IMPLEMENTATION OF FUEL SAVING TECHNIQUES AMONG AIRLINERS IN MALAYSIA

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2021

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THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF MECHANICAL ENGINEERING

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2021

UNIVERSITY OF MALAYA

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ABSTRACT

Fuel Management is a concept that has been ever evolving till date due to two main factors; the volatile fuel market which has increasing prices from time to time causing a significant negative impact on the aviation industries and also the contribution of harmful gases to the environment. These factors make it essential for the fuel management divisions to implement effective fuel saving techniques in order to reduce fuel usage. Past research only acknowledges on the fuel saving techniques around the world, but the studies did not provide empirical evidence on how efficient are those fuel saving techniques being practiced by the Malaysian Aviation Industry. This research focused on investigating the different fuel saving techniques implemented among airliners in Malaysia in order to overcome the negative impacts of fuel consumption because airlines are frequently under financial strain during times of crisis, therefore need to devise some ways to come through. The methodology applied to analyze the various techniques that implement among airliners in Malaysia includes an analysis of how these techniques proved to be successful was also carried out and this was mainly focused to Malaysia Airlines. The method used to gain information that is based on survey questionnaires distributed into two main divisions; the flight operations and the planning operations which are believed to play the most important role in flight planning and fuel optimization. The survey involved Air Asia, Air Asia X, Malindo Air, Firefly, Malaysia Airlines, Raya Airways, MASwings and a renowned MRO Sepang Aircraft Engineering (SAE). The result shows majority airlines in Malaysia proven to have most of the fuel saving techniques as stated in survey questionnaire. Some of these measures successfully support the result of previous research done on the evidence of the performance of Malaysia Airlines. However, there are few techniques couldn’t get to implement due to cost, incapability and time limitation. Therefore, further improvements needed by recommending new technique or enhancement of a current technique for fuel saving.

Keywords: fuel saving techniques, airlines, survey

ABSTRAK

Pengurusan bahan bakar adalah konsep yang telah berkembang sehingga kini kerana dua faktor utama; pasaran bahan bakar mudah turun naik yang meningkat dari semasa ke semasa menyebabkan kesan negatif yang signifikan terhadap industri penerbangan dan juga sumbangan gas berbahaya kepada alam sekitar. Faktor-faktor ini menjadikan bahagian pengurusan bahan bakar penting untuk menerapkan teknik penjimatan bahan bakar yang efektif untuk mengurangi penggunaan bahan bakar. Penyelidikan masa lalu hanya mengakui mengenai teknik penjimatan bahan bakar di seluruh dunia, tetapi kajian tersebut tidak memberikan bukti empirikal mengenai seberapa efisien teknik penjimatan bahan bakar yang dipraktikkan oleh Industri Penerbangan Malaysia. Penyelidikan ini difokuskan pada penyiasatan pelbagai teknik penjimatan bahan bakar yang dilaksanakan di antara syarikat penerbangan di Malaysia untuk mengatasi kesan negatif penggunaan bahan bakar kerana syarikat penerbangan sering mengalami tekanan kewangan pada masa krisis, oleh itu perlu mencari beberapa cara untuk dilalui. Metodologi yang digunakan untuk menganalisis pelbagai teknik yang dilaksanakan di antara kapal terbang di Malaysia termasuk analisis bagaimana teknik ini terbukti berjaya juga dilakukan dan ini terutama difokuskan kepada Malaysia Airlines. Kaedah yang digunakan untuk mendapatkan maklumat yang berdasarkan pada soal selidik tinjauan diedarkan ke dalam dua bahagian utama; operasi penerbangan dan operasi perancangan yang dipercayai memainkan peranan paling penting dalam perancangan penerbangan dan pengoptimuman bahan bakar. Tinjauan itu melibatkan Air Asia, Air Asia X, Malindo Air, Firefly, Malaysia Airlines, Raya Airways, MASwings dan MRO Sepang Aircraft Engineering (SAE) yang terkenal. Hasilnya menunjukkan syarikat penerbangan majoriti di Malaysia terbukti memiliki kebanyakan teknik penjimatan bahan bakar seperti yang dinyatakan dalam kuesioner tinjauan. Sebilangan langkah ini berjaya menyokong hasil penyelidikan sebelumnya yang dilakukan terhadap bukti prestasi Malaysia Airlines. Namun, ada beberapa teknik yang tidak dapat dilaksanakan kerana kos, ketidakupayaan dan batasan waktu. Oleh itu, penambahbaikan lebih lanjut diperlukan dengan mengesyorkan teknik baru atau peningkatan teknik semasa untuk penjimatan bahan bakar.

Kata kunci: teknik penjimatan bahan api, syarikat penerbangan, tinjauan

ACKNOWLEDGMENT

Thanks to god for giving us chance to complete this Research Project for this Semester, as one of the requirements to graduate and obtain Master of Mechanical Engineering (MEng).

Firstly, I would like to thank my supervisor; Associate Professor Dr. Salwa Hanim Binti Abdul Rashid for persevering with me as my advisor throughout the entire time it took me to complete this research and write the dissertation.

I am also grateful for the time and guidance that my advisor offered during the course of the year. The information, direction and feedback they provided was critical in completing this research in a timely manner.

Many thanks are due to Captain from Company A. He also provided relevant information pertaining to my thesis with relation to Malaysian Airliners. I must acknowledge the many friends, lecturers and other librarians as well who assisted, advised, and supported my research and writing efforts.

Last but not least, I need to express my gratitude and deep appreciation to my family, whose hospitality, knowledge, and wisdom have supported, enlightened, and entertained me and kept me in the momentum to complete my thesis. They have consistently helped me keep perspective on what is important in life and shown me how to deal with reality.

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LIST OF SYMBOLS AND ABBREVIATIONS

CO_2	:	Carbon Dioxide
CH_4	:	Methane
NO_x	:	Nitrogen Oxide
APU	:	Auxiliary Power Unit
GPU	:	Ground Power Unit
ULD	:	Unit Load Devices
LD	:	Load Devices
CM	:	Centimeter
KGS	:	Kilograms
NADP	:	Noise Abatement Departure Procedure
AGL	:	Above Ground Level
KTS	:	Knots
RWY	:	Runway
FT	:	Feet
FMS	:	Flight Management System
IFR	:	Instrument Flight Rules
RRR	:	Revolutionary Reinforced Radial
CDA	:	Continuous Descent Approach
ACARS	:	Aircraft Communication Addressing And Reporting System
MRO	:	Maintenance Repair Organization
SAE	:	Sepang Aircraft Engineering
SOP	:	Standard Operating Procedures
IATA	:	International Air Transport Association

ATR	:	Aerei da Trasporto Regionale

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CHAPTER 1: INTRODUCTION

INTRODUCTION

1.1 A Brief Overview

Jet propulsion dates back to centuries ago when the airplane was created by the great Egyptian Mathematician, Hero of Alexandria. As we know, the main driving energy of jet propulsion is fuel (Chevron Corporation, 2006). The early aircraft engines were the same as automobiles engine and therefore consumed the same type of fuel. However, as technology advancements took place so did the improvement of aircraft engines, this was due to the need of higher power requirements for the much larger and sophisticated aircrafts. As a result of these changes aviation fuel also began to contrast to fuel used by automobiles.

Nowadays there are two types of fuel that powers the aircraft, Jet fuel and Avgas. Jet fuel is a clear to straw colored fuel, based on either an unleaded paraffin oil (Jet A-1), or a naphtha-kerosene blend (Jet B) (ECON, 16 January 2021). Jet fuel is used for modern commercial airlines. Avgas on the other hand is a high-octane fuel used for aircraft. The term avgas is a combination of the word aviation gasoline.

Fuel prices have fluctuated dramatically over the last six years, resulting in increased demand for fuel-efficient aircraft. As a result, regional jets' market share has decreased drastically compared to the previous decade (Kharina & Rutherford, 2015). Increased jet fuel and diesel costs result from higher oil prices, and because fuel is one of the biggest expenses for airlines, a rise in fuel costs is passed on to passengers in the form of higher flight rates. Airline industry are significantly exposed to higher jet fuel prices. The rise in fuel prices no doubt affects every other business directly or indirectly but definitely not as significantly as to the aviation industries around the globe. According to

IATA (2019) Airlines have such high fuel requirements that fuel is second only to labor as their single largest cost.

Fuel has become an emerging significant source of energy. No matter how technology has advanced in many ways, the need for a huge amount of fuel is still essential for the aircraft to fly. This is because, it is the fuel that is the heart of all operations on an aircraft. This research has been narrowed to the Malaysian Aviation industry. Upon some basic research, it can be concluded that there are various ways on reducing fuel.

Fuel costs have shot up so much over the years that it may even go higher than the cost of the airline's most important assets, the aircraft itself. Finally, it becomes compulsory for the airlines to succeed or fail on their competency to survive in two factors that is prevent empty seats from being flown or manage their fuel costs. It has been deduced that the fuel consumption globally is up to about 188 billion which is about 23.7 percent of the operating costs of most airliners (IATA Economics, 2019). From this we can easily see the negative impact of aviation gases; Carbon dioxide (CO_2) and Nitrogen dioxide (NO_2) that are major contributors to the deterioration of the ozone layer (EASA, 2019).

