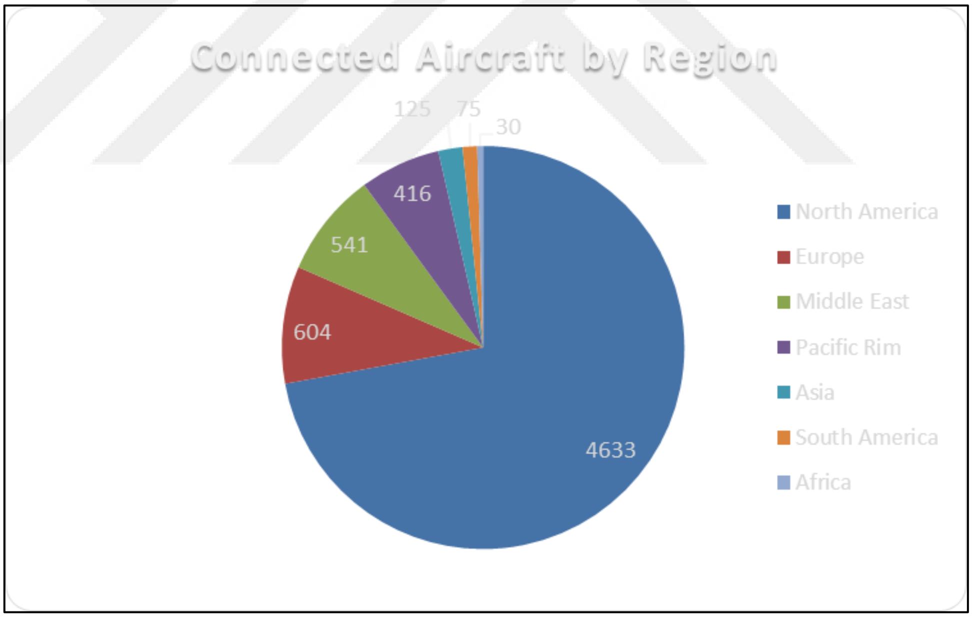



**Figure 1.4:** Connected Aircraft by Region




*Source:* (http://www.geemedia.com/services/research-consultancy#, 2017).

**Figure 1.5:** Current Fleets with IFE Charts

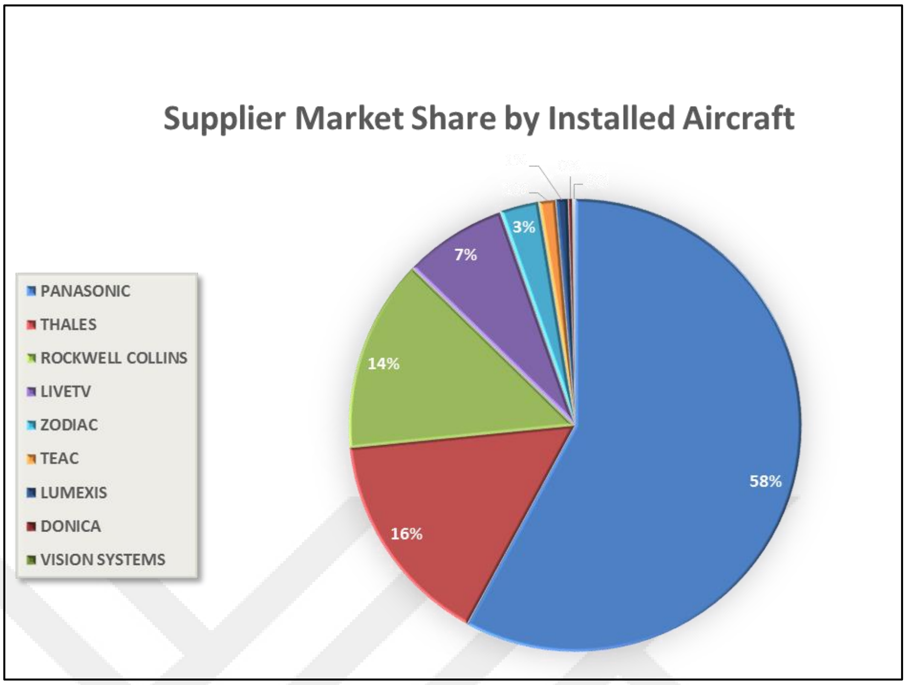
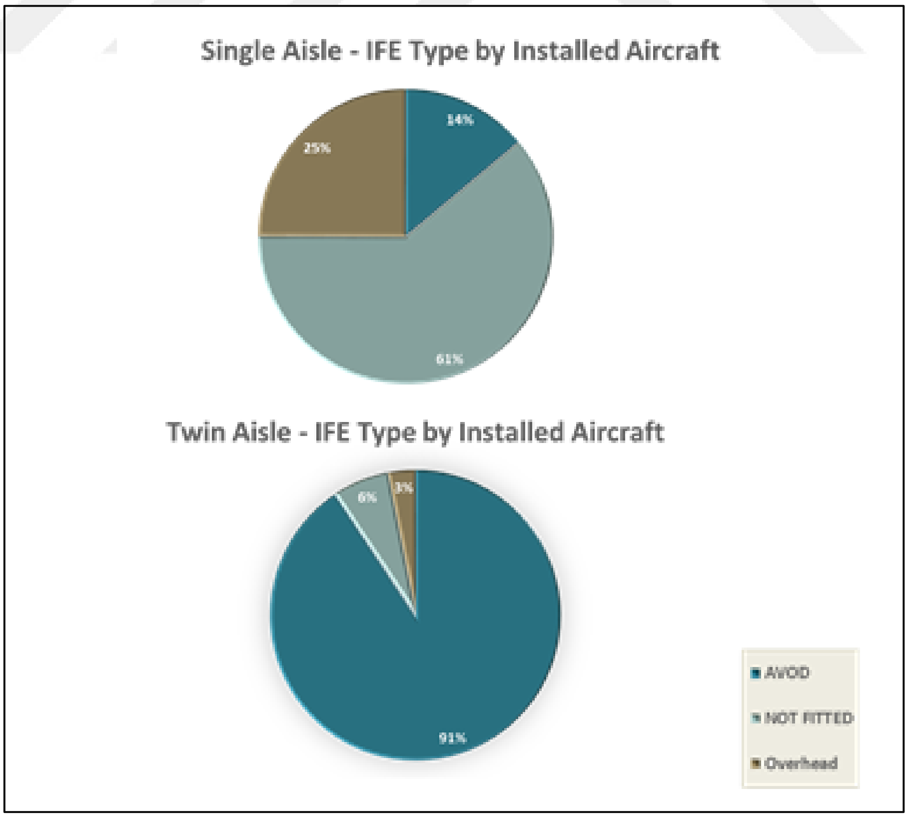
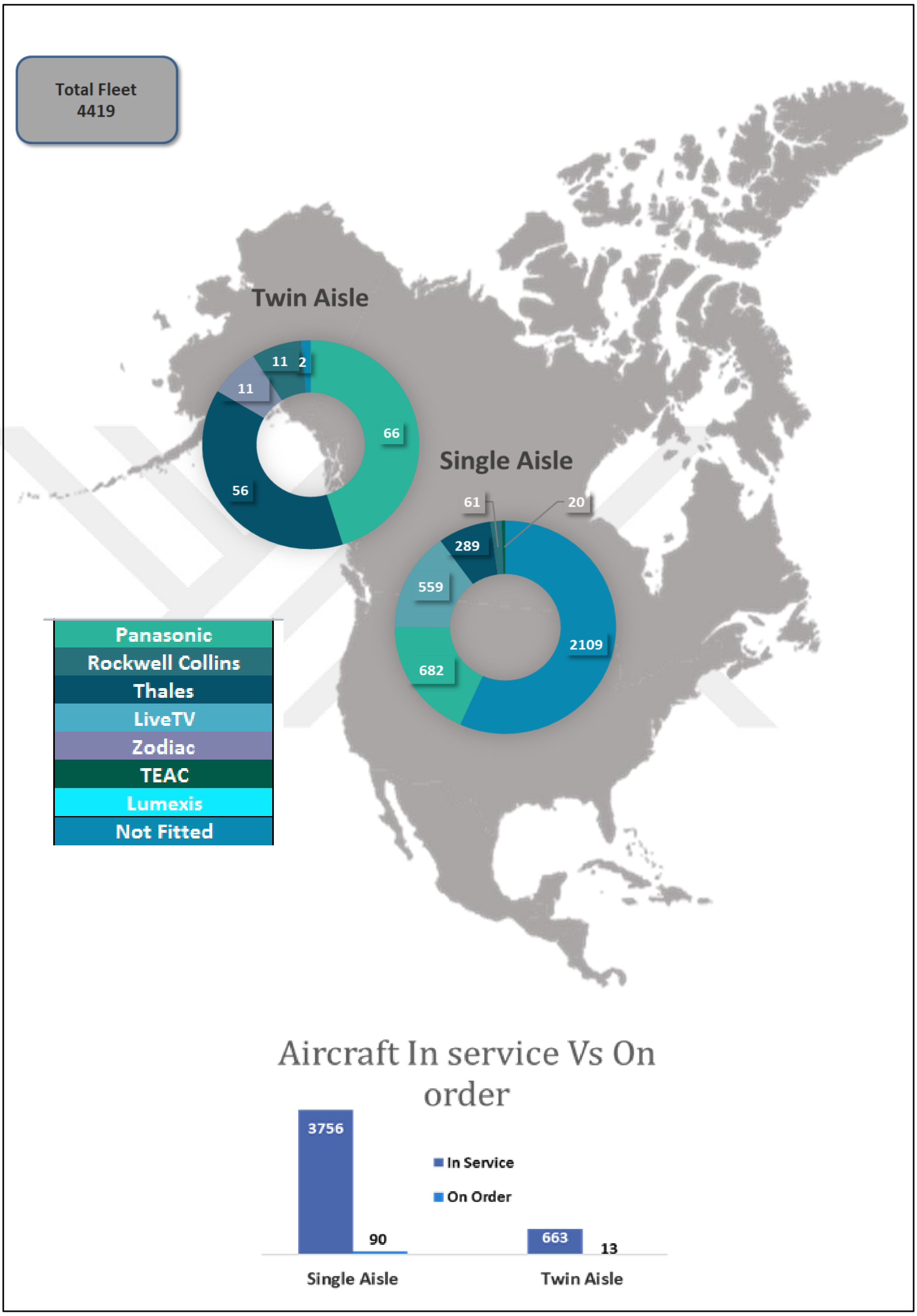



**Figure 1.6:** Aisle Types (Broadcast or AVOD)



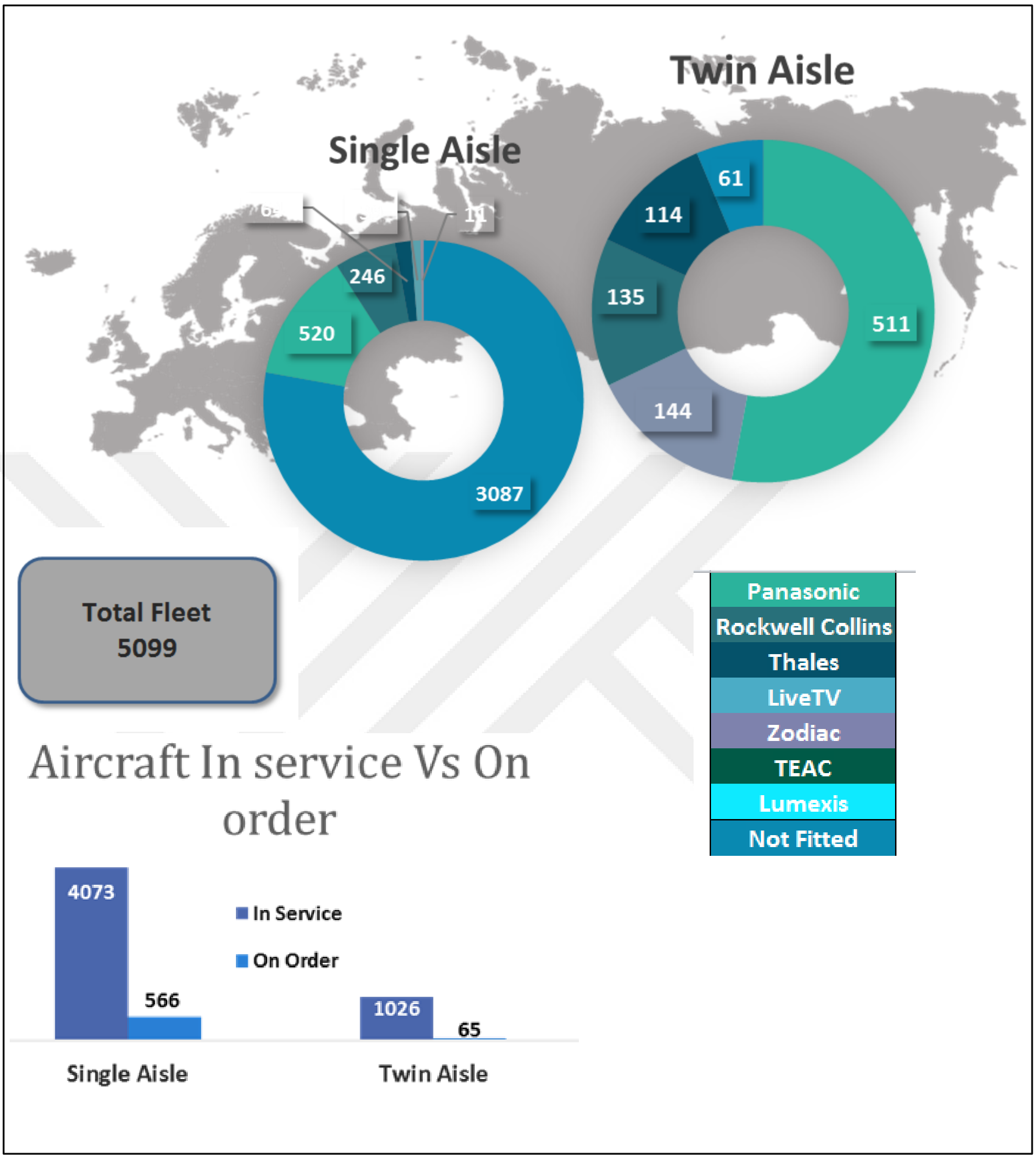

*Source:* (http://www.geemedia.com/services/research-consultancy#, 2017).

**Figure 1.7:** North America Fleet & IFE Suppliers




*Source:* (http://www.geemedia.com/services/research-consultancy#, 2017).

**Figure 1.8:** Europe Fleet & IFE Supplier

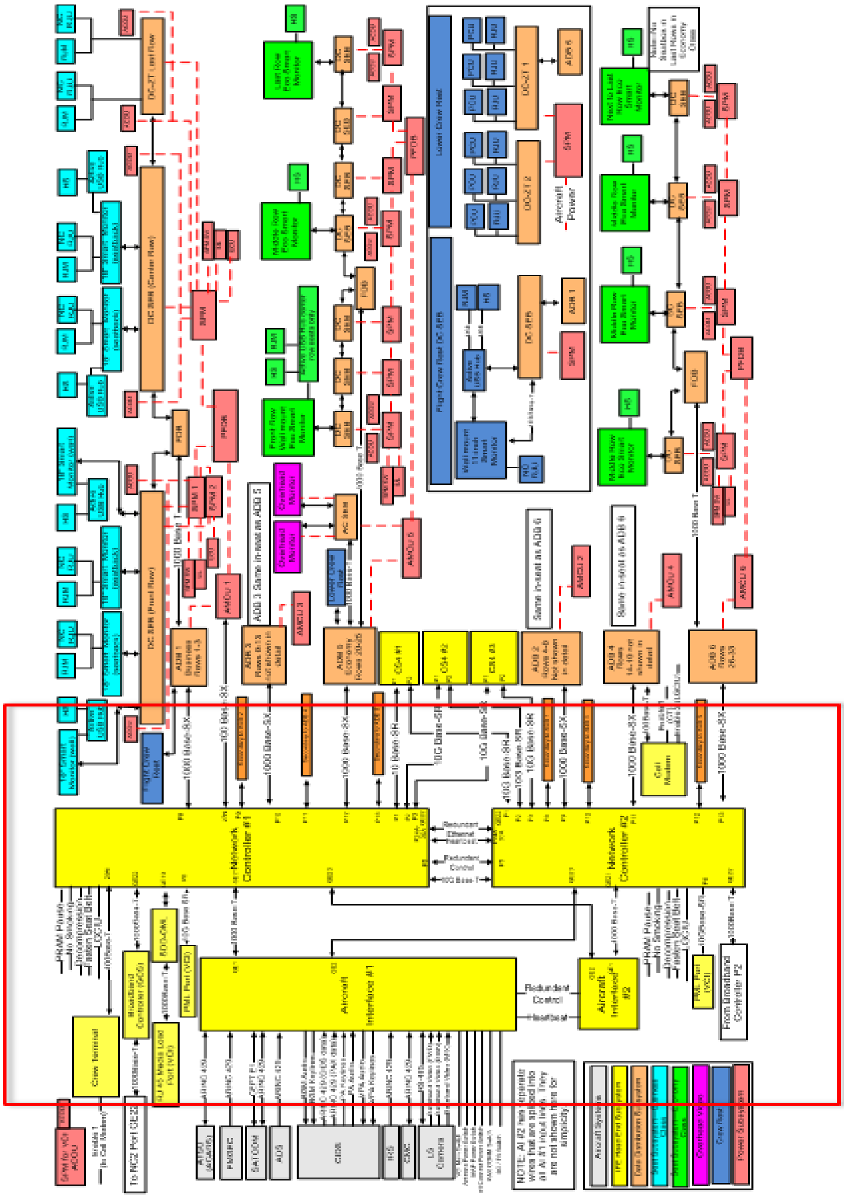



*Source:* (http://www.geemedia.com/services/research-consultancy#, 2017).