Managing fuel costs may become an issue for airliners that already financially saturated in the sense; they are having difficulty in balancing higher fuel costs as well as trying to keep their fares at a desired rate (Buchholz, 2019). As a result, airlines have taken cost-saving measures including limiting the number of flights on various routes and replacing large-capacity aircraft with smaller planes and also cutting the number of seats in order to conserve fuel (Hutchison, 2008). An example would be Air Asia, the only low-cost carrier currently operating in Malaysia. As a result, airliners end up adding a fuel surcharge to the ticket to fill in for the increase in fuel costs (Robertson, 2016). This is often troublesome to passengers who tend to have high expectations of that airline and its services. Below figure speaks the overall impact that we're facing now.

Trip Total Cost

Fare	3,177.00 MYR
Adult (x 3)	3,177.00 MYR
Taxes	5,382.00 MYR
Regulatory charge domestic and international (H8)	3.00 MYR
Airline fuel fee (YQ)	3,006.00 MYR
Security fee (I2)	66.00 MYR
Air passenger duty APD (GB)	1,266.00 MYR
Passenger service and security charge (MY)	219.00 MYR
Passenger service charge arrivals (UB)	756.00 MYR
Airport tax (OM)	66.00 MYR
Total to be charged	8,559.00 MYR

FIGURE 1.1: Malaysia Airline Air ticket (Malaysia Airlines, 21 April 2021)

1.1 Problem Statement

Aviation jet fuel conservation has been emphasized since the mid of 1970s (ATAG, 2010). Airliners still struggling to save fuels in every way possible all over the world. The same goes for the Malaysian aviation industry. Jet fuel prices have been fluctuating due to various environmental factors around the world such as the global issues, resource shortages, wars, fluctuating exchange rate etc. (Hsu & Eie, 2013). It is often heard that increase in fuel prices will have a significant impact on the aviation industry. As you know this is not new thing for the aviation industry to face about. Many fuel-saving techniques have been implemented by airlines across the world to decrease the impact of fuel price fluctuations. Few studies have looked at how an airline operator uses various fuel-saving techniques to mitigate the impact of fluctuating fuel prices. Increased in effective jet fuel costs will provide incentives for the airlines to improve on their fleet fuel technique efficiency and reduce the environmental effects of aviation (Morrison et al, 2010). It has been deduced that there are numerous ways that are currently being practiced by airliners around the globe. The question is how the aviation industry in Malaysia facing this crisis of increasing fuel prices. However, the researcher only acknowledges about the fuel saving techniques around the world, but their studies did not provide empirical evidence on how many fuel saving techniques and how efficient are those techniques that being practiced by the Malaysian Aviation Industry. Therefore, it has the research gap in this area. To fill this gap, the aim of this research is to investigate the implementation of fuel saving techniques that being practice among the airlines in Malaysia. This research is a case study that focused on identifying the potential fuel saving techniques that being practiced by the airliners in Malaysia to enhance fuel savings. It is often true that not all implementations can give a positive outcome. The aviation industry has been experienced important changes that impact fuel efficiency since 2009, research also found that the rate of fuel efficiency improvements fluctuating substantially (Kharina & Rutherford, 2015). Therefore, the more important issue is how efficient are those fuel saving techniques that are being practiced by the Malaysian Aviation Industry.

1.2 Research Aim and Objectives

The aim of this research is to investigate the implementation of fuel saving techniques that being practice among the airliners in Malaysia. This can be achieved through achieving these objectives:

1. To identify different fuel saving techniques used by airlines globally as reported.
2. To identify different fuel saving techniques that is being practiced by airliners in Malaysia.
3. To assess how efficient are the fuel saving techniques that are being implemented among airliners in Malaysia.

4. To recommend fuel saving techniques improvements to be implement by the Malaysian airliners

1.3 Research Scope

The scope of this research is to gather information on the different fuel saving techniques used within the Malaysian airliners. Firstly, the research begins with identifying different fuel saving techniques around the world as reported in literature review by using well known online collection and researchers. This part will be determined through quantitative research. Main focus will be on fuel saving techniques that being practice within Malaysian Airliners which will confirm and validate based on fuel saving techniques globally, this will determine through survey respondent thoughts which is also involve from quantitative research. Lastly the aviation industry impact on fuel saving techniques in Malaysia will be determined through interviewee thoughts and depth experience response involve from qualitative research. Time frame for this research will be around 6 – 9 months period. In this duration, data will be collected to finalize on fuel saving techniques implementation among airliners in Malaysia.

1.5 Summary

The research scopes cover all the objectives through quantitative and qualitative research to fill this gap to investigate on the implementation of fuel saving techniques that being practice strategies among the airlines in Malaysia. As mention in research scopes, literature reviews mainly review on fuel saving techniques around the world which to show on how many fuel saving techniques and how effective are the which will be discussed in next chapter. This will also help in developing the survey questionnaires construction and interview part to identify and conclude on what are the different fuel saving techniques that being practice by Malaysian Airliners. The recommendations on fuel saving techniques improvements for future use will be discussed in conclusion.

CHAPTER 2: LITERATURE REVIEW

LITERATURE REVIEW

2.1 Introduction

According to recent studies carried out by (IATA 2nd ed, 2015) fuel consumption is the second highest direct operating cost for the airlines, the first will always be the labor costs. Many theories have been introduced to explain the various techniques of fuel saving. However, this literature focuses on some of those techniques that being practice globally. The countries that have been focused upon include Canada, Japan, New Zealand, and The United Kingdom. This literature will concentrate on the techniques that have been adopted by the airliners in these countries.

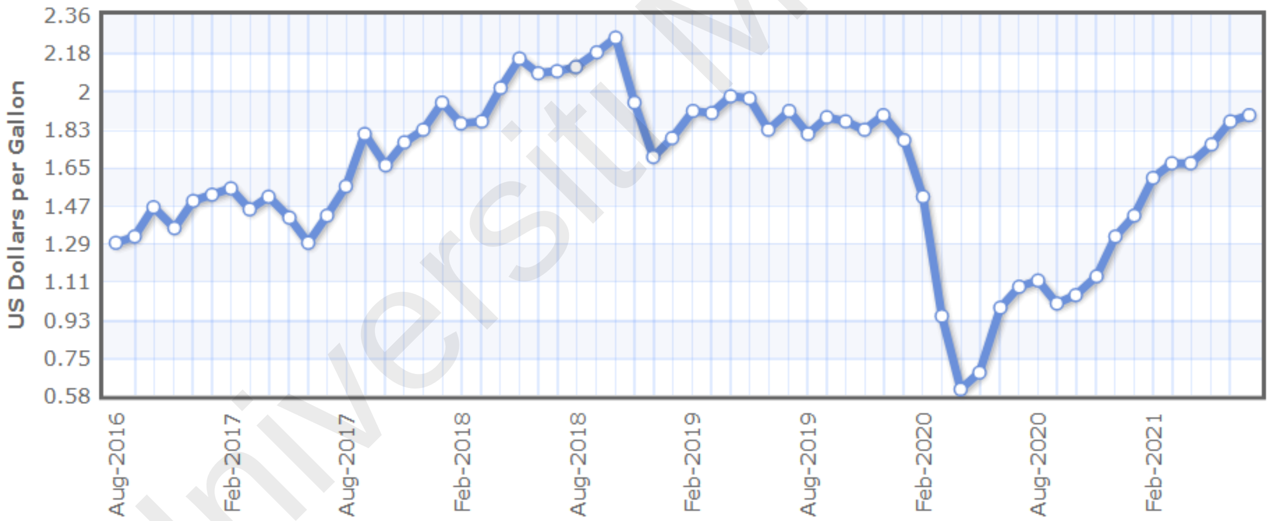


FIGURE 2.1: Jet Fuel Price Monitor (Index Mundi, 2021)

The above figure shows the price ranges of Jet Fuel over 5 years in US Dollars per Gallon. The trend shows that fuel prices are generally fluctuating. Fuel costs typically account for 20-30% of an airline's total expenses, therefore any price fluctuations will have an impact on the company's financial status (Rodrigue, 2019). This is one of the threats faced by the aviation industries and therefore various techniques should be introduce in order to help airliners save fuel. Jet fuel cost are significant but its highly variable expense for airlines globally. Cost of airline fuel greatly affect the profitability of airlines (Mazareanu, May 2021) This is why the airline keep implement fuel saving techniques as much as they need. The main objective will be analyzed with respected to collected information in this chapter.

2.2 Fuel Saving Techniques around the Globe

An increase in fuel prices as mentioned earlier has a great impact on the aviation industry. These are some of the many ways that the aviation industries around the globe have considered in order to face this crisis.

2.2.1 Air Transat, Canada

Canada has a whole different perspective on fuel saving. This is because Air Transat not only focused on just the flight operations or proper flight planning but they also focused on engineering and other ground services (FAA, 2013).