## Appendix A.2 IFE Subsystem

### Figure 2.1: Head-End IFE Subsystem of Panasonic eX3 System

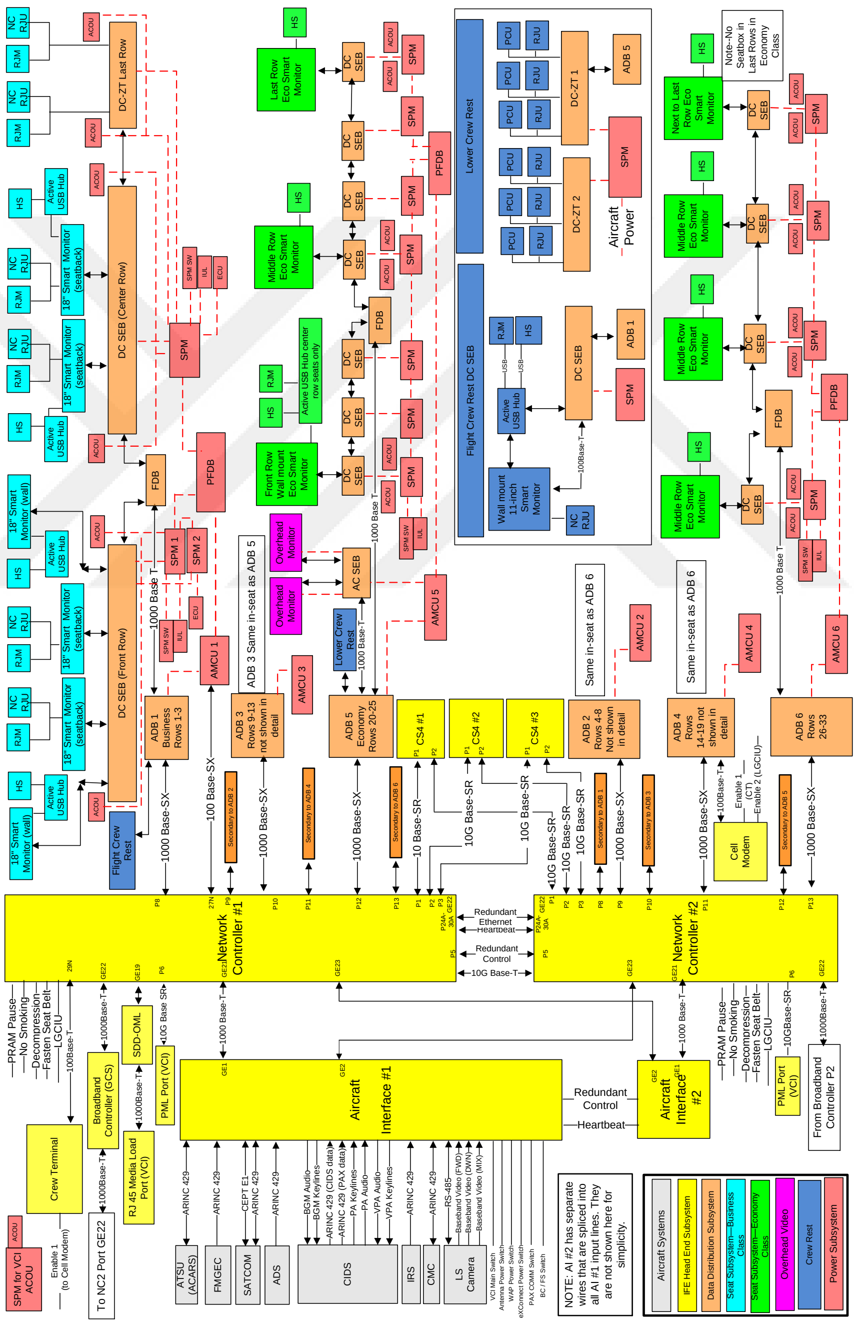
| LRU Name |
|---|
| Crew Terminal |
| Network Controllers |
| Aircraft Interfaces |
| Content Servers |
| SSD-OML |
| Cell Modem |
| Broadband Controller (GCS) |
| PML Port on VCI |



*Source:* (www.panasonic.aero, 2016)

## Figure 2.2: Cabin Distribution IFE Subsystem of Panasonic eX3 System

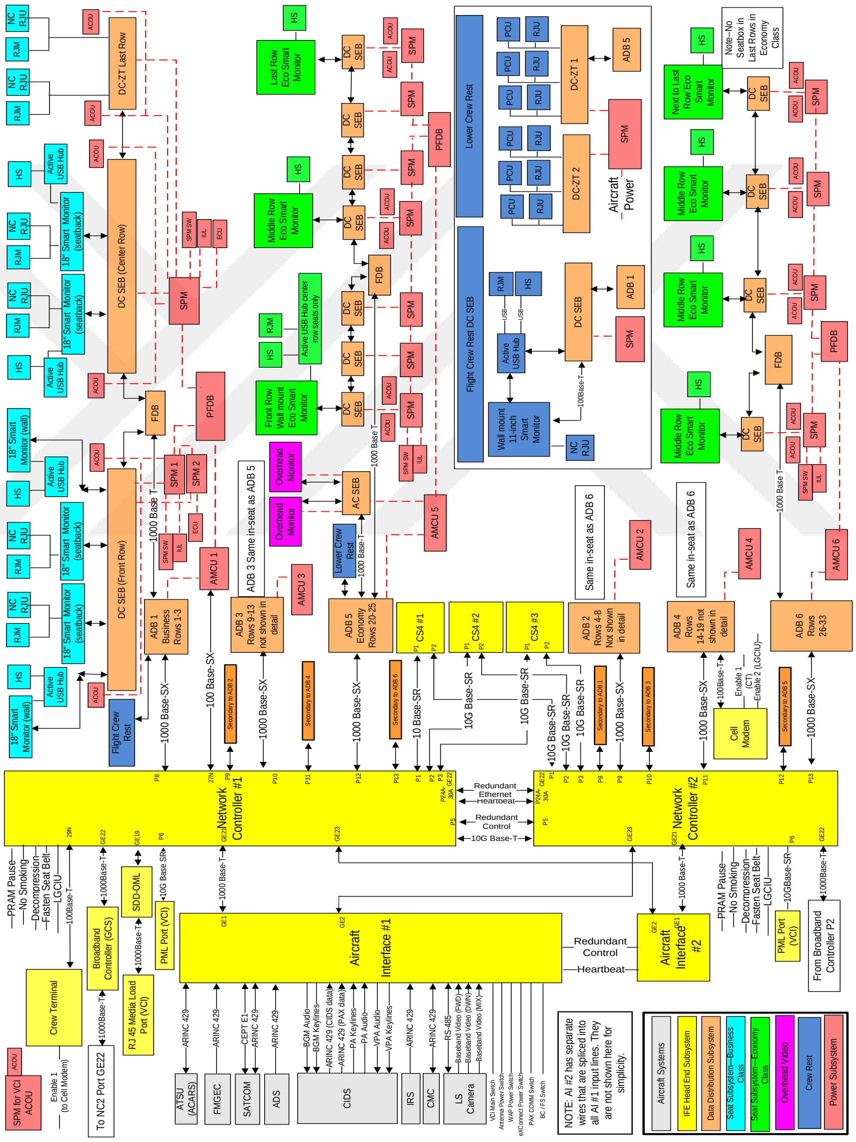
| LRU Name |
| --- |
| Area Distribution Boxes (six in total) |
| Floor Disconnect Boxes |
| DC Seat Electronics Box (DCSEB) |
| DC Zone Terminator (DCZT) |




*Source:* (www.panasonic.aero, 2016)

# Figure 2.3: Seat-End IFE Subsystem of Panasonic eX3 System

| LRU Name |
|---|
| 18” Elite Smart Monitor |
| Video Touchscreen Handset |
| Active USB Hub |
| Noise Cancelling Remote Jack Unit (NC-RJU) |
| USB Port (Remote Jack Module) |
| AC Outlet |



*Source:* (www.panasonic.aero, 2016)

## Appendix A.3 AMM Task Examples for EX3 IFE System (Boeing 777)

### Figure 3.1: An AMM Task for IFE System Initialization

**Panasonic Avionics Corporation**
**AIRCRAFT MAINTENANCE MANUAL SUPPLEMENT**
**eX3 with Global Communications Suite**

** ON A/C 001-016

**TASK 23-32-00-860-802**

**Log Out of the In-Flight Entertainment System**

1. Reason for the Job

   Log out of the In-Flight Entertainment System (IFES). Power off the IFES.

2. Job Set-up Information

   A. Referenced Information

| REFERENCE | DESIGNATION |
|---|---|
| 23-32-00-600-813 | Setting Flight and Entertainment Modes |
| 23-32-00-860-801 | Initialize the In-Flight Entertainment System |

3. Job Set-up

   Subtask 23-32-00-860-064

   A. Prerequisite

      (1) The IFES is initialized (Ref. TASK 23-32-00-860-801).

4. Procedure

   Subtask 23-32-00-860-067

   A. To log out of the IFES, do the steps that follow:

      (1) Close the flight (Ref. TASK 23-32-00-600-813).

   Subtask 23-32-00-860-063

   B. To power off the IFES, do the steps that follow:

      (1) Close the flight (Ref. TASK 23-32-00-600-813).

      (2) Put these switches to the OFF position:

      - IFE MSTR
      - IFE HEAD END
      - BROADBAND COM
      - MODULE PHONE PWR
      - CONNECTIVITY PWR
      - IFE SEAT END

EFF: TURKISH AIRLINES B777
001-016

**23-32-00**

Doc. No. 1000468

Page 2003
Mar 13/15

*Source:* (Panasonic Avionics Corporation, 2015)

**Figure 3.2: An AMM Task for IFE System Configuration Check**

**Panasonic Avionics Corporation**
**AIRCRAFT MAINTENANCE MANUAL SUPPLEMENT**
**eX3 with Global Communications Suite**

** **ON A/C 001-016**

**TASK 23-32-00-600-801**

**Configuration Check**

1. Reason for the Job

   To do a system, software, and component configuration check. Review the Content Status. Reference the Software Configuration Index (SCI) document that is shipped with the software.

2. Job Set-up Information

   A. Referenced Information

| REFERENCE | DESIGNATION |
|---|---|
| 23-32-00-860-801 | Initialize the In-Flight Entertainment System |
| 23-32-00-860-802 | Log Out of the In-Flight Entertainment System |
| Figure 3001 | |

3. Job Set-up

   Subtask 23-32-00-860-003

   A. Aircraft Maintenance Configuration

      (1) Initialize the In-Flight Entertainment System (IFES) (Ref. TASK 23-32-00-860-801).

4. Procedure

   Subtask 23-32-00-710-035

   (Refer to Figure 3001)

   A. To do a Configuration Check, do the steps that follow:

      (1) From the CABIN MAINTENANCE screen, open the Configuration folder, then select Config Check. The LMS CONFIG CHECK screen is shown.

      (2) From the LMS CONFIG CHECK screen, use the SCI document that is shipped with the software and make sure that the correct quantity of LRUs and their associated part numbers are reported, along with the correct software part numbers and versions.

      (3) If required, choose a specific LRU and then select the Details button to view specific details on the next LMS CONFIG CHECK screen.

         NOTE: If the LRU(s) is/are not yet reporting the correct information, allow the LRU(s) time to complete the download and boot-up process.

      (4) Select the Navigation icon to return to the CABIN MAINTENANCE Main Menu.

EFF: TURKISH AIRLINES B777
001-016

**23-32-00**
Doc. No. 1000468

Page 3003
Mar 13/15

*Source:* (Panasonic Avionics Corporation, 2015)

## Figure 3.3: An AMM Task for IFE System Configuration Check (cont.)

Panasonic Avionics Corporation
AIRCRAFT MAINTENANCE MANUAL SUPPLEMENT
eX3 with Global Communications Suite

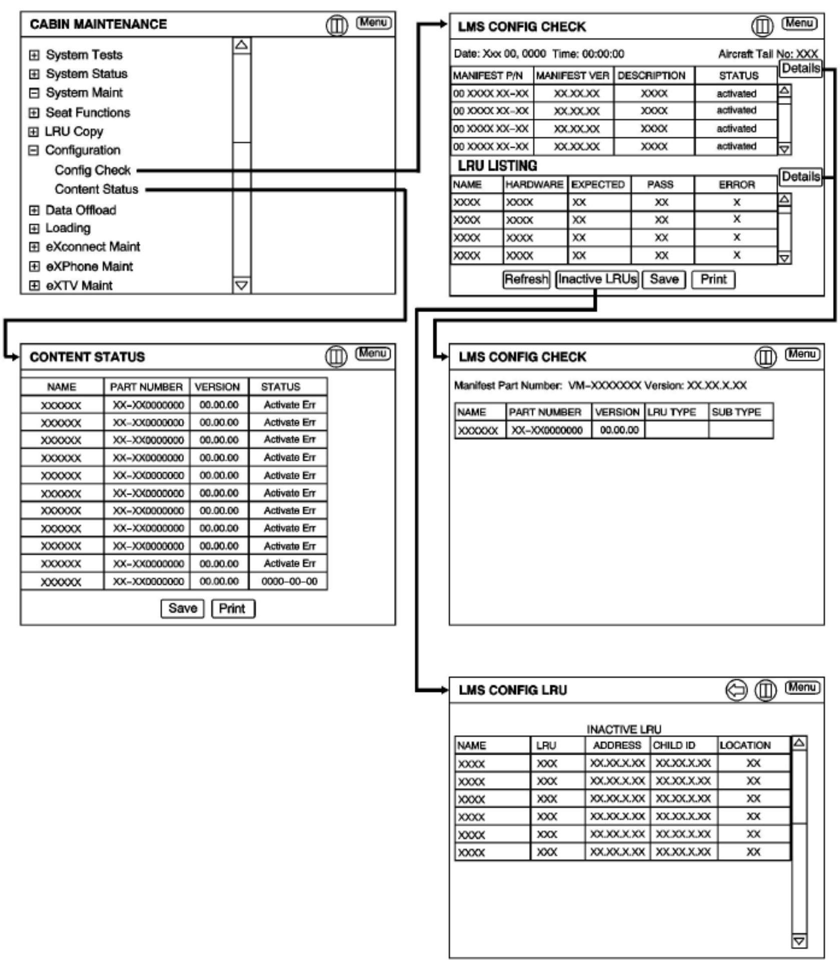



Figure 3001. Configuration - Config Check-Content Status - Maintenance Screens



*Source:* (Panasonic Avionics Corporation, 2015)

## Figure 3.4: An AMM Task for IFE System All Test

**Panasonic Avionics Corporation**
**AIRCRAFT MAINTENANCE MANUAL SUPPLEMENT**
**eX3 with Global Communications Suite**

**** ON A/C 001-016**

**TASK 23-32-00-740-802**

**All Test (BITE)**

1. Reason for the Job

   To identify comprehensive faults of the current flight. The All Test is an intrusive test and should be done when comprehensive results are required.

2. Job Set-up Information

   A. Referenced Information

| REFERENCE | DESIGNATION |
|---|---|
| 23-32-00-860-801 | Initialize the In-Flight Entertainment System |
| 23-32-00-860-802 | Log Out of the In-Flight Entertainment System |
| Figure 5002 | |

3. Job Set-up

   Subtask 23-32-00-860-018

   A. Aircraft Maintenance Configuration

      (1) Initialize the In-Flight Entertainment System (IFES) (Ref. TASK 23-32-00-860-801).

4. Procedure

   Subtask 23-32-00-740-006

   (Refer to Figure 5002)

   A. To do the All Test (BITE), do the steps that follow:

      NOTE: When an All Test is done, the system LRUs stop functioning in whatever mode they are in, then they do a self-test analysis, report any faults, and then pick up from the point where they stopped functioning. If video has been stopped, it will resume at the beginning of the video, not at the point of stoppage.

      (1) From the CABIN MAINTENANCE screen, open the System Tests folder, then select Start All Test. The ALL TEST screen is shown.

      (2) If further details are required, select the Details button.

      (3) From the ALL TEST DETAILS screen, review the details and do the recommended maintenance actions.

      (4) Select the Navigation icon to return to the CABIN MAINTENANCE Main Menu.

EFF: TURKISH AIRLINES B777
001-016

**23-32-00**

Doc. No. 1000468

Page 5005
Mar 13/15

*Source:* (Panasonic Avionics Corporation, 2015)

**Figure 3.5: An AMM Task for IFE System All Test (cont.)**



Subtask 23-32-00-740-007

(Refer to Figure 5002)

B. To review the All Test results, do the steps that follow:

(1) From the CABIN MAINTENANCE screen, open the System Tests folder, then select Review All Test. The ALL TEST screen is shown.

(2) From the ALL TEST screen, review the test results.

(3) If further details are required, select the Details button.

(4) From the ALL TEST DETAILS screen, review the details and do the recommended maintenance actions.

(5) Select the Navigation icon to return to the CABIN MAINTENANCE Main Menu.

5. Close-up

Subtask 23-32-00-860-019

A. Put the aircraft back to its initial configuration.

(1) Log Out of the IFES (Ref. TASK 23-32-00-860-802).