Upon the implementation of the new devised ways, it was discovered that approximately 5 percent of fuel was saved annually and this in turn contributed to a reduction in greenhouse gas emissions (CO_2, CH_4, and NO_x) of about 5 percent as well. These new devised ways were carried out on Air Transat's fleet of 11 A310 aircraft and 4 A330 aircraft (FAA, 2013). The different ways practiced by Air Transat are explained in detail.

i. Reduction in Aerodrag

Aerodrag is the abbreviation for aerodynamic drag, the arch-enemy of aviation and more significantly the performance of flight (Rogers, D. F. 2005). Drag is defined as any force that opposes the forward motion of the aircraft and is parallel to the direction of the free stream of airflow There are two main forms of drag; Parasite drag and Induced drag (Drag, 2008). Parasite drag usually arises due to the viscosity present at the fuselage skin. Viscosity is a physical property of a liquid or solid whereby the particles of that form tend to be very sticky with each other. There are three types of parasite drag; skin friction drag, form/pressure drag or interference drag (NASA, 21 May 2021) Skin friction drag as its name suggests is related to the reaction of airflow as it moves over the surface of the fuselage. It is known as the aerodynamic resistance due to the contact of moving air with the surface of an aircraft (NASA, 21 May 2021)

Pressure drag on the other hand forms when the molecules of air that are about to leave the surface of the fuselage create a sort of turbulence wake. This can be seen in the diagram below which distinguishes between the different types of surfaces and their corresponding wakes formed by comparing the pressure difference between the fore and aft of the surfaces (FAA, February 2021)

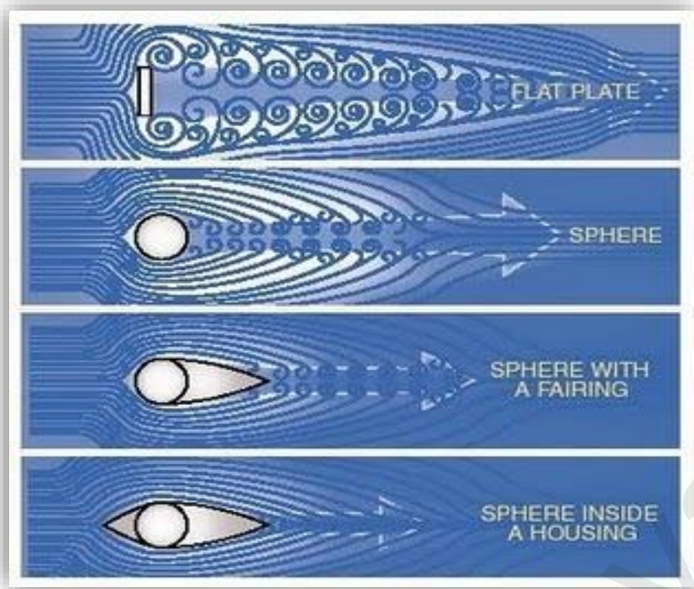


FIGURE 2.2: Pressure Drag / Form Drag (Aerodynamics of Flight, February 2021)

The above figure shows how the characteristics of airflow changes when passing over a flat plate and then a sphere. On the other hand, interference drag is a type of drag that is generated by the mixing of airflow streamlines between airframe components such as the wing and the fuselage (Flight Safety, 2017) Interference drag occurs at the wing root. An example would be the wing root as shown in the next figure:

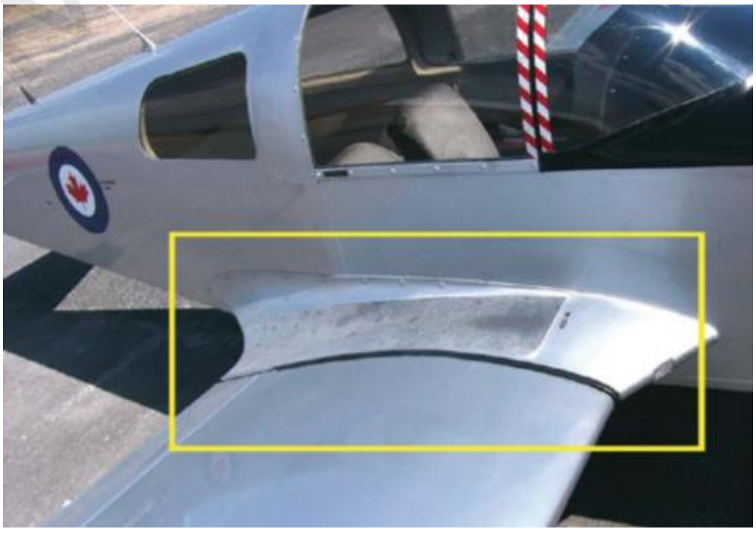


FIGURE 2.3: Interference Drag occur at wing root (Aerodynamics of Flight, February 2021)

Induced drag is a form of drag that generated as the wing is driven through the air to develop the difference in air pressures that we call lift (Flight Literacy, April 2021) A simplified way of understanding is by the figure shown below:

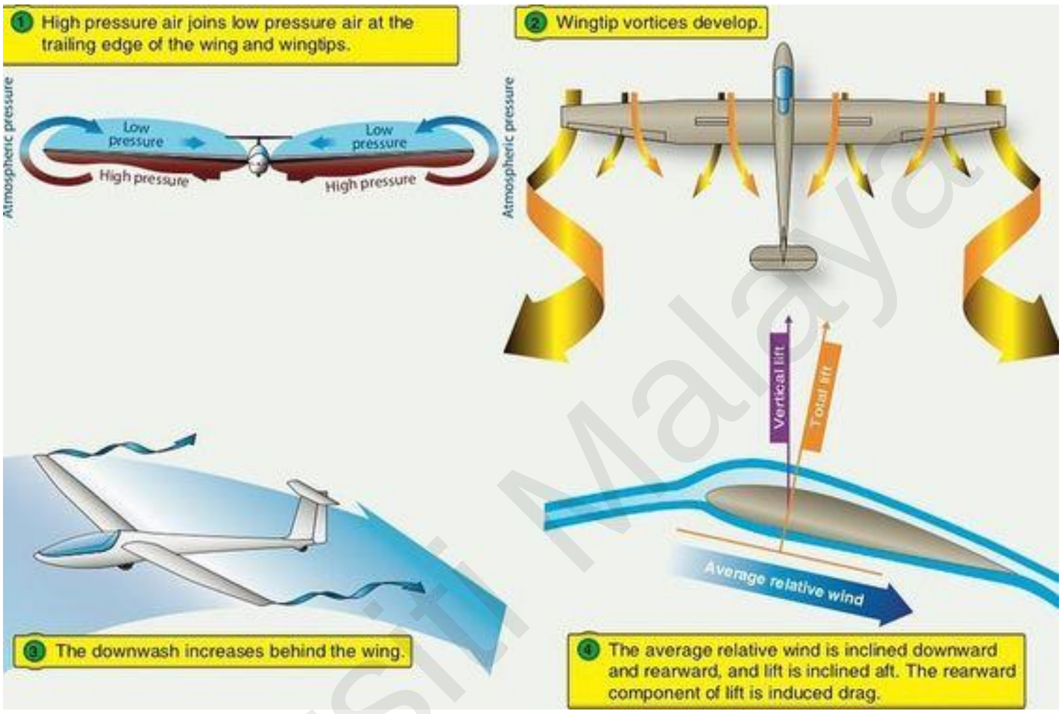


FIGURE 2.4: Formation of Induced Drag (Flight Literacy, April 2021)

Since aerodynamic drag may not be predicted, a routines inspection was carried out to inspect the aircraft's exterior surfaces for any abnormalities which would further be repaired. The types of defects that were searched for included chipped paint, scratches and damaged seals. Instead of making this aerodynamic drag check an independent one, it was included in the Type A check that was carried out every 4 weeks (Blanchette, 2017). By checking closely the health of the aircraft's exterior surfaces, it calculated that about 0.41 percent reduction in fuel consumption was attained annually. In fact, the costs spent on this extra aerodynamic drag inspection plus the repair was much lesser than what was saved on fuel.

ii. Engine water wash

FIGURE 2.5: Engine Water Wash (AZoCleantech, 2009)

The figures above show engine water wash being carried out. After repeated cycles of usage, the engine tends to accumulate dirt and other sorts of contaminants at the turbine blades and various parts of the engine. Therefore, an engine wash is carried out. This wash is done on areas of the engine that are easily accessed by the cleaning personnel (Transat, 2016).

Engine water wash does not require the removal of the engine as this would be too costly. Even though this water wash is not a thorough cleaning process, but it does however clean inside the engine hence allowing the engine to burn fuel more efficiently. This way contributed to an annual reduction of 0.42 percent despite the cost that was incurred into acquiring washing equipment and personnel (Transat, 2016).

iii. Lighter-Weight Tire

Weight is a major contribution to high fuel consumption., thus any measures taken to reduce weight will end up in saving fuel. Airplane tires are amazing to think off when it lands without explode it, they're like our car tires but way stronger in every way (Adams, 2016). Air Transat replaced the tires with new ones that were 6kg lighter (Blanchette, 2017). This change however did not jeopardize performance or the safety or service life of the aircraft and was carried out without any additional costs.

FIGURE 2.6: Aircraft Tire (Aircraft tire, July 2021)

This change showed a 0.02 percent reduction in annual fuel consumption. Though this is not ought to be a huge contribution as the other ways but then again, a little bit goes a long way (Blanchette, 2017). Michelin help Air Transport by to create and develop aircraft tires with lightweight radial design in order to make more sustainable fuel savings (Michelin, 2019)

iv. Potable Water

This is anti-bacterial water than is purely used for culinary purpose such as drinking water Noise Abatement Procedures, 2006). Air Transat believed that less of what was carried along was being used. This meant that there was a loss of not only payload but also the extra fuel that was being consumed for the unused water.