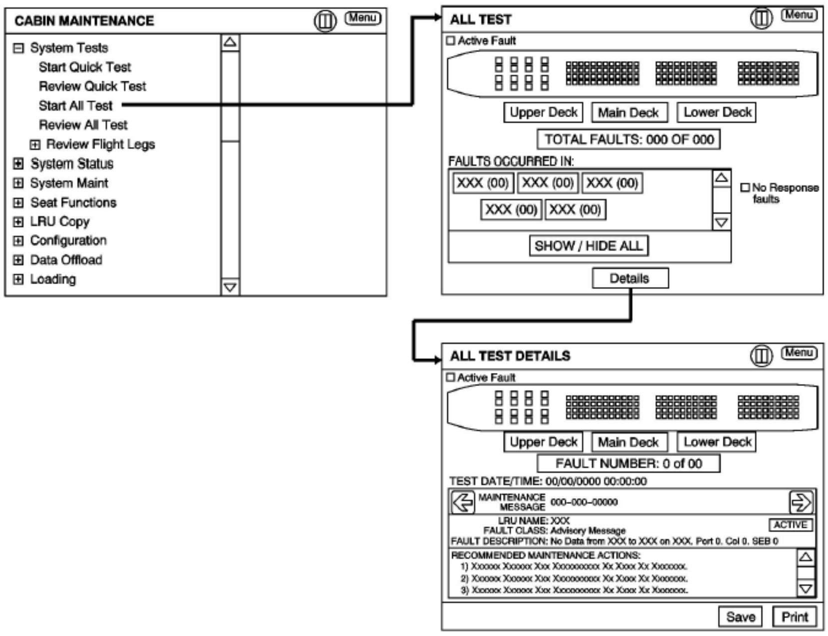
NOTE: Do this task as necessary if you are at the end of the test sequence.



*Source:* (Panasonic Avionics Corporation, 2015)

## Figure 3.6: An AMM Task for IFE System All Test (cont.)

Panasonic Avionics Corporation
AIRCRAFT MAINTENANCE MANUAL SUPPLEMENT
eX3 with Global Communications Suite




NOTE:
THE LOPA(S) SHOWN IN THE ILLUSTRATION REPRESENT
A NON-SPECIFIC AIRCRAFT CONFIGURATION.

L_MM_233200_5_0002_01_00

Figure 5002. System Tests - All Test - Maintenance Screens

EFF: TURKISH AIRLINES B777
001-016

**23-32-00**

Doc. No. 1000468

Page 5007
Mar 13/15

*Source*: (Panasonic Avionics Corporation, 2015)

**Figure 3.7: An AMM Task for IFE System Head-End Removal (ADB Removal Task)**

777 – AMM THY D633W101-THY
Rev 81 - 05 Sep 2017

BOEING

Printed by Toolbox: 13 Dec 2017, 05:15:49 PST
DO NOT USE AFTER 12 Jan 2018

TASK 44-25-20-000-801 Area Distribution Box (ADB) Removal

Issue Date: 05 Sep 2017

EFFECTIVITY: THY 001-030, 035-037

**TASK 44-25-20-000-801**

2. **Area Distribution Box (ADB) Removal** (Figure 401)

A. References

| Reference | Title |
|---|---|
| 20-41-01-000-803 | ESDS Handling for Metal Encased Unit Removal (P/B 201) |
| 25-21-06-000-801 | Main Ceiling Panel - Removal (P/B 401) |

B. Tools/Equipment

**NOTE: When more than one tool part number is listed under the same "Reference" number, the tools shown are alternates to each other within the same airplane series. Tool part numbers that are replaced or non-procurable are preceded by "Opt:", which stands for Optional.**

| Reference | Description |
|---|---|
| SPL-1541 | Platform - Access, Cabin Crown<br>**777-300ER**<br>(Part #: 1107WSCHSK, Supplier: 6Y876)<br>(Opt Part #: J12005-1, Supplier: 81205) |
| STD-1048 | Stepladder - 6 foot (1.83m) |

C. Location Zones

| Zone | Area |
|---|---|
| 200 | Upper Half of Fuselage |

D. Removal Procedure

SUBTASK 44-25-20-865-001

(1) Open these circuit breakers and install safety tags:

Left Power Management Panel, P110

| Row | Col | Number | Name |
|---|---|---|---|
| A | 24 | (C23366) | IFE ZIA 2B |
| **THY 001-030** | | | |
| A | 27 | (C23365) | IFE ZIA 2A |
| **THY 035-037** | | | |
| A | 27 | (C23373) | IFE ZIA 2A |
| **THY 001-030, 035-037** | | | |
| H | 13 | (C23367) | IFE ZIA 3A |
| J | 13 | (C23368) | IFE ZIA 3B |

Right Power Management Panel, P210

| Row | Col | Number | Name |
|---|---|---|---|
| **THY 013-016** | | | |

Selected Customer Effectivity Code 029 BOEING PROPRIETARY - Copyright © - Unpublished Work - See title page for details Page 1 of 5

*Source*: (Boeing, 2017)

**Figure 3.8: An AMM Task for IFE System Head-End Removal (ADB Removal Task)**

777 – AMM THY D633W101-THY
Rev 81 - 05 Sep 2017

BOEING

Printed by Toolbox: 13 Dec 2017, 05:15:49 PST
DO NOT USE AFTER 12 Jan 2018

TASK 44-25-20-000-801 Area Distribution Box (ADB) Removal — Issue Date: 05 Sep 2017

EFFECTIVITY: THY 001-030, 035-037

| | | | |
|---|---|---|---|
| A | 5 | (C23363) | IFE ZIA 1A |
| **THY 001-012, 017-030, 035-037** | | | |
| A | 5 | (C23371) | IFE ZIA 1A |
| **THY 013-016** | | | |
| B | 2 | (C23364) | IFE ZIA 1B |
| **THY 001-012, 017-030, 035-037** | | | |
| B | 2 | (C23372) | IFE ZIA 1B |
| **THY 001-030, 035-037** | | | |
| K | 20 | (C23370) | IFE ZIA 4B |
| K | 23 | (C23369) | IFE ZIA 4A |
| L | 23 | (C24688) | IFE SEATS FLT DECK SW |

SUBTASK 44-25-20-010-001

(2) To get access to the ADB, do this task: Main Ceiling Panel - Removal, TASK 25-21-06-000-801.

SUBTASK 44-25-20-500-001

(3) Use the cabin crown access platform, SPL-1541 or a 6 foot (1.83m) stepladder, STD-1048 to get access to the ADB.

SUBTASK 44-25-20-910-001

**CAUTION: DO NOT TOUCH THE UNIT BEFORE YOU DO THE PROCEDURE FOR DEVICES THAT ARE SENSITIVE TO ELECTROSTATIC DISCHARGE. ELECTROSTATIC DISCHARGE CAN CAUSE DAMAGE TO THE UNIT.**

(4) Before you touch the unit, refer to this task: ESDS Handling for Metal Encased Unit Removal, TASK 20-41-01-000-803.

SUBTASK 44-25-20-020-001

**WARNING: MAKE SURE THAT THE CONNECTORS ARE DISCONNECTED FROM THE EQUIPMENT AT THE TWO ENDS. OR SET THE EQUIPMENT TO OFF. THERE IS A RISK OF LASER RADIATION THAT YOU WILL NOT SEE. LASER RADIATION IS DANGEROUS FOR YOUR EYES.**

**WARNING: ALWAYS USE GLOVES IF YOU MUST TOUCH BROKEN FIBER-OPTIC CABLES. IF YOU TOUCH CABLES WITH YOUR BARE HANDS, FIBERS CAN GO INTO YOUR BODY THROUGH YOUR SKIN. THIS WILL CAUSE YOU INJURY.**

**CAUTION: INSTALL THE PROTECTIVE CAPS IMMEDIATELY AFTER YOU DISCONNECT THE CABLE. IT IS EASY TO CAUSE DAMAGE TO THE FIBER-OPTIC CABLE.**

**CAUTION: DO NOT BEND THE FIBER-OPTIC CABLE MORE THAN THE MINIMUM BEND RADIUS. THE CABLE IS EASILY DAMAGED.**

**CAUTION: DO NOT PULL OR PUSH THE FIBER-OPTIC CABLE. THE CABLE IS EASILY DAMAGED.**

(5) Remove the ADB from the adapter assembly:

(a) For the spring-latched electrical connectors [4], release the spring latches.

1) Attach an identification tag on the electrical connectors [4] and the fiber optic connector [6].

(b) Disconnect the electrical connectors [4] and the fiber optic connector [6].

Selected Customer Effectivity Code 029 — BOEING PROPRIETARY - Copyright © - Unpublished Work - See title page for details — Page 2 of 5

*Source*: (Boeing, 2017)

## Figure 3.9: An AMM Task for IFE System Head-End Removal (ADB Removal Task)

777 – AMM THY D633W101-THY
Rev 81 - 05 Sep 2017

BOEING

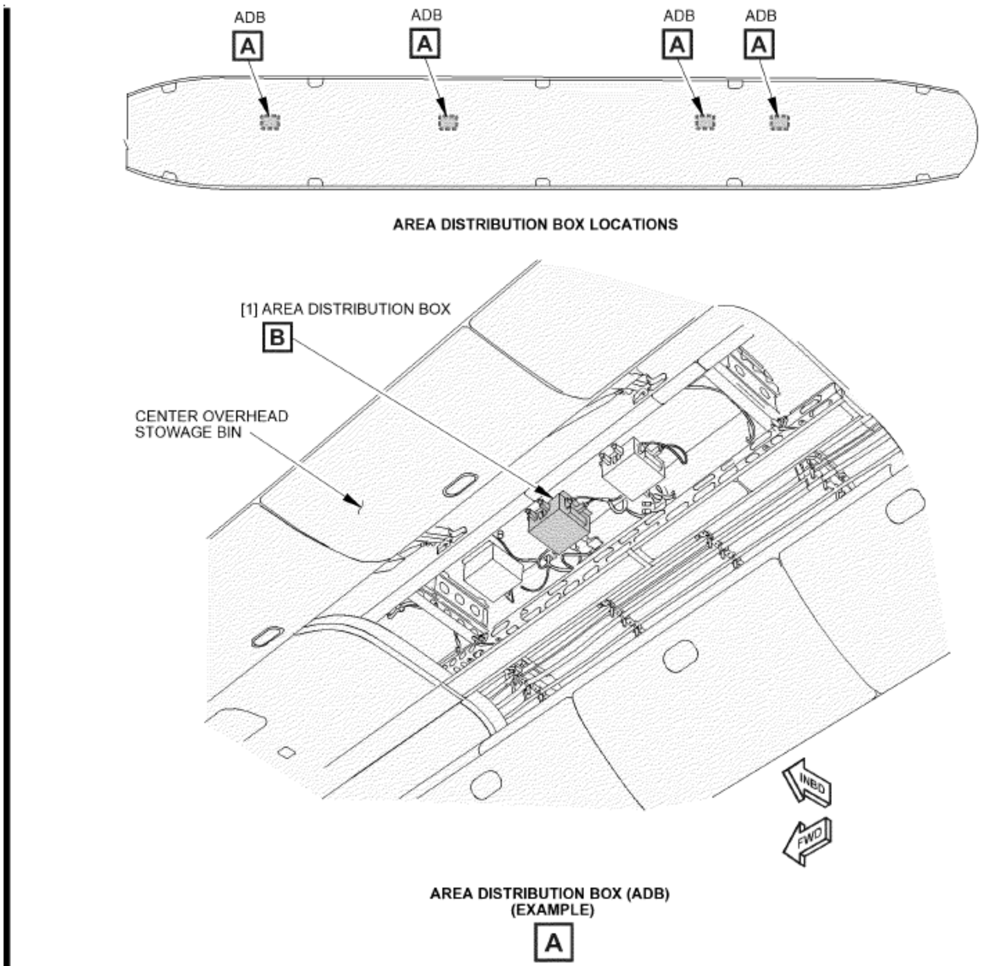
Printed by Toolbox: 13 Dec 2017, 05:15:49 PST
DO NOT USE AFTER 12 Jan 2018

TASK 44-25-20-000-801 Area Distribution Box (ADB) Removal

Issue Date: 05 Sep 2017

EFFECTIVITY: THY 001-030, 035-037

Fig. Issue Date: 05 Sep 2017




NOTE:
THE ADB IS ALSO KNOWN AS AN ENHANCED AREA DISTRIBUTION BOX (EABD)

1322574 S0000232987_V2

Figure 401. Area Distribution Box (ADB) Installation - Sheet 1

Selected Customer Effectivity Code 029

BOEING PROPRIETARY - Copyright © - Unpublished Work - See title page for details

Page 4 of 5

*Source:* (Boeing, 2017)

**Figure 3.10: An AMM Task for IFE System Head-End Removal (ADB Removal Task)**

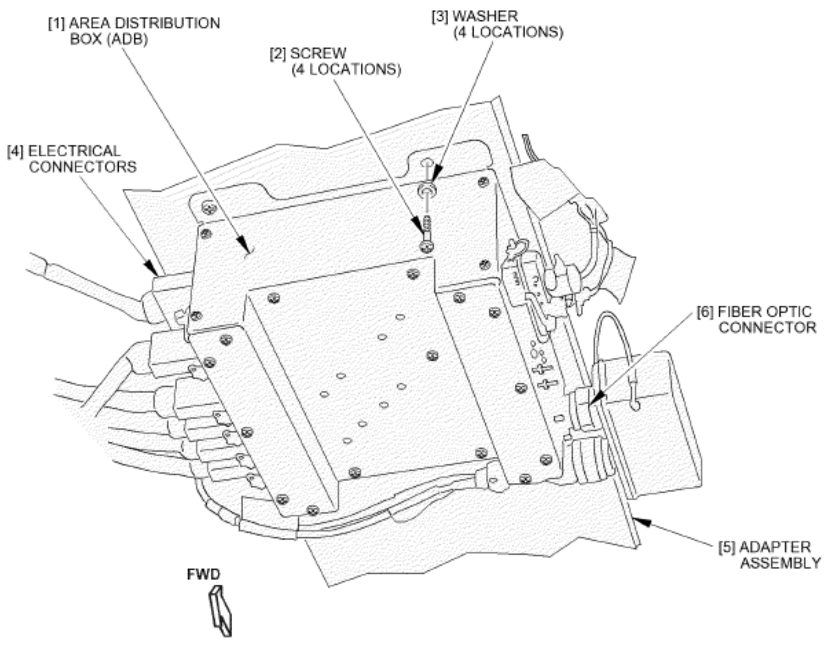
777 – AMM THY D633W101-THY
Rev 81 - 05 Sep 2017

Printed by Toolbox: 13 Dec 2017, 05:15:49 PST
DO NOT USE AFTER 12 Jan 2018

TASK 44-25-20-000-801 Area Distribution Box (ADB) Removal
EFFECTIVITY: THY 001-030, 035-037

Issue Date: 05 Sep 2017

Fig. Issue Date: 05 Sep 2017




AREA DISTRIBUTION BOX (ADB)
(EXAMPLE)
B

1332645 S0000235682_V3

Figure 401. Area Distribution Box (ADB) Installation - Sheet 2

Selected Customer Effectivity Code 029



Page 5 of 5

*Source:* (Boeing, 2017)

## Appendix A.4 Capability List of Turkish Technic

**Figure 4.1: Maintenance Organization Approval Schedule**

SİVİL HAVACILIK GENEL MÜDÜRLÜĞÜ
*DIRECTORATE GENERAL OF CIVIL AVIATION*

**BAKIM KURULUŞU ONAY KAPSAMI**
*MAINTENANCE ORGANISATION APPROVAL SCHEDULE*

**TÜRK HAVA YOLLARI TEKNİK A.Ş.**

Sabiha Gökçen Havalimanı E Kapısı 34912
Pendik/İSTANBUL

Onay/*Reference* : TR.145.001

| SINIF *Class* | KATEGORİ *Rating* | SINIRLAMA *Limitation* | ÜS *Base* | HAT *Line* |
|---|---|---|---|---|
| HAVA ARACI *(AIRCRAFT)* | A1 5700 kg üzeri uçaklar *(Aeroplanes above 5700 kg)* | Airbus A300 basic model (GE CF6) | X | X |
| | | Airbus A300-600 (GE CF6) | X | X |
| | | Airbus A300-600 (PW 4000) | X | X |
| | | Airbus A310 (GE CF6) | X | X |
| | | Airbus A318/A319/A320/A321 (CFM56) | X | X |
| | | Airbus A319/A320/A321 (IAE V2500) | X | X |
| | | Airbus A330 (GE CF6) | X | X |
| | | Airbus A330 (PW 4000) | X | X |
| | | Airbus A330 (RR RB 211 Trent 700) | X | X |
| | | Airbus A340 (CFM56) | X | X |
| | | Airbus A340 (RR RB211 Trent 500) | X | X |
| | | Boeing 737-300/400/500 (CFM56) | X | X |

İlk düzenlenme tarihi *Date of original Issue* : 12/09/2005
Düzenlenme tarihi *Date of this revision* 30/05/2017
Revizyon *Revision* : 12

Yetkili Otorite adına: SHGM
*For the competent authority: Turkish DGCA*

Gaye Betül DOĞAN
Genel Müdür Yrd. V.
*Acting Deputy Director General*

T.C. Ulaştırma Denizcilik ve Haberleşme Bakanlığı

DGCA / SHGM SHY-145
Sayfa *Page* 2 / 7

*Source:* (Turkish Technic, 2017)

**Figure 4.2: Maintenance Organization Approval Schedule (cont.)**

SİVİL HAVACILIK GENEL MÜDÜRLÜĞÜ
*DIRECTORATE GENERAL OF CIVIL AVIATION*

**BAKIM KURULUŞU ONAY KAPSAMI**
*MAINTENANCE ORGANISATION APPROVAL SCHEDULE*

**TÜRK HAVA YOLLARI TEKNİK A.Ş.**

Sabiha Gökçen Havalimanı E Kapısı 34912
Pendik/İSTANBUL

Onay/*Reference* : TR.145.001

| SINIF *Class* | KATEGORİ *Rating* | SINIRLAMA *Limitation* | ÜS *Base* | HAT *Line* |
|---|---|---|---|---|
| HAVA ARACI (AIRCRAFT) | A1 5700 kg üzeri uçaklar (Aeroplanes above 5700 kg) | Boeing 737-600/700/800/900 (CFM56) | X | X |
| | | Boeing 757-200/300 (RR RB211)(PW 2000) | X | X |
| | | Boeing 727 (PW JT8D) | X | X |
| | | Boeing 767-200/300 (GE CF6)(PW 4000) | X | X |
| | | Boeing 767-400 (GE CF6) | | X |
| | | Boeing 777-200/300 (GE 90) | X | X |
| | | Boeing 787-8-9 (GE Genx) | | X |
| | | Gulfstream G-IV Series (RRD Tay) | X | X |
| | | Gulfstream GV-SP Series (RRD BR710) | X | X |
| | | Gulfstream GIV-X Series (RRD Tay) | X | X |
| | | Cessna 560(PWC JT15D) | | X |
| | | Bombardier CL-600-2B19 (GE CF34) | | X |

İlk düzenlenme tarihi *Date of original Issue* : 12/09/2005
Düzenlenme tarihi *Date of this revision* : 30./05/2017
Revizyon *Revision* : 12

Yetkili Otorite adına: SHGM
*For the competent authority: Turkish DGCA*

Gaye Betül DOĞAN
Genel Müdür Yrd. V.
*Acting Deputy Director General*

T.C. Ulaştırma Denizcilik ve Haberleşme Bakanlığı

DGCA / SHGM SHY-145
Sayfa *Page* 3 / 7

*Source:* (Turkish Technic, 2017)

## Appendix A.5 Aircraft ATA Chapters Lists

- **00:** Introduction / Aircraft General
- **01-04:** Operations Information
- **05:** Periodic Inspections
- **06:** Dimensions and Areas
- **07:** Lifting & Shoring
- **08:** Leveling & Weighing
- **09:** Towing & Taxiing
- **10:** Parking, Mooring, Storage & Return To Service
- **11:** Placards & Markings
- **12:** Servicing Routine Maintenance
- **13-17:** Unassigned
- **18:** Vibration & Noise Analysis (Helicopter Only)
- **19:** Unassigned

### Airframe Systems

- **20:** Standard Practices-Airframe
- **21:** Air Conditioning
- **22:** Auto Flight
- **23:** Communications
- **24:** Electrical Power
- **25:** Equipment / Furnishings
- **26:** Fire Protection
- **27:** Flight Controls
- **28:** Fuel
- **29:** Hydraulic Power
- **30:** Ice & Rain Protection
- **31:** Indicating / Recording Systems
- **32:** Landing Gear
- **33:** Lights
- **34:** Navigation
- **35:** Oxygen
- **36:** Pneumatic
- **37:** Vacuum
- **38:** Water / Waste
- **39:** Electrical Electronic Panels & Multipurpose Compost -UNASSIGNED 2006
- **41:** Water Ballast
- **42:** Integrated Modular Avionics
- **44:** Cabin Systems
- **45:** Central Maintenance System (CMS)
- **46:** Information Systems
- **47:** Inert Gas System
- **49:** Airborne Auxiliary Power

## Appendix A.5 Aircraft ATA Chapters Lists

### Structures

- **50:** Cargo and Accessory Compartments
- **51:** Standard Practices & Structures General
- **52:** Doors
- **53:** Fuselage
- **54:** Nacelles / Pylons
- **55:** Stabilizers
- **56:** Windows
- **57:** Wings

### Propeller / Rotor

- **60:** Standard Practices-Propeller / Rotor
- **61:** Propellers / Propulsion
- **62:** Rotors
- **63:** Rotor Drive(s)
- **64:** Tail Rotor
- **65:** Tail Rotor Drive
- **66:** Folding Blades & Tail Pylon
- **67:** Rotors Flight Control

### Power Plant

- **70:** Standard Practices Engine
- **71:** Power Plant General
- **72:** Engine Turbine/Turboprop, Ducted Fan/Unducted Fan
- **72(R):** Engine - Reciprocating
- **73:** Engine Fuel & Control
- **74:** Ignition
- **75:** Air
- **76:** Engine Controls
- **77:** Engine Indicating
- **78:** Exhaust
- **79:** Oil
- **80:** Starting
- **81:** Turbines
- **82:** Water Injection
- **83:** Accessory Gear Boxes
- **84:** Propulsion Augmentation

## Appendix A.5 Aircraft ATA Chapters Lists

### Others

- **91: Charts**
- **97: Wiring Reporting**
- **100: Manufacturers Technical Data**
- **101: Specification For Ground Equipment Technical Data**
- **102: Computer Software Manual**
- **103: Standarts For Jet Fuel Quality Control At Airports**
- **104: Guidelines For Aircraft Maintenance Training**
- **105: Guidelines For Training And Qualifying Personnel In Non Destructive Testing Methods**
- **106: Sources And Approved Parts Qualification Guidelines**
- **115: Flight Simulator Systems**
- **116: Flight Simulator Cuing Systems**
- **117: Wiring Maintenance Practices/Guidelines**
- **300: Packaging of Airline Supplies**

*Source:* (Aviation Maintenance, 2017)

# Appendix A.6 Data Set of Ground Time

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | TOTAL | PAZARTESİ | | | SALI | | | ÇARŞAMBA | | | PERŞEMBE | | | CUMA | | | CUMARTESİ | | | PAZAR | | | Grand Total |
| 3 | Row Labels | EVENING | MORNIN | NIGHT | EVENING | MORNIN | NIGHT | EVENING | MORNIN | NIGHT | EVENING | MORNIN | NIGHT | EVENING | MORNIN | NIGHT | EVENING | MORNIN | NIGHT | EVENING | MORNIN | NIGHT | |
| 4 | 01.01.2017 | 547,87 | 868,15 | 352,33 | | | | | | | | | | | | | | | | | | | 1768,35 |
| 5 | 02.01.2017 | | | | 543,45 | 724,03 | 289,52 | | | | | | | | | | | | | | | | 1557 |
| 6 | 03.01.2017 | | | | | | | 588,09 | 677,54 | 301,02 | | | | | | | | | | | | | 1566,65 |
| 7 | 04.01.2017 | | | | | | | | | | 534,44 | 743,37 | 300,99 | | | | | | | | | | 1578,8 |
| 8 | 05.01.2017 | | | | | | | | | | | | | 553,05 | 730,76 | 326,27 | | | | | | | 1610,08 |
| 9 | 06.01.2017 | | | | | | | | | | | | | | | | 383,36 | 804,32 | 75,29 | | | | 1262,97 |
| 10 | 07.01.2017 | | | | | | | | | | | | | | | | | | | 189,07 | 132,75 | 203,64 | 525,46 |
| 11 | 08.01.2017 | 262,43 | 134,27 | 311,21 | | | | | | | | | | | | | | | | | | | 707,91 |
| 12 | 09.01.2017 | | | | 651,63 | 449 | 363,13 | | | | | | | | | | | | | | | | 1463,76 |
| 13 | 10.01.2017 | | | | | | | 460,75 | 365,57 | 241,37 | | | | | | | | | | | | | 1067,69 |
| 14 | 11.01.2017 | | | | | | | | | | 598,52 | 775,82 | 331,55 | | | | | | | | | | 1705,89 |
| 15 | 12.01.2017 | | | | | | | | | | | | | 436,25 | 769,5 | 255,86 | | | | | | | 1461,61 |
| 16 | 13.01.2017 | | | | | | | | | | | | | | | | 544,94 | 767,91 | 288,36 | | | | 1601,21 |
| 17 | 14.01.2017 | | | | | | | | | | | | | | | | | | | 536,7 | 632,58 | 325,73 | 1495,01 |
| 18 | 15.01.2017 | 450,7 | 723,83 | 326,46 | | | | | | | | | | | | | | | | | | | 1500,99 |
| 19 | 16.01.2017 | | | | 464,78 | 646,99 | 333,74 | | | | | | | | | | | | | | | | 1445,51 |
| 20 | 17.01.2017 | | | | | | | 581,69 | 623,35 | 288,85 | | | | | | | | | | | | | 1493,89 |
| 21 | 18.01.2017 | | | | | | | | | | 493,74 | 665,26 | 360,55 | | | | | | | | | | 1519,55 |
| 22 | 19.01.2017 | | | | | | | | | | | | | 428,81 | 683,25 | 298,45 | | | | | | | 1410,51 |
| 23 | 20.01.2017 | | | | | | | | | | | | | | | | 516,75 | 635,28 | 308,85 | | | | 1460,88 |
| 24 | 21.01.2017 | | | | | | | | | | | | | | | | | | | 486,73 | 699,98 | 273,35 | 1460,06 |
| 25 | 22.01.2017 | 407,77 | 673,4 | 281,13 | | | | | | | | | | | | | | | | | | | 1362,3 |
| 26 | 23.01.2017 | | | | 521,13 | 624,61 | 328,49 | | | | | | | | | | | | | | | | 1474,23 |
| 27 | 24.01.2017 | | | | | | | 574,18 | 683,96 | 322,99 | | | | | | | | | | | | | 1581,13 |
| 28 | 25.01.2017 | | | | | | | | | | 492,86 | 718,19 | 376,85 | | | | | | | | | | 1587,9 |
| 29 | 26.01.2017 | | | | | | | | | | | | | 453,84 | 664,55 | 331,9 | | | | | | | 1450,29 |
| 30 | 27.01.2017 | | | | | | | | | | | | | | | | 635,65 | 844,22 | 423,32 | | | | 1903,19 |
| 31 | 28.01.2017 | | | | | | | | | | | | | | | | | | | 600,03 | 770,05 | 291,31 | 1661,39 |
| 32 | 29.01.2017 | 452,1 | 810,63 | 311,96 | | | | | | | | | | | | | | | | | | | 1574,69 |
| 33 | 30.01.2017 | | | | 452,01 | 707,35 | 369,3 | | | | | | | | | | | | | | | | 1528,66 |
| 34 | 31.01.2017 | | | | | | | 543,51 | 765,05 | 344,71 | | | | | | | | | | | | | 1653,27 |
| 35 | 01.02.2017 | | | | | | | | | | 462,87 | 786,06 | 341,13 | | | | | | | | | | 1590,06 |
| 36 | 02.02.2017 | | | | | | | | | | | | | 441,48 | 806,38 | 305,85 | | | | | | | 1553,71 |
| 37 | 03.02.2017 | | | | | | | | | | | | | | | | 486,13 | 773,81 | 307,82 | | | | 1567,76 |
| 38 | 04.02.2017 | | | | | | | | | | | | | | | | | | | 447,27 | 676,72 | 266,74 | 1390,73 |
| 39 | 05.02.2017 | 458,82 | 738,28 | 264,67 | | | | | | | | | | | | | | | | | | | 1461,77 |
| 40 | 06.02.2017 | | | | 484,66 | 653,22 | 305,21 | | | | | | | | | | | | | | | | 1443,09 |
| 41 | 07.02.2017 | | | | | | | 571,96 | 773,89 | 344,1 | | | | | | | | | | | | | 1689,95 |
| 42 | 08.02.2017 | | | | | | | | | | 526,48 | 823,12 | 429,71 | | | | | | | | | | 1779,31 |
| 43 | 09.02.2017 | | | | | | | | | | | | | 548,62 | 725,02 | 330,21 | | | | | | | 1603,85 |
| 44 | 10.02.2017 | | | | | | | | | | | | | | | | 584,36 | 837,74 | 367,05 | | | | 1789,15 |
| 45 | 11.02.2017 | | | | | | | | | | | | | | | | | | | 455,49 | 725,32 | 345,39 | 1526,2 |
| 46 | 12.02.2017 | 483,36 | 854,87 | 336,8 | | | | | | | | | | | | | | | | | | | 1675,03 |
| 47 | 13.02.2017 | | | | 507,41 | 698,94 | 317,79 | | | | | | | | | | | | | | | | 1524,14 |
| 48 | 14.02.2017 | | | | | | | 596,12 | 781,15 | 422,89 | | | | | | | | | | | | | 1800,16 |
| 49 | 15.02.2017 | | | | | | | | | | 526,85 | 847,53 | 374,52 | | | | | | | | | | 1748,9 |
| 50 | 16.02.2017 | | | | | | | | | | | | | 490,94 | 746,33 | 355,48 | | | | | | | 1592,75 |
| 51 | 17.02.2017 | | | | | | | | | | | | | | | | 512,72 | 846,39 | 375,03 | | | | 1734,14 |
| 52 | 18.02.2017 | | | | | | | | | | | | | | | | | | | 533,72 | 713,27 | 321,78 | 1568,77 |
| 53 | 19.02.2017 | 539,06 | 879,7 | 306,59 | | | | | | | | | | | | | | | | | | | 1725,35 |
| 54 | 20.02.2017 | | | | 445,94 | 725,81 | 353,38 | | | | | | | | | | | | | | | | 1525,13 |
| 55 | 21.02.2017 | | | | | | | 592,55 | 719,47 | 404,55 | | | | | | | | | | | | | 1716,57 |
| 56 | 22.02.2017 | | | | | | | | | | 637,81 | 783,36 | 329,16 | | | | | | | | | | 1750,33 |
| 57 | 23.02.2017 | | | | | | | | | | | | | 513,29 | 840,58 | 373,24 | | | | | | | 1727,11 |
| 58 | 24.02.2017 | | | | | | | | | | | | | | | | 509,43 | 724,65 | 368,49 | | | | 1602,57 |
| 59 | 25.02.2017 | | | | | | | | | | | | | | | | | | | 553,66 | 676,57 | 274,68 | 1504,91 |
| 60 | 26.02.2017 | 546,48 | 742,36 | 324,55 | | | | | | | | | | | | | | | | | | | 1613,39 |
| 61 | 27.02.2017 | | | | 498,69 | 700,34 | 401,85 | | | | | | | | | | | | | | | | 1600,88 |
| 62 | 28.02.2017 | | | | | | | 640,82 | 737,27 | 255,53 | | | | | | | | | | | | | 1633,62 |
| 63 | 01.03.2017 | | | | | | | | | | 380,44 | 668,69 | 266,49 | | | | | | | | | | 1315,62 |
| 64 | 02.03.2017 | | | | | | | | | | | | | 512,99 | 689,13 | 493,62 | | | | | | | 1695,74 |
| 65 | 03.03.2017 | | | | | | | | | | | | | | | | 571,91 | 785,34 | 354,94 | | | | 1712,19 |
| 66 | 04.03.2017 | | | | | | | | | | | | | | | | | | | 473,2 | 735,04 | 292,28 | 1500,52 |
| 67 | 05.03.2017 | 508,82 | 718,54 | 300,89 | | | | | | | | | | | | | | | | | | | 1528,25 |
| 68 | 06.03.2017 | | | | 540,18 | 676,26 | 344,73 | | | | | | | | | | | | | | | | 1561,17 |
| 69 | 07.03.2017 | | | | | | | 655,3 | 713,89 | 331,84 | | | | | | | | | | | | | 1701,03 |
| 70 | 08.03.2017 | | | | | | | | | | 602,93 | 771,91 | 310,26 | | | | | | | | | | 1685,1 |
| 71 | 09.03.2017 | | | | | | | | | | | | | 531,55 | 775,03 | 312,39 | | | | | | | 1618,97 |
| 72 | 10.03.2017 | | | | | | | | | | | | | | | | 616,05 | 748,74 | 301,57 | | | | 1666,36 |
| 73 | 11.03.2017 | | | | | | | | | | | | | | | | | | | 523,04 | 660,03 | 294,85 | 1477,92 |
| 74 | 12.03.2017 | 527,38 | 820,07 | 326,21 | | | | | | | | | | | | | | | | | | | 1673,66 |
| 75 | 13.03.2017 | | | | 523,29 | 682,51 | 313,5 | | | | | | | | | | | | | | | | 1519,3 |
| 76 | 14.03.2017 | | | | | | | 617,85 | 704,51 | 404,27 | | | | | | | | | | | | | 1726,63 |
| 77 | 15.03.2017 | | | | | | | | | | 566,26 | 736,24 | 332,91 | | | | | | | | | | 1635,41 |
| 78 | 16.03.2017 | | | | | | | | | | | | | 515,71 | 808,63 | 377,85 | | | | | | | 1702,19 |
| 79 | 17.03.2017 | | | | | | | | | | | | | | | | 520,62 | 804,13 | 305,27 | | | | 1630,02 |
| 80 | 18.03.2017 | | | | | | | | | | | | | | | | | | | 451,07 | 688,55 | 240,79 | 1380,41 |
| 81 | 19.03.2017 | 510,06 | 785,12 | 304,83 | | | | | | | | | | | | | | | | | | | 1600,01 |
| 82 | 20.03.2017 | | | | 497,89 | 644,31 | 278,4 | | | | | | | | | | | | | | | | 1420,6 |
| 83 | 21.03.2017 | | | | | | | 568,76 | 701,8 | 368,38 | | | | | | | | | | | | | 1638,94 |
| 84 | 22.03.2017 | | | | | | | | | | 573,27 | 780,85 | 411,43 | | | | | | | | | | 1765,55 |
| 85 | 23.03.2017 | | | | | | | | | | | | | 542,89 | 860,91 | 348,63 | | | | | | | 1752,43 |
| 86 | 24.03.2017 | | | | | | | | | | | | | | | | 513,3 | 858,89 | 371,41 | | | | 1743,6 |
| 87 | 25.03.2017 | | | | | | | | | | | | | | | | | | | 477,2 | 712,79 | 321,95 | 1511,94 |
| 88 | 26.03.2017 | 440,79 | 685,17 | 392,39 | | | | | | | | | | | | | | | | | | | 1518,35 |
| 89 | 27.03.2017 | | | | 470,15 | 533,79 | 411,48 | | | | | | | | | | | | | | | | 1415,42 |
| 90 | 28.03.2017 | | | | | | | 587,25 | 614,87 | 559,19 | | | | | | | | | | | | | 1761,31 |
| 91 | 29.03.2017 | | | | | | | | | | 493 | 750,08 | 458,1 | | | | | | | | | | 1701,18 |
| 92 | 30.03.2017 | | | | | | | | | | | | | 513,59 | 700,49 | 460,83 | | | | | | | 1674,91 |
| 93 | 31.03.2017 | | | | | | | | | | | | | | | | 444,74 | 660,02 | 418,77 | | | | 1523,53 |
| 94 | 01.04.2017 | | | | | | | | | | | | | | | | | | | 443,25 | 553,1 | 394,47 | 1390,82 |
| 95 | 02.04.2017 | 511,98 | 649,34 | 406,37 | | | | | | | | | | | | | | | | | | | 1567,69 |
| 96 | 03.04.2017 | | | | 536,66 | 608,69 | 458,98 | | | | | | | | | | | | | | | | 1604,33 |
| 97 | 04.04.2017 | | | | | | | 516,66 | 728,22 | 498,21 | | | | | | | | | | | | | 1743,09 |
| 98 | 05.04.2017 | | | | | | | | | | 488,07 | 636,26 | 463,31 | | | | | | | | | | 1587,64 |
| 99 | 06.04.2017 | | | | | | | | | | | | | 453,83 | 664,88 | 458,49 | | | | | | | 1577,2 |
| 100 | 07.04.2017 | | | | | | | | | | | | | | | | 499 | 688,33 | 427,21 | | | | 1614,54 |
| 101 | 08.04.2017 | | | | | | | | | | | | | | | | | | | 543,82 | 623,04 | 461,82 | 1628,68 |
| 102 | 09.04.2017 | 519,23 | 621,82 | 410,19 | | | | | | | | | | | | | | | | | | | 1551,24 |
| 103 | 10.04.2017 | | | | 460,56 | 604,47 | 438,44 | | | | | | | | | | | | | | | | 1503,47 |
| 104 | 11.04.2017 | | | | | | | 542,81 | 744,15 | 510,38 | | | | | | | | | | | | | 1797,34 |
| 105 | 12.04.2017 | | | | | | | | | | 502,71 | 746,3 | 493,6 | | | | | | | | | | 1742,61 |
| 106 | 13.04.2017 | | | | | | | | | | | | | 504,43 | 723,63 | 449,42 | | | | | | | 1677,48 |
| 107 | 14.04.2017 | | | | | | | | | | | | | | | | 541,22 | 720,68 | 524,32 | | | | 1786,22 |
| 108 | 15.04.2017 | | | | | | | | | | | | | | | | | | | 514,47 | 604,54 | 415,07 | 1534,08 |
| 109 | 16.04.2017 | 542,15 | 734,89 | 415,24 | | | | | | | | | | | | | | | | | | | 1692,28 |
| 110 | 17.04.2017 | | | | 559,18 | 543,54 | 446,1 | | | | | | | | | | | | | | | | 1548,82 |
| 111 | 18.04.2017 | | | | | | | 544,15 | 726,02 | 389,01 | | | | | | | | | | | | | 1659,18 |
| 112 | 19.04.2017 | | | | | | | | | | 503 | 676,16 | 480,13 | | | | | | | | | | 1659,29 |
| 113 | 20.04.2017 | | | | | | | | | | | | | 430,46 | 648,15 | 417,94 | | | | | | | 1496,55 |
| 114 | 21.04.2017 | | | | | | | | | | | | | | | | 398,05 | 626,01 | 428,64 | | | | 1452,7 |
| 115 | 22.04.2017 | | | | | | | | | | | | | | | | | | | 460,42 | 566,16 | 435,17 | 1461,75 |
| 116 | 23.04.2017 | 562,37 | 636,11 | 384,91 | | | | | | | | | | | | | | | | | | | 1583,39 |
| 117 | 24.04.2017 | | | | 464,02 | 620,79 | 479,69 | | | | | | | | | | | | | | | | 1564,5 |
| 118 | 25.04.2017 | | | | | | | 525,4 | 688,87 | 439,07 | | | | | | | | | | | | | 1653,34 |
| 119 | 26.04.2017 | | | | | | | | | | 483,35 | 641,14 | 495,86 | | | | | | | | | | 1620,35 |
| 120 | 27.04.2017 | | | | | | | | | | | | | 541,05 | 676,64 | 460,63 | | | | | | | 1678,32 |
| 121 | 28.04.2017 | | | | | | | | | | | | | | | | 481,33 | 638,39 | 435,68 | | | | 1555,4 |
| 122 | 29.04.2017 | | | | | | | | | | | | | | | | | | | 488,4 | 607,25 | 411,04 | 1506,69 |
| 123 | 30.04.2017 | 456,65 | 690,66 | 385,92 | | | | | | | | | | | | | | | | | | | 1533,23 |
| 124 | 01.05.2017 | | | | 480,76 | 587,12 | 422,16 | | | | | | | | | | | | | | | | 1490,04 |
| 125 | 02.05.2017 | | | | | | | 538,86 | 695,34 | 445,15 | | | | | | | | | | | | | 1679,35 |
| 126 | 03.05.2017 | | | | | | | | | | 450,6 | 671,04 | 524,07 | | | | | | | | | | 1645,71 |
| 127 | 04.05.2017 | | | | | | | | | | | | | 507,41 | 627,37 | 456,76 | | | | | | | 1591,54 |
| 128 | 05.05.2017 | | | | | | | | | | | | | | | | 478,75 | 703,29 | 451,95 | | | | 1633,99 |
| 129 | 06.05.2017 | | | | | | | | | | | | | | | | | | | 502,57 | 594,56 | 427,84 | 1524,97 |
| 130 | 07.05.2017 | 430,77 | 658,45 | 477,61 | | | | | | | | | | | | | | | | | | | 1566,83 |
| 131 | 08.05.2017 | | | | 427,8 | 625,39 | 456,18 | | | | | | | | | | | | | | | | 1509,37 |
| 132 | 09.05.2017 | | | | | | | 547,36 | 687,09 | 496,35 | | | | | | | | | | | | | 1730,8 |
| 133 | 10.05.2017 | | | | | | | | | | 451,11 | 665,77 | 527,4 | | | | | | | | | | 1644,28 |
| 134 | 11.05.2017 | | | | | | | | | | | | | 482,82 | 638,39 | 414,31 | | | | | | | 1535,52 |
| 135 | 12.05.2017 | | | | | | | | | | | | | | | | 424,87 | 635,4 | 413,35 | | | | 1473,62 |
| 136 | 13.05.2017 | | | | | | | | | | | | | | | | | | | 437,77 | 544,98 | 420,05 | 1402,8 |
| 137 | 14.05.2017 | 437,01 | 659,95 | 352,44 | | | | | | | | | | | | | | | | | | | 1449,4 |
| 138 | 15.05.2017 | | | | 527,21 | 621,82 | 471,26 | | | | | | | | | | | | | | | | 1620,29 |
| 139 | 16.05.2017 | | | | | | | 543,15 | 660,9 | 490,48 | | | | | | | | | | | | | 1694,53 |
| 140 | 17.05.2017 | | | | | | | | | | 478,32 | 750,32 | 450,86 | | | | | | | | | | 1679,5 |
| 141 | 18.05.2017 | | | | | | | | | | | | | 526,86 | 630,01 | 418,96 | | | | | | | 1575,83 |
| 142 | 19.05.2017 | | | | | | | | | | | | | | | | 477,26 | 647,62 | 424,18 | | | | 1549,06 |
| 143 | 20.05.2017 | | | | | | | | | | | | | | | | | | | 527,31 | 621,48 | 487,34 | 1636,13 |
| 144 | 21.05.2017 | 465,09 | 703,57 | 360,37 | | | | | | | | | | | | | | | | | | | 1529,03 |
| 145 | 22.05.2017 | | | | 533,08 | 649,42 | 457,04 | | | | | | | | | | | | | | | | 1639,54 |
| 146 | 23.05.2017 | | | | | | | 568,41 | 707,91 | 570,26 | | | | | | | | | | | | | 1846,58 |
| 147 | 24.05.2017 | | | | | | | | | | 491,02 | 730,63 | 480,72 | | | | | | | | | | 1702,37 |