Therefore an analysis was carried out to see how much water was actually being used (Blanchette, 2017). In conclusion, some extra water was added to the analyzed quantity to make sure that there were no shortages during flights. To make sure that there was no wastage of water in flight, a chart was put up to guide the flight attendants on the usage of the water (Aviaso, 2015). Air Transat managed to reduce weight by at least 100 kilograms per aircraft which in turn came up to about 0.09 percent reductions in fuel consumption annually (Aviaso, 2015).

v. Auxiliary Power Unit Usage

The use of auxiliary power units (APUs) is usually to provide the aircraft with heating, electricity, and air conditioning when the aircraft is on ground and is not being supplied with any external power supply. However, sometimes the APU may be used extensively for example to supply heat to the cabin when it's the first flight of the day during a cold climate. Therefore, it was deduced that the APU should be used for a maximum of 20 minutes. According to Transat (2016), the most suitable way to use APU are:

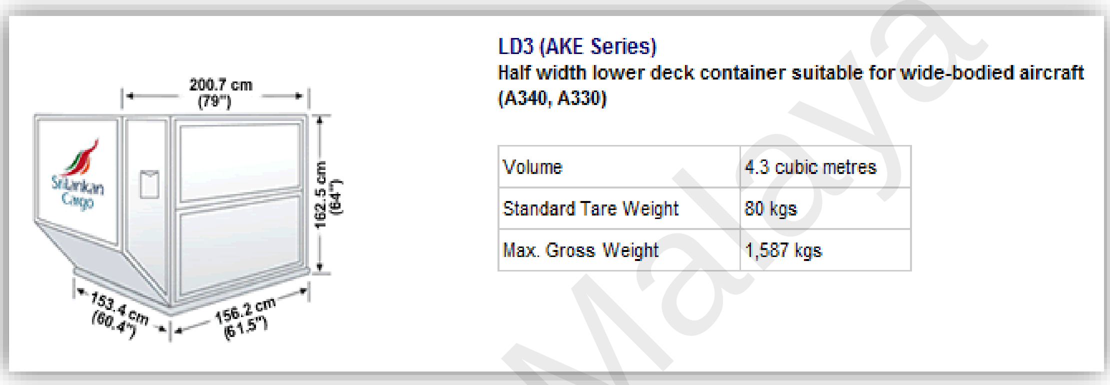
a) Connect ground power unit (GPU) until 15 minutes before takeoff and therefore turning on APU only in that 15 minutes.

b) Connect ground power unit (GPU) not more than 5 minutes upon reaching the gate and therefore having APU on for only 5 minutes.

However, due to the absence of external ground power at many of the airports and this caused the usage of APU to increase from 20 minutes to 60 minutes. Despite this increase, there was still a significant reduction in fuel consumption annually of about 0.10 percent (Transat, 2016).

vi. Load Container Weight

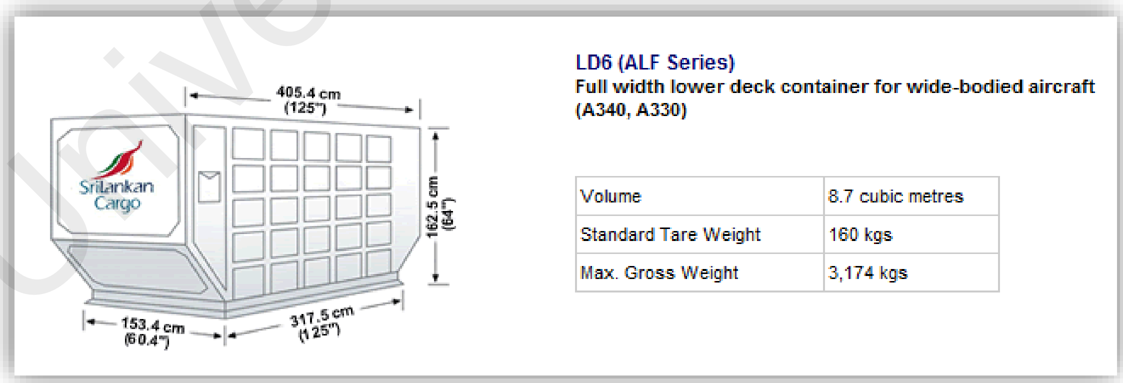
Unit Load Devices (ULDs) are used for carrying loads in aircraft and often classified according to their weight as light or heavy. These are usually used to carry passenger luggage or cargo items. Two main types of ULDs are used by airliners are LD3 ULDs and LD6 ULDs, as shown in the figures below ("Unit load device," 2021).



Volume	4.3 cubic metres
Standard Tare Weight	80 kgs
Max. Gross Weight	1,587 kgs

FIGURE 2.7: Dimensions of Ld3 Unit Load Devices ("ULD Container Types," n.d)

LD3 is used for carrying luggage.



Volume	8.7 cubic metres
Standard Tare Weight	160 kgs
Max. Gross Weight	3,174 kgs

FIGURE 2.8: Dimensions of Ld6 Unit Load Devices ("ULD Container Types," n.d)

LD6 is used for carrying bulky cargo.

The lightweight ULD's are normally comprised of aluminum extrusions as well as composite side and roof panels The difference in weight between the heavy and light versions of containers is 8 kg for the LD3 and 25 kg for the LD6 ("Unit load device," 2021) & ("ULD Container Types," n.d).These lightweight ULDs allowed an annual reduction in fuel consumption by 0.02 percent (Blanchette, 2017).

vii. Flight Plan Optimization

Flight planning is the act of devising a flight plan for a particular aircraft flight. The flight plan usually focuses on two safety-critical factors:

TABLE 2.1: Safety Critical Factors ("Flight planning," 2021).

FACTORS	REASON
Fuel calculation	To make sure that the aircraft would safely arrive at the desired destination
Conformity with the air traffic control requirements	To cut down on the cost incurred in that particular flight. This can be done by proper choice of route, height, speed and loading of minimum necessary fuel

Air Transat introduced a very practical and well devised flight planning system that takes into consideration quite a number of factors that would aid in more economical and efficient flying. The kind of factors accounted for include, navigation charges, cost of weight, maintenance costs, fuel cost, navigation fees, wind, cost index and different flight levels. Improved flight planning system contributed an annual reduction in fuel consumption by 0.76 percent (Aviaso, 2015).

viii. Contingency Fuel

Often when an aircraft flies, there are a number of factors that may not be determined. One of the consumptions of fuel is during the flight. This is why pilots often request for contingency fuel to be allowed on board to compensate for any unexpected occurrences of over consumption of fuel. Many of a time, this extra fuel was not tracked down to see how much is being requested for, the reason for such a request and whether it was actually used (Aviaso, 2015).

As far as fuel for sudden unexpected occurrences is concerned, it is not such a bulky amount. However, it was discovered that too much was being asked for as extra fuel. Therefore, upon the introduction of the new and improved flight management system, the contingency fuel was carefully tracked down and if more than expected fuel was requested for by pilots, a justification was to be given by carefully planning how much extra fuel should be taken on board, an annual reduction of fuel reduction of 0.77 percent was achieved (Transat, 2016).

ix. Variable Cost Index

A cost index is basically a ratio between time-related costs and cost of fuel. Many jet aircraft are equipped with different kind of performance computers that aid in determining the optimum speed at which to travel in order to minimize the total operating cost of the flight.

Air Transat used to keep a common cost index for all destinations as well as aircraft types. It was later discovered that by this way, for certain flights fuel was being over burned unnecessarily (Aviaso, 2015). Therefore, to counter this problem a variable cost index was introduced to the flight planning that considered the aircraft type and destination. A variable cost index, as its name suggests is a cost index that can be varied accordingly to suit various flying conditions, aircraft, destinations and many more. This ensured some aircraft flew at lower operating speeds hence reducing fuel consumption. By having a variable cost index, Air Transat was able to allow some flights to fly fast during the winter season. Using variable cost indices reduced annual fuel consumption by about 1.29 percent (Transat, 2016).

x. Single-Engine Taxi

Taxiing is the movement of aircraft on ground on its own without any external towing or push-back assistance. However, taxiing does not refer to the time an airplane is accelerating just before taking off or decelerating just after touchdown (Pushback, 2020).

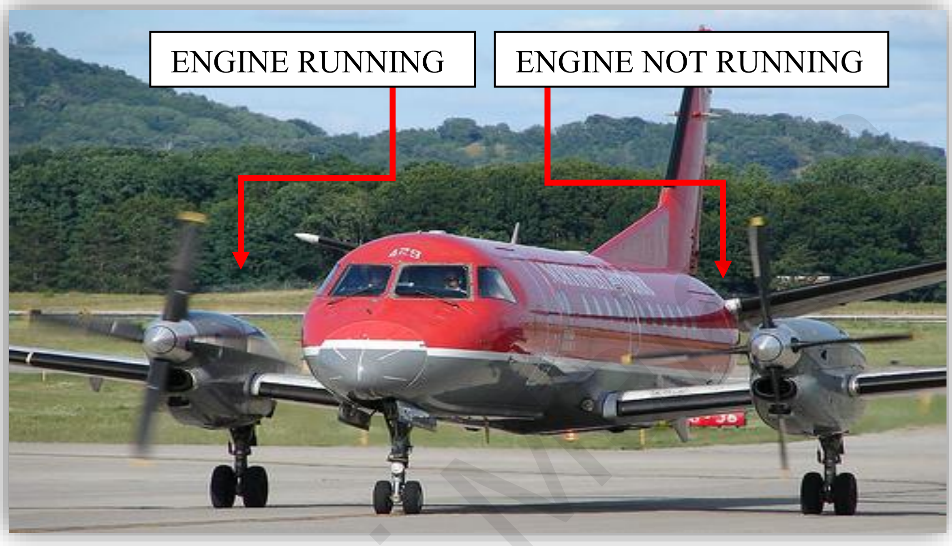


FIGURE 2.9: Single Engine Taxi

Generally taxing is done by the aid of both engines, for example on twin engine aircraft. Nonetheless, Air Transat decided upon a single-engine taxing between the respective gate and runway. An example of single engine taxing can be seen in the figure above. The aircraft is then controlled by the use of control surfaces such as rudder so as to prevent the aircraft from running off its taxiway (Transat, 2016). This technique has proven to be quite efficient and does not jeopardize as well as contributes to an annual reduction in fuel.

xi. Flight Operations

Flight operations is a relatively large area to consider and hence can be further segregated into more focused area of interest. Basically, the aim of flight operations is to manage any disrupted or for that matter normal flying conditions by altering the behavior of the aircraft. However great care must taken when changing any kind of flight operation techniques as they should not compromise safety. A change in various flight operations contributed a 0.31 percent reduction in fuel consumption annually (Transat, 2016). The changes that were implemented are as follows:

Idle Reverse Thrust after Landing

Reverse thrust means the opposite of forward thrust. This is when the thrust of the aircraft is directed forward instead of the normal aft direction. Reverse thrust is generally used on ground immediately after touchdown and it can be done by diverting the engine's exhaust to the opposite direction as shown in the next figure The main usage of reverse thrust includes shorter landing distance, reduced noise levels and lesser wear on the brakes (Ronald, 2005).

FIGURE 2.10: Thrust Reversal by Air Transat

Apart from this, reverse thrust also contributes to reduced fuel consumption. As practiced by Air Transat, right after touchdown of the main landing gear, reverse levers are pulled to idle position and no auto brakes are applied. This was usually done on an uncontaminated runway of more than 8,000 feet. The aircraft is allowed to slow down and then manual braking is reinforced. By doing this, fuel consumption was reduced by 0.09 percent (Canada Action Plan, 2012).

Take-Off Profile

There are two types of take-off climb profiles that have been approved by the International Civil Aviation Organization (ICAO) (Canada Action Plan, 2012).

That being:

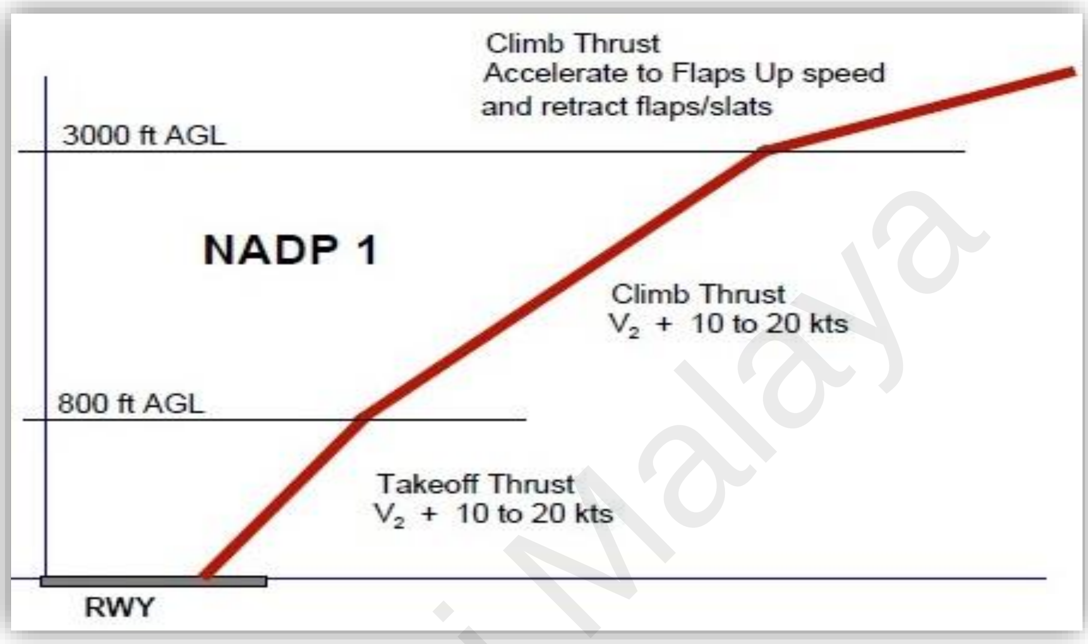


FIGURE 2.11: The Noise Abatement Departure Procedure 1 (Boone, 2006)

The figure above shows the procedures involved for The Noise Abatement Departure Procedure 1 (NADP 1).

Note: AGL refers to Above Ground Level

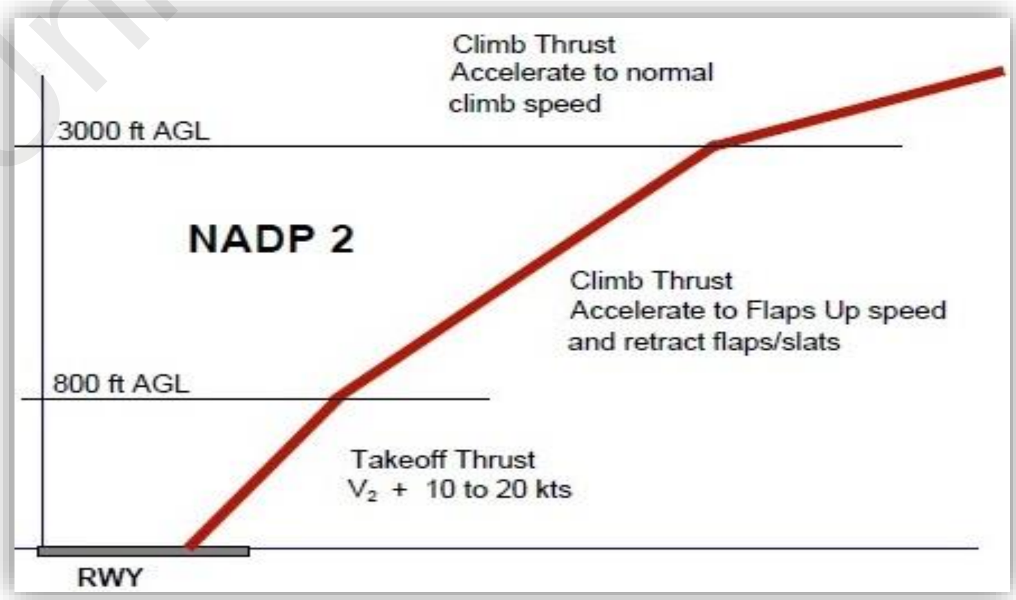


FIGURE 2.12: The Noise Abatement Departure Procedure 2 (Boone, 2006)

The figure above shows the procedures involved for The Noise Abatement Departure Procedure 2 (NADP 2). The NADP2 allows the aircraft to retract the flaps and simultaneously accelerate to a lower altitude with the flaps in the retracted position. By doing this, drag is reduced and this makes the aircraft fly more efficiently hence reducing fuel consumption as well as exhaust emissions However, the NADP2 is permitted at certain areas only. This method allowed an annual fuel reduction by 0.10 percent (Canada Action Plan, 2012).

Economic Climb

An economic climb means that the aircraft is accelerated to a particular climb speed as soon as the flaps are completely retracted and the aircraft has turned to the required flight direction. Economic climb is only allowed at certain airports that do not restrict speed below FL100 (flight level 10,000 feet) to 250 knots This measure reduced annual fuel consumption by 0.12 percent (Canada Action Plan, 2012).

Reduced Weight of Catering Items

Catering items usually consists of the food trolley, beverage makers, trash can, reading items for passengers and/or passenger comfort items like blankets, extra pillows. An urge was taken to reduce the unwanted items such as magazines, newspapers, over capacity of beverages and comfort items. This was especially advisable for short haul flights (Canada Action Plan, 2012).

Some of catering and passenger comfort items can be seen in the figure below.

FIGURE 2.13: In-Flight Catering & Passenger Items

Despite the need for this reduction, one thing had to be taken into consideration and that being the customer needs which in this case is the customer comfort. Hence, without jeopardizing this factor Air Transat managed to remove almost 255 kg from A310 aircraft and 534 kg from A330 aircraft thereby reducing 0.42 percent of fuel consumption annually (Canada Action Plan, 2012).

2.2.2 All Nippon Airways, Japan

All Nippon Airways (ANA) also took several initiatives to reduce fuel consumption as well as CO2 emissions. These efforts were influenced by various divisions including air transportation, flight planning, maintenance and in-flight services (ANA Holdings Inc, 2017).

i. Flight Technologies

It was believed that the implementation of any way should be first introduced to the flight crews since they are the ones in control at all times during flight. Hence this was done by giving out the Eco Flight Guidebook which contained various flight improvements that were decided upon in order to enhance fuel conservation (ANA Holdings Inc, 2017).