# Appendix A.6 Data Set of Ground Time

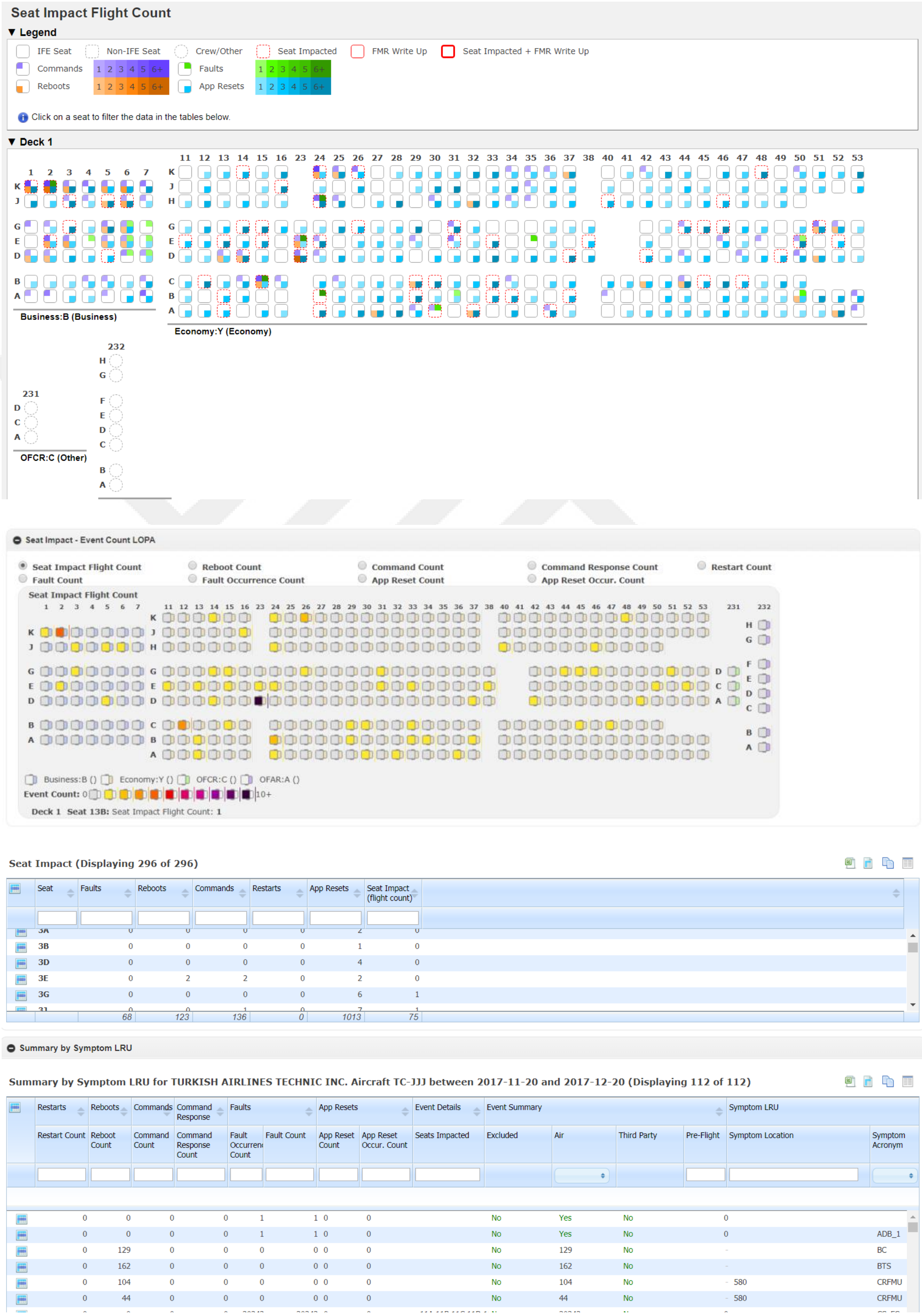
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 147 | 24.05.2017 | | | | | | | | | | 491,02 | 730,63 | 480,72 | | | | | | | | | | 1702,37 |
| 148 | 25.05.2017 | | | | | | | | | | | | | 503,95 | 644,18 | 488,37 | | | | | | | 1636,5 |
| 149 | 26.05.2017 | | | | | | | | | | | | | | | | 485,91 | 579,92 | 426,63 | | | | 1492,46 |
| 150 | 27.05.2017 | | | | | | | | | | | | | | | | | | | 503,6 | 628,04 | 469,02 | 1600,66 |
| 151 | 28.05.2017 | 475,4 | 661,36 | 461,3 | | | | | | | | | | | | | | | | | | | 1598,06 |
| 152 | 29.05.2017 | | | | 464,88 | 617,45 | 494,14 | | | | | | | | | | | | | | | | 1576,47 |
| 153 | 30.05.2017 | | | | | | | 509,03 | 823,04 | 469,41 | | | | | | | | | | | | | 1801,48 |
| 154 | 31.05.2017 | | | | | | | | | | 523,62 | 754,43 | 478,16 | | | | | | | | | | 1756,21 |
| 155 | 01.06.2017 | | | | | | | | | | | | | 540,06 | 677,68 | 446,36 | | | | | | | 1664,1 |
| 156 | 02.06.2017 | | | | | | | | | | | | | | | | 466,63 | 716,14 | 432,26 | | | | 1615,03 |
| 157 | 03.06.2017 | | | | | | | | | | | | | | | | | | | 408,61 | 590,36 | 467,47 | 1466,44 |
| 158 | 04.06.2017 | 466,35 | 702,6 | 401,93 | | | | | | | | | | | | | | | | | | | 1570,88 |
| 159 | 05.06.2017 | | | | 443,62 | 631,37 | 497,04 | | | | | | | | | | | | | | | | 1572,03 |
| 160 | 06.06.2017 | | | | | | | 530,98 | 685,93 | 497,28 | | | | | | | | | | | | | 1714,19 |
| 161 | 07.06.2017 | | | | | | | | | | 488,82 | 758,89 | 481,77 | | | | | | | | | | 1729,48 |
| 162 | 08.06.2017 | | | | | | | | | | | | | 540,07 | 718,46 | 531,5 | | | | | | | 1790,03 |
| 163 | 09.06.2017 | | | | | | | | | | | | | | | | 479,88 | 704,64 | 434,11 | | | | 1618,63 |
| 164 | 10.06.2017 | | | | | | | | | | | | | | | | | | | 486,58 | 577,42 | 474,46 | 1538,46 |
| 165 | 11.06.2017 | 516,78 | 679,91 | 380,07 | | | | | | | | | | | | | | | | | | | 1576,76 |
| 166 | 12.06.2017 | | | | 492,24 | 620,71 | 497,45 | | | | | | | | | | | | | | | | 1610,4 |
| 167 | 13.06.2017 | | | | | | | 524,74 | 733,98 | 558,49 | | | | | | | | | | | | | 1817,21 |
| 168 | 14.06.2017 | | | | | | | | | | 500,83 | 750,84 | 514,6 | | | | | | | | | | 1766,27 |
| 169 | 15.06.2017 | | | | | | | | | | | | | 447,24 | 632,46 | 437,76 | | | | | | | 1517,46 |
| 170 | 16.06.2017 | | | | | | | | | | | | | | | | 445,53 | 658,44 | 397,91 | | | | 1501,88 |
| 171 | 17.06.2017 | | | | | | | | | | | | | | | | | | | 499,63 | 625,28 | 433,88 | 1558,79 |
| 172 | 18.06.2017 | 493,28 | 712,41 | 360,56 | | | | | | | | | | | | | | | | | | | 1566,25 |
| 173 | 19.06.2017 | | | | 461,75 | 592,87 | 432,97 | | | | | | | | | | | | | | | | 1487,59 |
| 174 | 20.06.2017 | | | | | | | 466,44 | 662,38 | 485,23 | | | | | | | | | | | | | 1614,05 |
| 175 | 21.06.2017 | | | | | | | | | | 463,99 | 610,88 | 423,98 | | | | | | | | | | 1498,85 |
| 176 | 22.06.2017 | | | | | | | | | | | | | 494,76 | 622,28 | 441,96 | | | | | | | 1559 |
| 177 | 23.06.2017 | | | | | | | | | | | | | | | | 448,09 | 581,59 | 374,9 | | | | 1404,58 |
| 178 | 24.06.2017 | | | | | | | | | | | | | | | | | | | 458,9 | 593,67 | 422,87 | 1475,44 |
| 179 | 25.06.2017 | 458,97 | 681,56 | 390,36 | | | | | | | | | | | | | | | | | | | 1530,89 |
| 180 | 26.06.2017 | | | | 466,4 | 634,64 | 389,48 | | | | | | | | | | | | | | | | 1490,52 |
| 181 | 27.06.2017 | | | | | | | 439,63 | 680,8 | 409,36 | | | | | | | | | | | | | 1529,79 |
| 182 | 28.06.2017 | | | | | | | | | | 418,71 | 568,71 | 431,66 | | | | | | | | | | 1419,08 |
| 183 | 29.06.2017 | | | | | | | | | | | | | 455,44 | 519,75 | 443,73 | | | | | | | 1418,92 |
| 184 | 30.06.2017 | | | | | | | | | | | | | | | | 444,17 | 657,26 | 350,11 | | | | 1451,54 |
| 185 | 01.07.2017 | | | | | | | | | | | | | | | | | | | 403,03 | 578,94 | 341,13 | 1323,1 |
| 186 | 02.07.2017 | 497,73 | 550,38 | 388,03 | | | | | | | | | | | | | | | | | | | 1436,14 |
| 187 | 03.07.2017 | | | | 466,55 | 594,55 | 421,49 | | | | | | | | | | | | | | | | 1482,59 |
| 188 | 04.07.2017 | | | | | | | 461,85 | 601,29 | 435,6 | | | | | | | | | | | | | 1498,74 |
| 189 | 05.07.2017 | | | | | | | | | | 437,04 | 551,24 | 396,61 | | | | | | | | | | 1384,89 |
| 190 | 06.07.2017 | | | | | | | | | | | | | 430,1 | 641,42 | 433,69 | | | | | | | 1505,21 |
| 191 | 07.07.2017 | | | | | | | | | | | | | | | | 437,24 | 587,2 | 416,26 | | | | 1440,7 |
| 192 | 08.07.2017 | | | | | | | | | | | | | | | | | | | 446,61 | 580,83 | 381,94 | 1409,38 |
| 193 | 09.07.2017 | 468,73 | 575,39 | 357,33 | | | | | | | | | | | | | | | | | | | 1401,45 |
| 194 | 10.07.2017 | | | | 470,54 | 586,31 | 406,99 | | | | | | | | | | | | | | | | 1463,84 |
| 195 | 11.07.2017 | | | | | | | 490,95 | 626,14 | 410,46 | | | | | | | | | | | | | 1527,55 |
| 196 | 12.07.2017 | | | | | | | | | | 444,63 | 635,66 | 405,36 | | | | | | | | | | 1485,65 |
| 197 | 13.07.2017 | | | | | | | | | | | | | 424,42 | 644,85 | 377,24 | | | | | | | 1446,51 |
| 198 | 14.07.2017 | | | | | | | | | | | | | | | | 458,29 | 653,75 | 389,53 | | | | 1501,57 |
| 199 | 15.07.2017 | | | | | | | | | | | | | | | | | | | 457,95 | 607,62 | 395,39 | 1460,96 |
| 200 | 16.07.2017 | 489,61 | 602,61 | 337,13 | | | | | | | | | | | | | | | | | | | 1429,35 |
| 201 | 17.07.2017 | | | | 455,88 | 574,09 | 419,53 | | | | | | | | | | | | | | | | 1449,5 |
| 202 | 18.07.2017 | | | | | | | 433,43 | 570,86 | 386,64 | | | | | | | | | | | | | 1390,93 |
| 203 | 19.07.2017 | | | | | | | | | | 471,32 | 593,42 | 451,32 | | | | | | | | | | 1516,06 |
| 204 | 20.07.2017 | | | | | | | | | | | | | 473 | 623,55 | 411,45 | | | | | | | 1508 |
| 205 | 21.07.2017 | | | | | | | | | | | | | | | | 471,28 | 519 | 455,55 | | | | 1445,83 |
| 206 | 22.07.2017 | | | | | | | | | | | | | | | | | | | 483,85 | 554,09 | 390,37 | 1428,31 |
| 207 | 23.07.2017 | 383,69 | 622,28 | 390,5 | | | | | | | | | | | | | | | | | | | 1396,47 |
| 208 | 24.07.2017 | | | | 479,66 | 520,21 | 406,82 | | | | | | | | | | | | | | | | 1406,69 |
| 209 | 25.07.2017 | | | | | | | 489,84 | 546 | 369,8 | | | | | | | | | | | | | 1405,64 |
| 210 | 26.07.2017 | | | | | | | | | | 415,91 | 662,69 | 358,43 | | | | | | | | | | 1437,03 |
| 211 | 27.07.2017 | | | | | | | | | | | | | 477,66 | 585,91 | 409,54 | | | | | | | 1473,11 |
| 212 | 28.07.2017 | | | | | | | | | | | | | | | | 461,26 | 436,96 | 377,77 | | | | 1275,99 |
| 213 | 29.07.2017 | | | | | | | | | | | | | | | | | | | 496,09 | 451,64 | 417,59 | 1365,32 |
| 214 | 30.07.2017 | 400,94 | 606 | 372,42 | | | | | | | | | | | | | | | | | | | 1379,36 |
| 215 | 31.07.2017 | | | | 390,88 | 518,43 | 360,82 | | | | | | | | | | | | | | | | 1270,13 |
| 216 | 01.08.2017 | | | | | | | 401,43 | 554,09 | 324,21 | | | | | | | | | | | | | 1279,73 |
| 217 | 02.08.2017 | | | | | | | | | | 416,29 | 594,6 | 379,55 | | | | | | | | | | 1390,44 |
| 218 | 03.08.2017 | | | | | | | | | | | | | 395,85 | 580,98 | 345,68 | | | | | | | 1322,51 |
| 219 | 04.08.2017 | | | | | | | | | | | | | | | | 395,43 | 558,98 | 349,28 | | | | 1303,69 |
| 220 | 05.08.2017 | | | | | | | | | | | | | | | | | | | 434,69 | 558,37 | 375,66 | 1368,72 |
| 221 | 06.08.2017 | 416,44 | 534,7 | 426,31 | | | | | | | | | | | | | | | | | | | 1377,45 |
| 222 | 07.08.2017 | | | | 418,64 | 563,95 | 344,58 | | | | | | | | | | | | | | | | 1327,17 |
| 223 | 08.08.2017 | | | | | | | 421,66 | 575,22 | 370,63 | | | | | | | | | | | | | 1367,51 |
| 224 | 09.08.2017 | | | | | | | | | | 398,51 | 582,78 | 364,27 | | | | | | | | | | 1345,56 |
| 225 | 10.08.2017 | | | | | | | | | | | | | 404,76 | 546,33 | 358,33 | | | | | | | 1309,42 |
| 226 | 11.08.2017 | | | | | | | | | | | | | | | | 435,77 | 647,06 | 354,32 | | | | 1437,15 |
| 227 | 12.08.2017 | | | | | | | | | | | | | | | | | | | 432,54 | 561,05 | 357,36 | 1350,95 |
| 228 | 13.08.2017 | 497,16 | 552,96 | 347,88 | | | | | | | | | | | | | | | | | | | 1398 |