The most efficient technique implemented was the way the thrust reversers were utilized during landings. Without jeopardizing safety, the thrust reversers were kept on idle only when the runway and certain circumstances permitted so. Apart from aiding in reduction to fuel consumption, this practice also cuts CO2 emissions and also protects the engine and reduces the noise emissions (ANA Holdings Inc, 2017).

Other than altering the profile of aircraft when landing some flight systems were also taken into consideration. This includes the familiarization of flight management systems (FMS) functions that took wind conditions into consideration. Hence, fuel consumption could be reduced as an optimum cruising altitude at which the aircraft should begin its descent could be determined (ANA Holdings Inc, 2017).

ii. Technologies for Taxiing and Parking

Together with the introduction of new plans for flight operations, ground operations were also improved. It was concluded that large amounts of fuel were burned when taxiing the aircraft to the tarmac. Therefore, engines were turn off during certain intervals of the taxiing and parking process and instead the Auxiliary Power Unit (APU) was used (ANA Holdings Inc, 2017).

"Our approach limits the scope of use of the APU by placing priority on the use of the ground power units (GPU) at airports." 25. All Nippon Airways Co. Ltd. Together We Can (All Nippon Airways, 2016)

iii. Flight Routing

ANA introduced the use of RNAV. RNAV is an abbreviation for Radio Navigation. This is an alternative technique of the Instrument Flight Rules (IFR) navigation that permits the aircraft to choose any course within an allowable range of areas consisting of airport navigating beacons. In other cases, satellite signals and the aircraft's own navigation equipment can be used. Therefore, rather than going directly from one station to another. This effectively shortens the flight distance as well as flight time (ANA Holdings Inc, 2017).

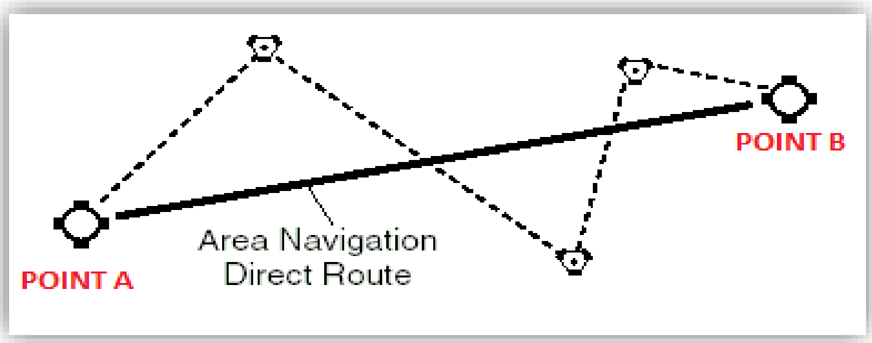


FIGURE 2.14: Area Navigation Method

The figure shown before is a simplified way to show the RNAV method. The dotted line shows the use of area navigation method which allows the aircraft to choose its own course hence making the journey shorter. On the other hand, the straight line shows the direct route. At other times, instead of just an indirect flight the RNAV methods also allows some domestic cargo and mail flights to be flown at high altitudes where fuel efficiency is greater (ANA Holdings Inc, 2017).

iv. Aircraft Weight Management

As mentioned earlier, aircraft weight plays a very important role towards fuel consumption. Other than that, even the dynamics of lift allow reduced fuel consumption. That is, by having the center of gravity of the aircraft closer to rear of the fuselage (ANA Holdings Inc, 2017).

v. In-Flight Service Survey

In-flight services often include services that are provided for passenger comfort. Some of this includes personal entertainment like television, music or even Wi-Fi. Others include beverages, snacks, reading materials or even extra pillows (ANA Holdings Inc, 2017). The figure below shows some of in-flight services provided during flight.

FIGURE 2.15: In-Flight Services

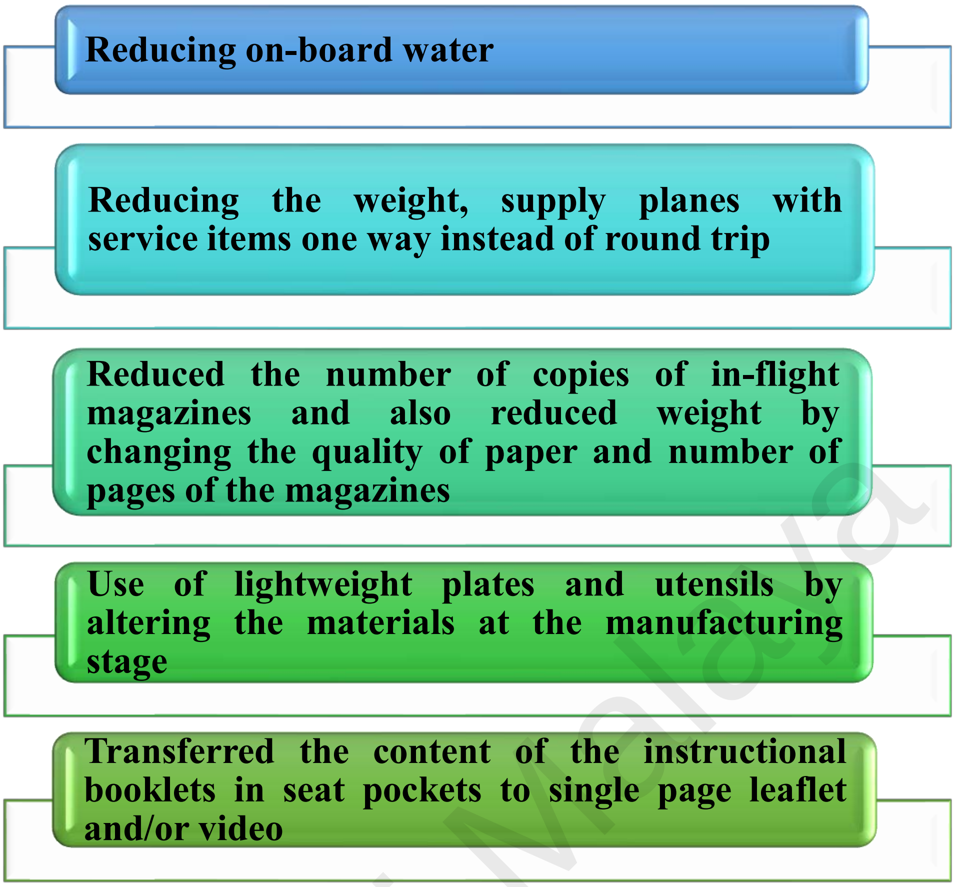


FIGURE 2.16: Steps Taken After In-Flight Survey (ANA Holdings Inc, 2017)

The figure above shows results from the in-flight survey that was carried out. The survey was carried out to determine what items included in the in-flight services could be altered or reduced in order to reduce weight. The reduction in weight would then reduce fuel consumption. All the above steps were taken while still maintaining the quality of services provided in-flight (ANA Holdings Inc, 2017).

vi. Aircraft

There is variety of areas of concern when it comes to reducing fuel consumption. One of which is changes to the aircraft itself. All Nippon Airways began to use tires that had a new structure as a whole. This new structure of the tires allowed in a reduction of weight and also contributed to better safety and fuel efficiency (ANA Holdings Inc, 2017).

This new structure of the tire is referred to as the revolutionary reinforced radial construction which has the following advantages ("Tire and Care Maintenance," n.d):

a) Improves abrasion resistance, therefore handle more landing.

b) Economical as it is lighter than conventional tires, which helps reduce fuel consumption.

c) Safer design since it is cut resistance; this is because the tension of the tire thread has been lowered.

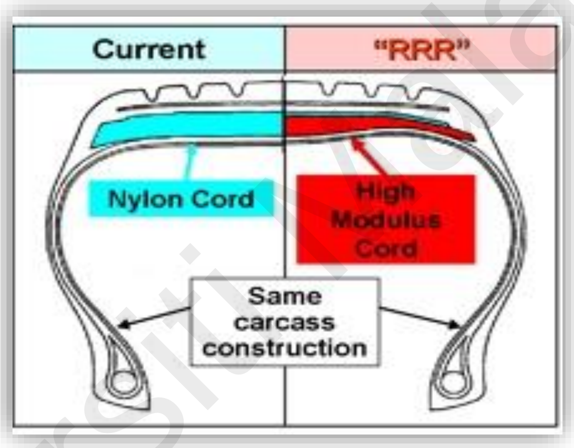


FIGURE 2.17: Revolutionary Reinforced Radial Construction (RRR)

The figure above shows that for the revolutionary reinforced radial construction, high modulus cord is used rather than the nylon cord. This allows the cord to be shaped in a convex shape hence making it abrasion resistance ("Tire and Care Maintenance," n.d). By implementing this change on 12 main tires (main landing gear); it reduced the aircraft weight by 80 kilograms, which in turn contributed to a reduced annual fuel consumption of 105 kiloliters (ANA Holdings Inc, 2017).

vii. Engines

Engine technology has continuously evolved over the last 70 years, and this has been always driving force in fuel burn reduction (EASA, 2019) As mentioned earlier, engine washing at regular intervals allow for cleaner more efficient operations within the engine. All Nippon Airways follows a similar practice and it is proven that each engine wash allows fuel efficiency to rise by almost 1 percent (ANA Holdings Inc, 2017).

viii. Fleet Strategy

Managing the fleet strategies may also provide some benefits in terms of reduction in fuel consumption. Some of the ways practiced by All Nippon Airways included(ANA Holdings Inc, 2017):

a) Using the latest engine technologies to provide smooth operations

b) Improving wing structure that reduces air resistance and therefore reduce drag formation.

c) Using composite materials that reduce weight and also provide lower maintenance cost as it requires less repainting.

2.2.3 Air New Zealand, New Zealand

FIGURE 2.18: Blended Winglets (Boeing 737 MAX, 2012)

Air New Zealand expected to get a 4.5 percent improvement from installing the blended winglets, but it actually achieved 5.3 percent. These blended winglets were first installed on the Boeing 767 and it was believed that this implementation could save about 1.3 million liters of fuel (Boeing 737 MAX, 2012). Boeing did mention that aircraft winglets productions increase its range by 3.5% over the 747-300 (Sumit Singh, 2020). On the other side, Airbus introduce new types of winglet which call as ‘sharklet’ for newer aircraft models and it does not resemble as shark fins as in older devices and provide a significant role in reducing drag and eventually saving fuel (Arnot, 2019)

i. Blended Winglets

Blended winglets are one of the many different types of winglet designs made of carbon-fiber composite. It is attached to the wing with a smooth curve instead of a sharp one. These winglets provide smooth interference at the wing/winglet junction as well as cut down on CO_2 and NOx emissions. Flight test data showed that blended winglets reduce fuel and carbon dioxide (CO_2) emissions. This can be seen in the table below:

TABLE 2.2: Percent Reduction

AIRCRAFT	PERCENT
737	4 percent
757,767	5 percent

Some advantages of blended winglets can be seen in the figure below:

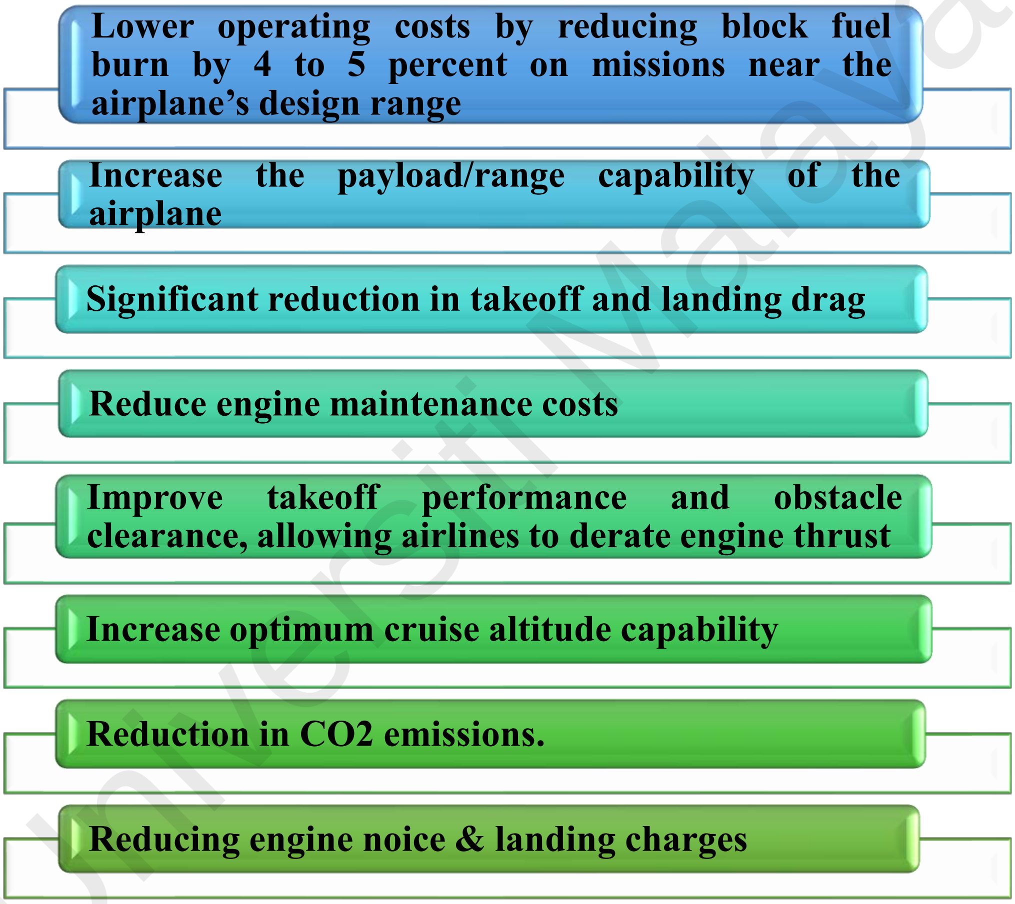


FIGURE 2.19: Advantages of Blended Winglets (Boeing 737 MAX, 2012)

However, the main purpose of wingtip devices is usually to reduce the amount of induce drag created. Induce drag is one of the many drags acting on an aircraft and it is due to the effects of lift (Boeing 737 MAX, 2012).

2.2.4 The United Kingdom

i. Continuous Descent Approach (CDA)

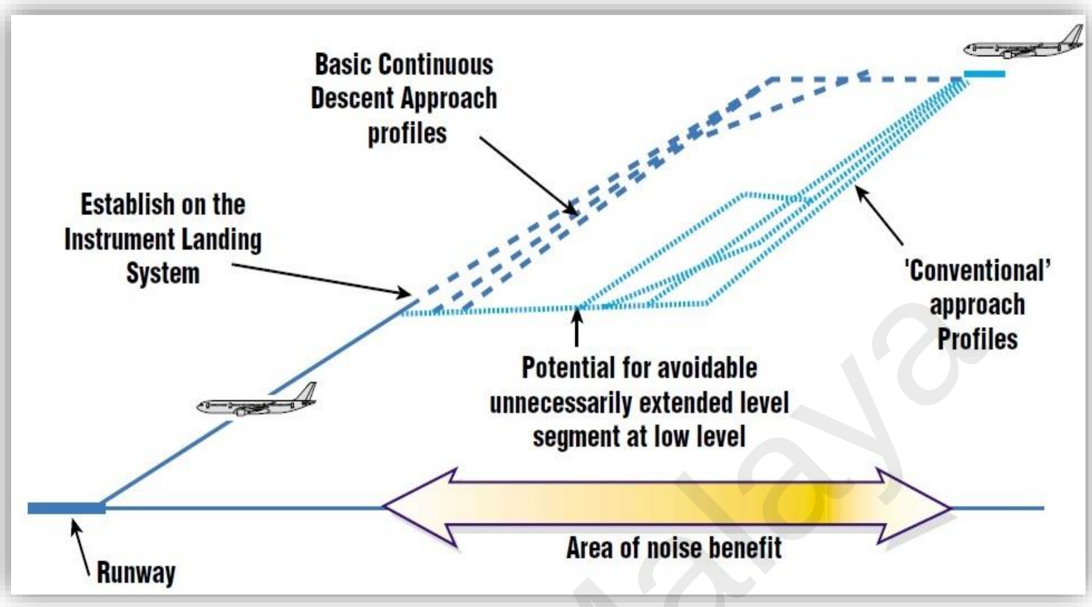


FIGURE 2.20: Continuous Descent Approach ("Continuous Descent Approach," n.d)

An aircraft's flight cycle is basically as simple as take-off, cruise and finally land. There are two types of approach adopted by airliners when descending for landing. This can be seen in the figure above. One is the Conventional Aircraft Approach and the other is the Continuous Descent Approach (CDA).

The conventional approach, as its name suggests is the traditional way that most airliners have been practicing over the years. In this approach, an aircraft would request for clearance from the Air Traffic Control at an altitude of about 6000 or 7000 feet to descend to an altitude of about 3000 feet. Over this distance, the aircraft would fly different levels of flight as shown in the figure above – Conventional approach Profiles. As the pilot changes from the different levels of altitude, additional engine power would be required to maintain constant speed. This additional power means additional fuel burned ("Continuous Descent Approach," n.d).

On the contrary, a continuous descent approach (CDA) is a method of descending the aircraft for landing where the aircraft maintains a high altitude for a longer period of time rather than descending to various levels. This is also shown in the figure above – Basic Continuous Descent Approach Profiles. After maintaining a certain high level altitude the aircraft descends in a constant manner. This ensures that lesser fuel is burned as less engine thrust is required ("Continuous Descent Approach," n.d).

Advantages of CDA

a) Fuel Saving and Reduced Emissions

For the conventional approach, the aircraft needs to descend to the various specified altitudes. However, there can be significant fuel savings (for the final arrival phase of flight) with a CDA because less engine power is required - this also means that aircraft emissions will be reduced. In fact, airlines estimate that each continuous descent approach can save 150kg of jet fuel (around 500kgs of CO2) ("Continuous Descent Approach," n.d).

b) Noise Reductions

As we are aware, one of the main nuisances of aviation is the aviation noise. The most common source of aviation noise is the aircraft itself. The main contributor of noise in an aircraft is the engines. The exhaust gases that leave the engine are of such high velocity that they tend to create turbulence which is the cause of the noise. Since the aircraft is at a high altitude for a longer period of time, the influence of the noise created on the ground is reduced greatly ("Continuous Descent Approach," n.d).