| 229 | 14.08.2017 | | | | 485,65 | 557,22 | 368,25 | | | | | | | | | | | | | | | | 1411,12 |
| 230 | 15.08.2017 | | | | | | | 471,86 | 643,18 | 421,51 | | | | | | | | | | | | | 1536,55 |
| 231 | 16.08.2017 | | | | | | | | | | 430,72 | 607,02 | 376,57 | | | | | | | | | | 1414,31 |
| 232 | 17.08.2017 | | | | | | | | | | | | | 405,94 | 542,66 | 310,21 | | | | | | | 1258,81 |
| 233 | 18.08.2017 | | | | | | | | | | | | | | | | 418,54 | 583,58 | 340,88 | | | | 1343 |
| 234 | 19.08.2017 | | | | | | | | | | | | | | | | | | | 480,03 | 545,87 | 334,68 | 1360,58 |
| 235 | 20.08.2017 | 436,1 | 587,1 | 333,72 | | | | | | | | | | | | | | | | | | | 1356,92 |
| 236 | 21.08.2017 | | | | 492,91 | 605,31 | 316,61 | | | | | | | | | | | | | | | | 1414,83 |
| 237 | 22.08.2017 | | | | | | | 461,51 | 626,85 | 420,24 | | | | | | | | | | | | | 1508,6 |
| 238 | 23.08.2017 | | | | | | | | | | 421,42 | 567,11 | 356,62 | | | | | | | | | | 1345,15 |
| 239 | 24.08.2017 | | | | | | | | | | | | | 399,83 | 559,84 | 399,1 | | | | | | | 1358,77 |
| 240 | 25.08.2017 | | | | | | | | | | | | | | | | 413,04 | 565,76 | 379,75 | | | | 1358,55 |
| 241 | 26.08.2017 | | | | | | | | | | | | | | | | | | | 438,73 | 659,54 | 342,25 | 1440,52 |
| 242 | 27.08.2017 | 429,69 | 626,56 | 342,13 | | | | | | | | | | | | | | | | | | | 1398,38 |
| 243 | 28.08.2017 | | | | 551,16 | 582,82 | 371,12 | | | | | | | | | | | | | | | | 1505,1 |
| 244 | 29.08.2017 | | | | | | | 512,66 | 707,25 | 463,45 | | | | | | | | | | | | | 1683,36 |
| 245 | 30.08.2017 | | | | | | | | | | 439,65 | 666,74 | 505,78 | | | | | | | | | | 1612,17 |
| 246 | 31.08.2017 | | | | | | | | | | | | | 491,48 | 654,47 | 425,19 | | | | | | | 1571,14 |
| 247 | 01.09.2017 | | | | | | | | | | | | | | | | 524,22 | 731,56 | 412,9 | | | | 1668,68 |
| 248 | 02.09.2017 | | | | | | | | | | | | | | | | | | | 484,69 | 628,64 | 389,75 | 1503,08 |
| 249 | 03.09.2017 | 415,11 | 634,96 | 368,16 | | | | | | | | | | | | | | | | | | | 1418,23 |
| 250 | 04.09.2017 | | | | 434,78 | 598,3 | 368 | | | | | | | | | | | | | | | | 1401,08 |
| 251 | 05.09.2017 | | | | | | | 489,76 | 622,72 | 421,18 | | | | | | | | | | | | | 1533,66 |
| 252 | 06.09.2017 | | | | | | | | | | 441,73 | 589,37 | 423,14 | | | | | | | | | | 1454,24 |
| 253 | 07.09.2017 | | | | | | | | | | | | | 442,2 | 608,55 | 391,76 | | | | | | | 1442,51 |
| 254 | 08.09.2017 | | | | | | | | | | | | | | | | 475,59 | 575,86 | 410,88 | | | | 1462,33 |
| 255 | 09.09.2017 | | | | | | | | | | | | | | | | | | | 453,39 | 506,74 | 376,08 | 1336,21 |
| 256 | 10.09.2017 | 412,85 | 557,28 | 377,02 | | | | | | | | | | | | | | | | | | | 1347,15 |
| 257 | 11.09.2017 | | | | 464,07 | 526,56 | 350,14 | | | | | | | | | | | | | | | | 1340,77 |
| 258 | 12.09.2017 | | | | | | | 349,95 | 554 | 335,92 | | | | | | | | | | | | | 1239,87 |
| 259 | 13.09.2017 | | | | | | | | | | 432,07 | 614,17 | 376,09 | | | | | | | | | | 1422,33 |
| 260 | 14.09.2017 | | | | | | | | | | | | | 444,97 | 545,51 | 427,83 | | | | | | | 1418,31 |
| 261 | 15.09.2017 | | | | | | | | | | | | | | | | 444,12 | 602,82 | 365,36 | | | | 1412,3 |
| 262 | 16.09.2017 | | | | | | | | | | | | | | | | | | | 418,68 | 564,35 | 401,6 | 1384,63 |
| 263 | 17.09.2017 | 372,31 | 527,71 | 348,18 | | | | | | | | | | | | | | | | | | | 1248,2 |
| 264 | 18.09.2017 | | | | 403,6 | 507,34 | 368,89 | | | | | | | | | | | | | | | | 1279,83 |
| 265 | 19.09.2017 | | | | | | | 451,06 | 721,32 | 395,23 | | | | | | | | | | | | | 1567,61 |
| 266 | 20.09.2017 | | | | | | | | | | 453,2 | 633,15 | 413,95 | | | | | | | | | | 1500,3 |
| 267 | 21.09.2017 | | | | | | | | | | | | | 409,13 | 680,29 | 395,74 | | | | | | | 1485,16 |
| 268 | 22.09.2017 | | | | | | | | | | | | | | | | 408,77 | 603,23 | 348,99 | | | | 1360,99 |
| 269 | 23.09.2017 | | | | | | | | | | | | | | | | | | | 448,59 | 601,07 | 418,95 | 1468,61 |
| 270 | 24.09.2017 | 414,97 | 703,97 | 344,57 | | | | | | | | | | | | | | | | | | | 1463,51 |
| 271 | 25.09.2017 | | | | 424,5 | 527,53 | 397,92 | | | | | | | | | | | | | | | | 1349,95 |
| 272 | 26.09.2017 | | | | | | | 456,68 | 607,64 | 493,3 | | | | | | | | | | | | | 1557,62 |
| 273 | 27.09.2017 | | | | | | | | | | 446,47 | 646,98 | 419,73 | | | | | | | | | | 1513,18 |
| 274 | 28.09.2017 | | | | | | | | | | | | | 481,9 | 634,03 | 457,42 | | | | | | | 1573,35 |
| 275 | 29.09.2017 | | | | | | | | | | | | | | | | 421,81 | 611,13 | 421,1 | | | | 1454,04 |
| 276 | 30.09.2017 | | | | | | | | | | | | | | | | | | | 516,47 | 611,18 | 369,97 | 1497,62 |
| 277 | 01.10.2017 | 400,18 | 674,11 | 388,92 | | | | | | | | | | | | | | | | | | | 1463,21 |
| 278 | 02.10.2017 | | | | 396,14 | 567,68 | 384,73 | | | | | | | | | | | | | | | | 1348,55 |
| 279 | 03.10.2017 | | | | | | | 493,52 | 624,03 | 430,85 | | | | | | | | | | | | | 1548,4 |
| 280 | 04.10.2017 | | | | | | | | | | 442,14 | 650,04 | 464,33 | | | | | | | | | | 1556,51 |
| 281 | 05.10.2017 | | | | | | | | | | | | | 496,94 | 668,69 | 446,84 | | | | | | | 1612,47 |
| 282 | 06.10.2017 | | | | | | | | | | | | | | | | 469,31 | 700,08 | 391,46 | | | | 1560,85 |
| 283 | 07.10.2017 | | | | | | | | | | | | | | | | | | | 507,63 | 687,31 | 385,33 | 1580,27 |
| 284 | 08.10.2017 | 443,21 | 652,5 | 359,21 | | | | | | | | | | | | | | | | | | | 1454,92 |
| 285 | 09.10.2017 | | | | 504,62 | 588,17 | 375,21 | | | | | | | | | | | | | | | | 1468 |
| 286 | 10.10.2017 | | | | | | | 483,76 | 643,92 | 379,91 | | | | | | | | | | | | | 1507,59 |
| 287 | 11.10.2017 | | | | | | | | | | 435,24 | 679,12 | 400,65 | | | | | | | | | | 1515,01 |
| 288 | 12.10.2017 | | | | | | | | | | | | | 427,31 | 603,54 | 415,62 | | | | | | | 1446,47 |
| 289 | 13.10.2017 | | | | | | | | | | | | | | | | 394,92 | 707,4 | 407,55 | | | | 1509,87 |
| 290 | 14.10.2017 | | | | | | | | | | | | | | | | | | | 421,45 | 630,51 | 407,95 | 1459,91 |
| 291 | 15.10.2017 | 377,61 | 662,6 | 349,34 | | | | | | | | | | | | | | | | | | | 1389,55 |
| 292 | 16.10.2017 | | | | 494,75 | 611,43 | 387,5 | | | | | | | | | | | | | | | | 1493,68 |
| 293 | 17.10.2017 | | | | | | | 434,02 | 696,97 | 404,76 | | | | | | | | | | | | | 1535,75 |
| 294 | 18.10.2017 | | | | | | | | | | 428,66 | 669,53 | 405,71 | | | | | | | | | | 1503,9 |
| 295 | 19.10.2017 | | | | | | | | | | | | | 436,43 | 666,77 | 406,7 | | | | | | | 1509,9 |
| 296 | 20.10.2017 | | | | | | | | | | | | | | | | 492,94 | 721,57 | 401,83 | | | | 1616,34 |
| 297 | 21.10.2017 | | | | | | | | | | | | | | | | | | | 499,05 | 634,83 | 407,96 | 1541,84 |
| 298 | 22.10.2017 | 495,79 | 690,58 | 388,06 | | | | | | | | | | | | | | | | | | | 1574,43 |
| 299 | 23.10.2017 | | | | 479,43 | 649,6 | 461,7 | | | | | | | | | | | | | | | | 1590,73 |
| 300 | 24.10.2017 | | | | | | | 472,85 | 678,95 | 498,07 | | | | | | | | | | | | | 1649,87 |
| 301 | 25.10.2017 | | | | | | | | | | 427,75 | 728,53 | 419,19 | | | | | | | | | | 1575,47 |
| 302 | 26.10.2017 | | | | | | | | | | | | | 454,78 | 611,69 | 407,09 | | | | | | | 1473,56 |
| 303 | 27.10.2017 | | | | | | | | | | | | | | | | 553,8 | 766,98 | 477,8 | | | | 1798,58 |
| 304 | 28.10.2017 | | | | | | | | | | | | | | | | | | | 514,82 | 698,04 | 445,3 | 1658,16 |
| 305 | 29.10.2017 | 617,46 | 911,76 | 307,95 | | | | | | | | | | | | | | | | | | | 1837,17 |
| 306 | 30.10.2017 | | | | 463,94 | 668,21 | 409,9 | | | | | | | | | | | | | | | | 1542,05 |
| 307 | Grand Total | 20441,3 | 29500,5 | 15854,2 | 21197,1 | 26773,2 | 17271,7 | 22153,2 | 28687,4 | 17810,1 | 20516,4 | 29484 | 17787,1 | 20408,1 | 28623,5 | 17256,2 | 20587 | 29222,1 | 16488,6 | 20340,8 | 26214,2 | 16112,3 | 462728,62 |
| 308 | | 44 | 44 | 44 | 44 | 44 | 44 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 303 |
| 309 | AVERAGE | 464,574 | 670,465 | 360,322 | 481,752 | 608,481 | 392,538 | 515,192 | 667,148 | 414,189 | 477,125 | 685,674 | 413,653 | 474,607 | 665,663 | 401,307 | 478,767 | 679,583 | 383,457 | 473,042 | 609,631 | 374,703 | 1527,157162 |

## Appendix A.7 Data Set of Defects

| | A | B | C | D | E | F | G | H | I | J | K | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AC | AC_TYPE | DEFECT_T | DEFECT | DEFEC | FLIGHT | CHAPTER | SECTION | TO_CHAR(DR.RE | REPORTED_D | REPORTED_DATE | DEFECT_DESCRIPTION |
| 59 | TC-JSP | A321 | CABIN | MCA486269 | 1 | TK1984 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC510) MEDIA BOX / IFE BOX AT THE VIDEO CENTER IS NOT WORKING PROPERLY - MUSIC AND |
| 60 | TC-JML | A321 | CABIN | MCA486270 | 1 | TK2305 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC512) MEDIA BOX / IFE BOX AT THE VIDEO CENTER IS COMPLETELY UNSERVICEABLE - |
| 61 | TC-LJE | B777 | CABIN | MCA486237 | 1 | TK5 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB1211) LCD MONITOR AT THE 4J IS NO RESPONSE - 4J MONITOR IS NOT WORKING PROPERLY |
| 62 | TC-JSV | A321 | CABIN | MCA486493 | 1 | TK1598 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC212) VTR (VIDEO TAPE REPRODUCER) AT THE VIDEO CENTER IS COMPLETELY UNSERVICEABLE |
| 63 | TC-JSI | A321 | CABIN | MCA486736 | 1 | TK694 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2112) LCD MONITOR AT THE 18D IS COMPLETELY UNSERVICEABLE - 18D LCD SCREEN IS U/S. |
| 64 | TC-JSI | A321 | CABIN | MCA486737 | 1 | TK694 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2112) LCD MONITOR AT THE 17D IS COMPLETELY UNSERVICEABLE - 17D LCD SCREEN IS U/S. |
| 65 | TC-JRV | A321 | CABIN | MCA486771 | 1 | TK1786 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2112) LCD MONITOR AT THE 17D IS COMPLETELY UNSERVICEABLE - 17D SCREEN IS NOT WOF |
| 66 | TC-JSB | A321 | CABIN | MCA486777 | 1 | TK1920 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE263) HANDSET AT THE 31A IS LOOSE/DETACHED - HANDSET IS LOOSE |
| 67 | TC-JRE | A321 | CABIN | MCA486835 | 1 | TK1877 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC512) MEDIA BOX / IFE BOX AT THE VIDEO CENTER IS COMPLETELY UNSERVICEABLE - AIRSHOV |
| 68 | TC-JJR | B777 | CABIN | MCA486844 | 1 | TK1 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2411) ISPS PLUG AT THE 6D IS NO RESPONSE - |
| 69 | TC-JSB | A321 | CABIN | MCA486779 | 1 | TK1920 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE213) LCD MONITOR AT THE 8F IS LOOSE/DETACHED - LCD MONITOR IS NOT DETACHED. |
| 70 | TC-JSN | A321 | CABIN | MCA486848 | 1 | TK1987 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2110) LCD MONITOR AT THE 9D IS NOT WORKING PROPERLY - |
| 71 | TC-JSO | A321 | CABIN | MCA486776 | 1 | TK1996 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE262) HANDSET AT THE 28A IS DAMAGED/BROKEN - 28A HEADPHONES SOCKET OUTLET IS BLC |
| 72 | TC-JJR | B777 | CABIN | MCA486843 | 1 | TK1 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2801) HANDSET AT THE 6D IS JAMMED - |
| 73 | TC-LJH | B777 | CABIN | MCA486463 | 1 | TK26 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2402) ISPS PLUG AT THE 52K IS DAMAGED / BROKEN - 52 K SEAT'S ISPS PLUG IS DAMAGED. |
| 74 | TC-JFJ | B737 | CABIN | MCA486338 | 1 | TK7235 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC0710) MEDIA BOX / IFE BOX AT THE VIDEO CENTER IS NOT WORKING PROPERLY - IFE LIGHT D |
| 75 | TC-JHU | B737 | CABIN | MCA486464 | 1 | TK1757 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE3220) HANDSET (IFE) AT THE 13B IS CAN NOT BE STOWED - |
| 76 | TC-JNH | A330 | CABIN | MCA486733 | 1 | TK618 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | 35A SEAT HANDSET CORD IS UNSERVICEABLE. CAN NOT BE STOWED. |
| 77 | TC-JTJ | A321 | CABIN | MCA486829 | 1 | TK780 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CB2424) LCD MONITOR AT THE FRONT B/C ZONE IS CANNOT BE OPENED/CLOSED PROPERLY - 1. |
| 78 | TC-JHN | B737 | CABIN | MCA486761 | 1 | TK1424 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2610) LCD MONITOR AT THE 19C IS NOT WORKING PROPERLY - 19C SCREEN IS NOT WORKIN |
| 79 | TC-JSH | A321 | CABIN | MCA486709 | 1 | TK1045 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE262) HANDSET AT THE 18D IS DAMAGED/BROKEN - HANDSET HAS BEEN TAKEN FROM AIRCRA |
| 80 | TC-JYB | B737 | CABIN | MCA486763 | 1 | TK589 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2610) LCD MONITOR AT THE 4E IS NOT WORKING PROPERLY - 4E LCD MONITOR IS NOT WOR |
| 81 | TC-JSM | A321 | CABIN | MCA486714 | 1 | TK1843 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE262) HANDSET AT THE 14A IS DAMAGED/BROKEN - 14A HANDSET STOWAGE IS DAMAGED |
| 82 | TC-JKO | B737 | CABIN | MCA486715 | 1 | TK2249 | 23 | 42 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2507) ATTENDANT CALL AT THE 9C IS MISSING / MISSING PART - 9C SEAT ATT CALL LENS IS MI |
| 83 | TC-JTH | A321 | CABIN | MCA486805 | 1 | TK1706 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CB1224) MONITOR (RETRACTABLE) AT THE FRONT B/C ZONE IS CANNOT BE OPENED/CLOSED PR |
| 84 | TC-JGH | B737 | CABIN | MCA486700 | 1 | TK2685 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2902) POWER OUTLET AT THE 15E IS DAMAGED / BROKEN - |
| 85 | TC-JGN | B737 | CABIN | MCA486380 | 1 | TK1813 | 23 | 34 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB1102) PCU AT THE 3C IS DAMAGED / BROKEN - 3ABC PCU IS FELT DOWN |
| 86 | TC-JGM | B737 | CABIN | MCA486384 | 1 | TK2965 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2610) LCD MONITOR AT THE 25A IS NOT WORKING PROPERLY - 25ABC MONITOR DOESNT CL |
| 87 | TC-JRN | A321 | CABIN | MCA486507 | 1 | TK1885 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SA268) HANDSET AT THE ATTENDANT SEAT LCH IS NOT LEVEL - FWD HANDSET SOUND İS SO SİZZ |
| 88 | TC-JNA | A330 | CABIN | MCA486361 | 1 | TK800 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC1410) MEDIA BOX / IFE BOX AT THE VIDEO CENTER IS NOT WORKING PROPERLY - THE WHOLI |
| 89 | TC-JHE | B737 | CABIN | MCA486376 | 1 | TK2553 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CC4310) VIDEO CAMERA AT THE REAR E/C ZONE IS NOT WORKING PROPERLY - |
| 90 | TC-JTE | A321 | CABIN | MCA486780 | 1 | TK1594 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC22) VTR (VIDEO TAPE REPRODUCER) AT THE VIDEO CENTER IS DAMAGED/BROKEN - WE CAN N |
| 91 | TC-JMH | A321 | CABIN | MCA486783 | 1 | TK1864 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2112) LCD MONITOR AT THE 30C IS COMPLETELY UNSERVICEABLE - 30 C,B,A LCD MONITOR A |
| 92 | TC-LJB | B777 | CABIN | MCA486794 | 1 | TK15 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2810) HANDSET AT THE 6A IS NOT WORKING PROPERLY - |
| 93 | TC-LKB | B777 | CABIN | MCA486795 | 1 | TK760 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE1210) LCD MONITOR AT THE 37E IS NOT WORKING PROPERLY - 37E MONITOR NOT WORKINC |
| 94 | TC-LKB | B777 | CABIN | MCA486797 | 1 | TK760 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE1208) LCD MONITOR AT THE 36G IS NOT LEVEL - 36 G VIDEO SYSTEM IS NOT WORKING PROP |
| 95 | TC-JNK | A330 | CABIN | MCA486806 | 1 | TK460 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE1210) LCD MONITOR AT THE 10E IS NOT WORKING PROPERLY - |
| 96 | TC-JGA | B737 | CABIN | MCA486627 | 1 | TK2809 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2610) LCD MONITOR AT THE 14D IS NOT WORKING PROPERLY - OVERHEADBIN LCD MONITO |
| 97 | TC-LNG | A330 | CABIN | MCA486656 | 1 | TK65 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2810) HANDSET AT THE 2J IS NOT WORKING PROPERLY - |
| 98 | TC-JSM | A321 | CABIN | MCA486813 | 1 | TK1844 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC510) MEDIA BOX / IFE BOX AT THE VIDEO CENTER IS NOT WORKING PROPERLY - IFE BOX LCD |
| 99 | TC-JYO | B737 | CABIN | MCA486669 | 1 | TK1756 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2608) LCD MONITOR AT THE 14B IS NOT LEVEL - 14B IFE LCD MONITOR IS NOT WORKING PR( |
| 100 | TC-JOK | A330 | CABIN | MCA486689 | 1 | TK3 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2820) HANDSET AT THE 1D IS CANNOT BE STOWED - |
| 101 | TC-JTL | A321 | CABIN | MCA486738 | 1 | TK494 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CB1224) MONITOR (RETRACTABLE) AT THE FRONT B/C ZONE IS CANNOT BE OPENED/CLOSED PR |
| 102 | TC-JRM | A321 | CABIN | MCA486333 | 1 | TK815 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC510) MEDIA BOX / IFE BOX AT THE VIDEO CENTER IS NOT WORKING PROPERLY - AIR SHOW IS |
| 103 | TC-JHY | B737 | CABIN | MCA486335 | 1 | TK151 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2612) LCD MONITOR AT THE 3B IS COMPLETELY UNSERVICABLE - 3ABC OVER HEADBIN MONI |
| 104 | TC-JSI | A321 | CABIN | MCA486567 | 1 | TK1938 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE272) HANDSET CRADLE AT THE 29D IS DAMAGED/BROKEN - |
| 105 | TC-JOK | A330 | CABIN | MCA486687 | 1 | TK3 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE1212) LCD MONITOR AT THE 19F IS COMPLETELY UNSERVICEABLE - |
| 106 | TC-JPO | A320 | CABIN | MCA486353 | 1 | TK381 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CA2412) LCD MONITOR AT THE B/C ZONE IS COMPLETELY UNSERVICEABLE - B/C LCD ON THE CU |
| 107 | TC-LJC | B777 | CABIN | MCA486250 | 1 | TK33 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2810) HANDSET AT THE 3D IS NOT WORKING PROPERLY - |
| 108 | TC-LJC | B777 | CABIN | MCA486251 | 1 | TK33 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2810) HANDSET AT THE 4D IS NOT WORKING PROPERLY - |
| 109 | TC-JSC | A321 | CABIN | MCA486302 | 1 | TK810 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE223) LCD MONITOR ARM AT THE 8E IS LOOSE/DETACHED - |
| 110 | TC-JII | A340 | CABIN | MCA486313 | 1 | TK95 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE487) PERSONAL MEDIA REMOTE JACK MODULE AT THE 36K IS MISSING/MISSING PART - UZAK |
| 111 | TC-JII | A340 | CABIN | MCA486314 | 1 | TK95 | 44 | 26 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE1210) LCD MONITOR AT THE 21B IS NOT WORKING PROPERLY - 21B EKRAN ÇALIŞMIYOR |
| 112 | TC-JSY | A321 | CABIN | MCA486322 | 1 | TK371 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CY2412) LCD MONITOR AT THE FRONT Y/C ZONE IS COMPLETELY UNSERVICEABLE - 6 L OVERHEA |
| 113 | TC-JSY | A321 | CABIN | MCA486323 | 1 | TK371 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CB2412) LCD MONITOR AT THE FRONT Y/C ZONE 2 IS COMPLETELY UNSERVICEABLE - 20 LEFT AI |
| 114 | TC-JSA | A321 | CABIN | MCA486630 | 1 | TK1886 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2112) LCD MONITOR AT THE 21C IS COMPLETELY UNSERVICEABLE - |
| 115 | TC-JSA | A321 | CABIN | MCA486631 | 1 | TK1886 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2112) LCD MONITOR AT THE 21D IS COMPLETELY UNSERVICEABLE - |
| 116 | TC-JZE | B737 | CABIN | MCA486646 | 1 | TK2463 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC0908) DIGITAL VIDEO PLAYER AT THE VIDEO CENTER IS NOT LEVEL - STAR ALLIANCE GOLD BEI |
| 117 | TC-JRY | A321 | CABIN | MCA486649 | 1 | TK1953 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CW1212) MONITOR (RETRACTABLE) AT THE WHOLE CABIN IS COMPLETELY UNSERVICEABLE - 3L |
| 118 | TC-JOK | A330 | CABIN | MCA486688 | 1 | TK3 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB1210) LCD MONITOR AT THE 3D IS NOT WORKING PROPERLY - 3D LCD MONITOR TURNS OFF |
| 119 | TC-JVM | B737 | MAINT | 355498 | 1 | TK2832 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | IFE GREET MEET SERVİCES |
| 120 | TC-JMN | A321 | CABIN | MCA486252 | 1 | TK1956 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CW2410) LCD MONITOR AT THE WHOLE CABIN IS NOT WORKING PROPERLY - BETWEEN 20 TO 3 |
| 121 | TC-JMN | A321 | CABIN | MCA486254 | 1 | TK1956 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB261) HANDSET AT THE 3F IS JAMMED - 3F HANDSET CAN NOT REMOVED. |
| 122 | TC-JYA | B737 | CABIN | MCA486234 | 1 | TK539 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CA4224) LCD MONITOR AT THE B/C ZONE IS CAN NOT BE OPENED/ CLOSED PROPERLY - |
| 123 | TC-JVY | B737 | CABIN | MCA486240 | 1 | TK423 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CA4202) LCD MONITOR AT THE B/C ZONE IS DAMAGED/BROKEN - LEFT LCD MONITOR AT THE B( |
| 124 | TC-LJE | B777 | CABIN | MCA486538 | 1 | TK6 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB1211) LCD MONITOR AT THE 5D IS NO RESPONSE - MONITOR DOESN T WORK. |
| 125 | TC-JPD | A320 | CABIN | MCA486434 | 1 | TK1792 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2110) LCD MONITOR AT THE 4D IS NOT WORKING PROPERLY - 4D LCD MONITOR IS NOT WOI |
| 126 | TC-JRI | A321 | CABIN | MCA486449 | 1 | TK961 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC412) CREW PANEL AT THE VIDEO CENTER IS COMPLETELY UNSERVICEABLE - AFTER TAKE OFF ( |
| 127 | TC-JSO | A321 | CABIN | MCA486417 | 1 | TK681 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2110) LCD MONITOR AT THE 11F IS NOT WORKING PROPERLY - |
| 128 | TC-JJU | B777 | CABIN | MCA486591 | 1 | TK10 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB1812) PASSENGER CONTROL UNIT AT THE 6A IS COMPLETELY UNSERVICABLE - DOES NOT WO |
| 129 | TC-LJC | B777 | CABIN | MCA486605 | 1 | TK34 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB1202) LCD MONITOR AT THE 4G IS DAMAGED / BROKEN - 4 G SCREEN IS DAMAGED. |
| 130 | TC-JVG | B737 | CABIN | MCA486474 | 1 | TK2675 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE3002) HANDSET CRADLE (IFE) AT THE 9A IS DAMAGED / BROKEN - |
| 131 | TC-JNK | A330 | CABIN | MCA486503 | 1 | TK749 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2812) HANDSET AT THE 3D IS COMPLETELY UNSERVICEABLE - |
| 132 | TC-JVD | B737 | CABIN | MCA486608 | 1 | TK2255 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC0110) AIRSHOW AT THE VIDEO CENTER IS NOT WORKING PROPERLY - |
| 133 | TC-JST | A321 | CABIN | MCA486626 | 1 | TK1994 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2110) LCD MONITOR AT THE 5A IS NOT WORKING PROPERLY - 5A TOUCH SCREEN IS NOT WO |
| 134 | TC-JOK | A330 | CABIN | MCA486691 | 1 | TK3 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2812) HANDSET AT THE 5A IS COMPLETELY UNSERVICEABLE - |
| 135 | TC-JRR | A321 | CABIN | MCA486692 | 1 | TK1723 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2110) LCD MONITOR AT THE 17B IS NOT WORKING PROPERLY - 17B LCD MONITOR IS NOT W |
| 136 | TC-JJY | B777 | CABIN | MCA486852 | 1 | TK17 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2811) HANDSET AT THE 5B IS NO RESPONSE - |
| 137 | TC-JVI | B737 | CABIN | MCA486858 | 1 | TK710 | 23 | 32 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (CW4210) LCD MONITOR AT THE WHOLE CABIN IS NOT WORKING PROPERLY - MOST OF SCREEN |
| 138 | TC-JJY | B777 | CABIN | MCA486854 | 1 | TK17 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2811) HANDSET AT THE 4D IS NO RESPONSE - |
| 139 | TC-JHA | B737 | CABIN | MCA486403 | 1 | TK2631 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SE2612) LCD MONITOR AT THE 5B IS COMPLETELY UNSERVICABLE - |
| 140 | TC-JJZ | B777 | CABIN | MCA486404 | 1 | TK72 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (SB2812) HANDSET AT THE 6A IS COMPLETELY UNSERVICABLE - |
| 141 | TC-JIZ | A330 | MAINT | 508324 | 1 | | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | 30K SEAT'S USB MULTIPORT JACK UNIT HAS DAMAGE. |
| 142 | TC-JHB | B737 | MAINT | 354658 | 1 | TK2116 | 23 | 0 | MONDAY | 02.01.2017 | 02.01.2017 01:30 | MEET GREET |
| 143 | TC-JML | A321 | MAINT | 354666 | 1 | TK2305 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 02:00 | MEET GREET |
| 144 | TC-JMN | A321 | MAINT | 354652 | 1 | TK1956 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 02:23 | IFE MEET GREET SERVICE |
| 145 | TC-JSP | A321 | MAINT | 354675 | 1 | TK1984 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | MEET SERVICE |
| 146 | TC-JSP | A321 | MAINT | 354674 | 1 | | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | 15F MONITOR IS US |
| 147 | TC-JJR | B777 | MAINT | 354920 | 1 | TK1 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | IFE MEET GREET |
| 148 | TC-JOK | A330 | MAINT | 354688 | 1 | TK3 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 04:10 | IFE GREET MEET |
| 149 | TC-LKB | B777 | CABIN | MCA486796 | 1 | TK760 | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 04:20 | (SE1210) LCD MONITOR AT THE 37G IS NOT WORKING PROPERLY - SOME MOVIE IS PAUSING SO |
| 150 | TC-JTF | A321 | MAINT | 354690 | 1 | TK868 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 04:30 | GREET MEET SERVICE |
| 151 | TC-JTK | A321 | MAINT | 354885 | 1 | TK1873 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | IFE MEET GREET SERVICE |
| 152 | TC-JHY | B737 | MAINT | 354696 | 1 | TK1081 | 44 | 23 | MONDAY | 02.01.2017 | 02.01.2017 04:30 | IFE MEET GREET |
| 153 | TC-JOL | A330 | MAINT | 354726 | 1 | | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 04:30 | IFE GREET MEET. |
| 154 | TC-LJA | B777 | MAINT | 354921 | 1 | TK91 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | IFE MEET GREET |
| 155 | TC-JYL | B737 | MAINT | 354714 | 1 | TK774 | 44 | 21 | MONDAY | 02.01.2017 | 02.01.2017 05:00 | GREET MEET SERVICE |
| 156 | TC-JHY | B737 | MAINT | 354698 | 1 | | 44 | 25 | MONDAY | 02.01.2017 | 02.01.2017 05:09 | 22C HANDSET IS U/S |
| 157 | TC-JRM | A321 | MAINT | 354722 | 1 | TK821 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 05:10 | IFE GREET MEET |
| 158 | TC-JSZ | A321 | MAINT | 354719 | 1 | | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 05:15 | IFE GREET MEET. |
| 159 | TC-JMN | A321 | MAINT | 354712 | 1 | | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | SAFETY DEMO DOES NOT WORK PROPERLY |
| 160 | TC-LJF | B777 | MAINT | 354922 | 1 | TK79 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | IFE MEET GREET |
| 161 | TC-JJI | B777 | MAINT | 354925 | 1 | TK44 | 44 | 21 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | IFE SYSTEM GREET MEET |
| 162 | TC-JII | A340 | MAINT | 354744 | 1 | | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | CMEU#2 IS U/S |
| 163 | TC-JGM | B737 | CABIN | MCA486668 | 1 | TK2976 | 23 | 36 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | (VC0912) DIGITAL VIDEO PLAYER AT THE VIDEO CENTER IS COMPLETELY UNSERVICABLE - SAFETY |
| 164 | TC-JNA | A330 | MAINT | 354781 | 1 | TK800 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 06:45 | MEET GREET SERVICE |
| 165 | TC-JRK | A321 | MAINT | 354884 | 1 | TK1783 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | IFE MEET GREET SERVICE |
| 166 | TC-JII | A340 | MAINT | 354950 | 1 | | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 07:00 | IFE SYETEM MEET GREET |
| 167 | TC-JNG | A330 | MAINT | 355101 | 1 | | 23 | 0 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | 3TH OCCUPANT CREW OXYGEN MASK MIC. IS NOT WORKING PROPERLY |
| 168 | TC-JTD | A321 | MAINT | 354845 | 1 | TK878 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 07:40 | IFE GREET MEET |
| 169 | TC-JYA | B737 | MAINT | 354917 | 1 | TK539 | 44 | 21 | MONDAY | 02.01.2017 | 02.01.2017 09:15 | MEET GREET SERVICE |
| 170 | TC-JPD | A320 | MAINT | 354944 | 1 | TK1792 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 09:30 | IFE MEET GREET |
| 171 | TC-JRI | A321 | MAINT | 354956 | 1 | TK1805 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 09:45 | IFE GREET MEET. |
| 172 | TC-JPI | A320 | MAINT | 354980 | 1 | TK1877 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 10:00 | IFE GREET MEET |
| 173 | TC-JSO | A321 | MAINT | 355061 | 1 | TK681 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | IFE MEET GREET SERVICE |
| 174 | TC-JPI | A320 | MAINT | 354994 | 1 | TK1877 | 23 | 33 | MONDAY | 02.01.2017 | 02.01.2017 10:00 | IFE GREET MEET |
| 175 | TC-JVG | B737 | MAINT | 355068 | 1 | | 44 | 21 | MONDAY | 02.01.2017 | 02.01.2017 10:45 | IFE MT GREET |
| 176 | TC-JHY | B737 | MAINT | 355155 | 1 | TK334 | 44 | 21 | MONDAY | 02.01.2017 | 02.01.2017 00:00 | IFE GREET MEET |

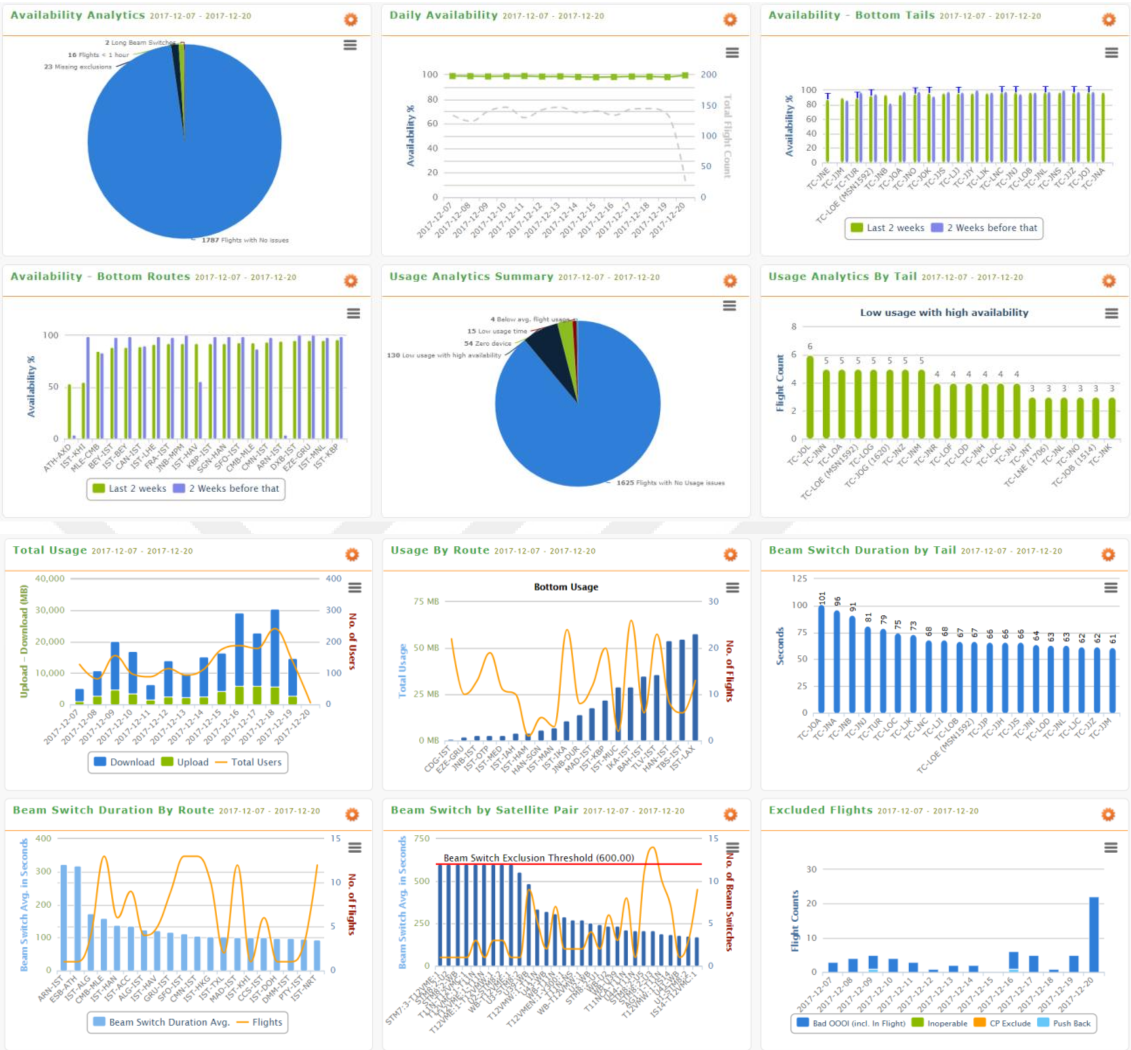
# Appendix A.8 Health Monitoring Tool Feature Examples

## LRU Location Summary:

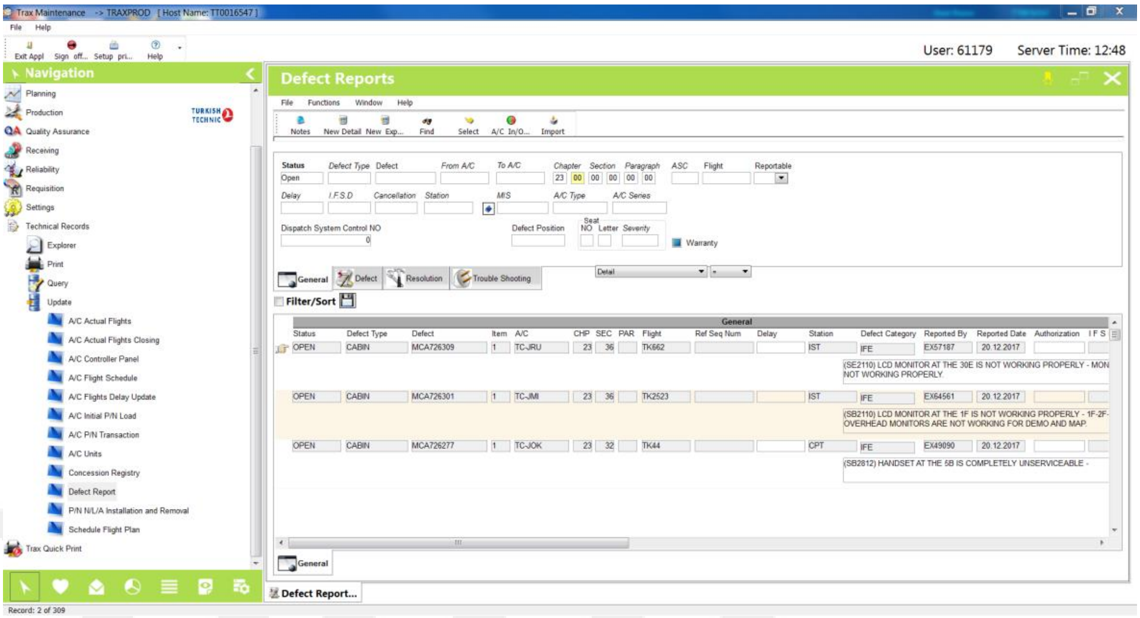


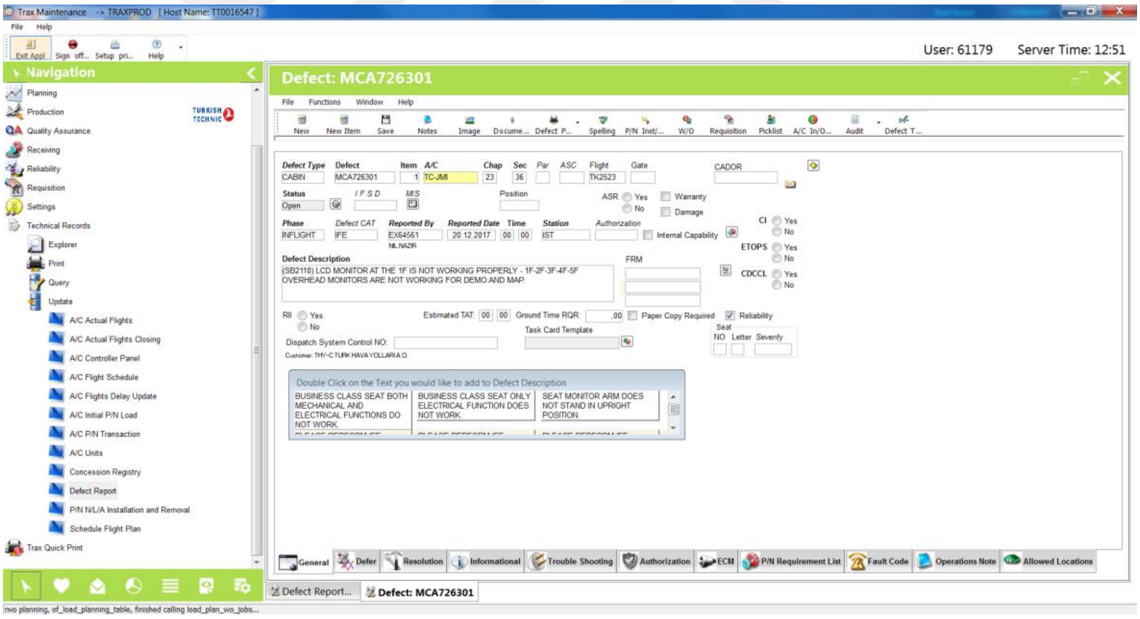
# Appendix A.8 Health Monitoring Tool Feature Examples

## Connectivity:




## Appendix A.9 Trax-Defect Report Examples





*Source:* (Turkish Technic Maintenance Software-TRAX, 2017)

**CURRICULUM VITAE**

**NAME SURNAME:** MUSTAFA İÇELOĞLU

**ADRESS:** ATATURK AIRPORT B GATE LINE MAINTENANCE DIRECTORATE 34149, YESILKOY/ISTANBUL

**BIRTH DATE AND PLACE:** 06.01.1982, ISTANBUL

**LANGUAGES:** TURKISH, ENGLISH

**EDUCATION**

| | |
|---|---|
| 2014-PRESENT | : M.Sc. INDUSTRIAL ENGINEERING, BAHCESEHIR UNIVERSITY, ISTANBUL |
| 1999-2003 | : B.Sc. ELECTRIC AND ELECTRONIC ENGINEERING, SAKARYA UNIVERSITY |

**EXPERIENCE**

| | |
|---|---|
| 2003-2006 | : TURKISH AIRLINES AVIONICS ENGINEER |
| 2006-2010 | : TURKISH TECHNIC AVIONICS ENGINEER |
| 2006-2007 | : MILITARY SERVICE, AFYON |
| 2010-2012 | : TURKISH AIRLINES IFE AND CABIN INTERIOR CHIEF ENGINEER |
| 2012-2016 | : TURKISH TECHNIC IFE CHIEF ENGINEER |
| 2016-PRESENT | : IFE AND MEDIA MANAGER |