Limitations of CDA

a) Aircraft Can Still Be Heard

A continuous descent approach often does not provide complete silence from the aircraft's noise. The noise levels do decrease a certain amount and this is why a continuous descent is said to provide some noise benefits compared to the conventional approach ("Continuous Descent Approach," n.d).

b) Noise Benefits Only in Certain Locations

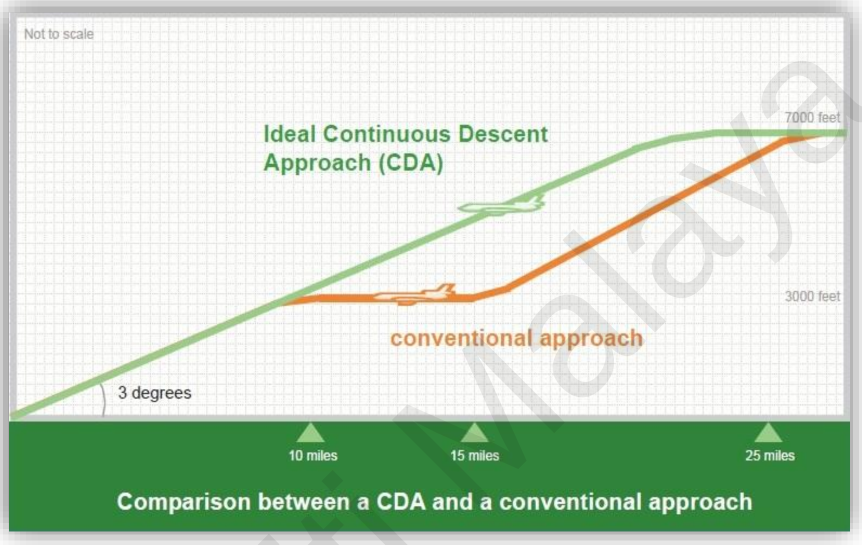


FIGURE 2.21: Comparison of Continuous Descent Approach & Conventional Approach ("Continuous Descent Approach," n.d)

As shown in the figure above, the continuous descent approach provides its benefits only up to almost 3000 feet. This is the altitude at which both the continuous descent approach and the conventional approach are at a similar glide path, the final 3 degree glide path ("Continuous Descent Approach," n.d).

c) Cannot Always Be Flown

It is not possible for an aircraft to always use the continuous descent approach because there is certain airspace that restricts this pattern of aircraft descends. Other than just general restrictions, some airports may not allow this practice due to fear of jeopardizing safety to other aircrafts in air ("Continuous Descent Approach," n.d).

Theoretically, a continuous descend approach may look like a straight line down. However, in all actuality the aircraft still needs a short section of level flight. This is necessary for the aircraft to reduce speed or change its orientation ("Continuous Descent Approach," n.d).

2.3 Results of Fuel Saving Techniques around the Globe

2.3.1 Results Summary of Air Transat, Canada

TABLE 2.3: Summary of the Fuel-Reducing Initiatives

FUEL SAVING MEASURE	Fuel Reduction (Percentage of Annual Fuel Cost)
Aerodrag	0.41
Engine Water Wash	0.42
Lighter Weight Tires	0.02
Portable Water	0.09
APU Usage	0.10
Light Container (ULD) Weight	0.02
Flight Plan Optimization	0.76
Contingency Fuel	0.77
Variable Cost Index	1.29
Single Engine Taxi	0.40
Flight Operation	0.31
Reduce Weight of Catering Items	0.42
Total Calculated Saving, % Annual Fuel Cost	5.01%

The new techniques introduced reduced fuel consumption about 5 percent as shown in the table above. Other than providing benefits to the airlines, this reduction in fuel consumption also reduced greenhouse gas emissions. Other ways to determine the results is to monitor how pilots fly the aircraft, may it be during idle reverse, economic climb, takeoff profile and/or APU usage. This can be done by means of ACARS (aircraft communication addressing and reporting system) that Air Transat has installed on all aircraft (Transat, 2016).

2.3.2 Results Summary of Air New Zealand, New Zealand

Blended winglets can provide a significant reduction in drag, save fuel, cut CO2 and NOx emissions, and reduce community noise (Freitag & Schulze, 2009) All these elements may contribute to additional payload (Boeing 737 MAX, 2012). Pay load is the sum of weight of the passengers, their luggage, and any cargo that is paid for. The table below shows a comparison of fuel burnt for an aircraft without winglets to an aircraft with winglets.

TABLE 2.4: Comparison of Fuel Consumption (Freitag & Schulze, 2009)

MODEL	LOAD (PASSENGERS)	MISSING (NAUTICAL MILES	FUEL USE WITHOUT WINGLETS (LBS)	FUEL USE WITH WINGLETS (LBS)	ESTIMATED FUEL SAVINGS (%)
737-800	162	500	7,499	7,316	2.5%
		1,000	13,386	12,911	3.5%
757-200	200	1,000	16,975	16,432	3.2%
767-300ER	218	3,000	65,288	62,419	4.4%

2.3.3 Results Summary of All Nippon Airways, Japan

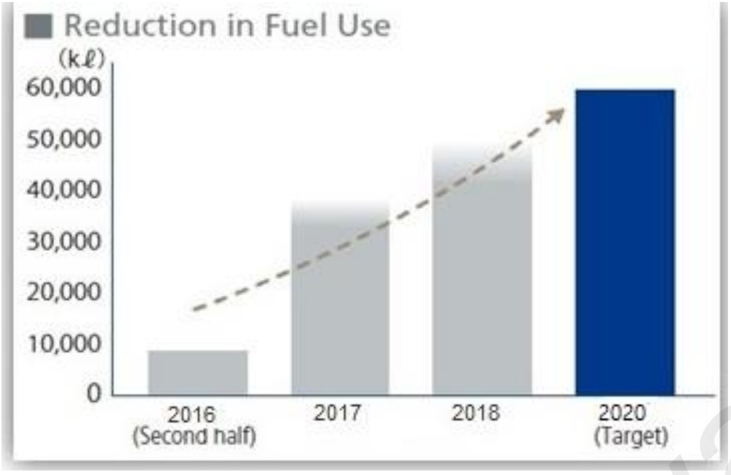


FIGURE 2.22: Trend Depicting Reduction in Fuel Use (ANA Holdings Inc, 2017)

The above figure shows the trend between year 2016 and year 2018 together with forecasts for year 2020. All Nippon Airways managed to reduce fuel use by about 8,500 kiloliters (kl) after implementing new ways introduced earlier. This is equivalent to reducing CO2 emissions by approximately 21 thousand tons (ANA Holdings Inc, 2017). Apart from the above, fuel prices were hedged in order to prevent the airliner from getting affected by fuel price volatility that resulted from fluctuations that occurred in the crude oil and currency markets. Fuel hedging is basically when an airliner agrees on a contract that would allow them to come up with a fixed cost for future purchases of fuel. This practice however, has its pros and cons (ANA Holdings Inc, 2017).

The disadvantages include, if the fuel prices drop ever lower which is often of extremely low probability. On the other hand, the advantage is that the airliners will not get affected from the varying conditions that lead rising fuel cost.

2.4 Fuel Saving Techniques Among 3 Airlines

TABLE 2.5: 3 Airlines Fuel Saving Techniques Summary

Techniques	**Type of Airlines**		
	Air Transat Canada	**All Nippon Airways**	**Air New Zealand**
Aerodrag	✓	✓	✓
Engine Water Wash	✓	✓	✓
Lighter Weight Tires	✓	✓	✓
Portable Water	✓	✓	✓
APU Usage	✓	✓	✓
Light Container (ULD) Weight	✓		✓
Flight Plan Optimization	✓		✓
Contingency Fuel	✓		✓
Fuel Hedging	✓	✓	✓
Variable Cost Index	✓	✓	✓
Single Engine Taxi	✓	✓	✓
Flight Operation - NADP 1 & NADP 2	✓	✓	✓
Technologies for Taxiing and Parking	✓	✓	
Flight Routing		✓	
Radio Navigation (RNAV)	✓	✓	✓
In-Flight Service Survey		✓	
Fleet Strategy	✓	✓	✓
Winglets	✓	✓	✓
Continuous Descent Approach (CDA)	✓	✓	✓
Total	**17**	**16**	**16**

Table above shows fuel saving techniques implementations summary of Air Transat Canada, All Nippon Airways and Air New Zealand. Most of the fuel saving techniques implement by all 3 airlines. Most common fuel saving techniques is aerodrag, engine water wash, lighter weight tires, portable water, APU usage, variable cost index, fuel hedging, single engine taxi, flight operation and technologies. There are few techniques still yet to be implement by these airlines like flight routing, in-flight survey, light container (ULD) weight and flight optimization as show in the table above. This is because of delay from stakeholders and government decision and also some incapable reason that been face by the airliners.

2.5 Summary

Based on the report as explain above along with the analysis on graphical representations provided with various fuel saving techniques has been implemented by Air Transit Canada, All Nippon Airways and Air New Zealand airlines. From this, it shows the result that have proven to be efficient in saving fuel and environment. However, Air Transit Canada is proven to apply most of fuel saving techniques which summarized in Table 2.4. There are some techniques are expected to be relatively inexpensive, easy to implement, and could yield fuel consumption benefits based commercial experience. These potential savings from reduced fuel could be used for other requirements, it can contribute to the betterment of the airliner financially as well as the environment. There are few methodologies is being discussed in next chapter which shows quantitative and qualitative methods to gather information and empirical evidence of fuel saving techniques that being practice among airliners in Malaysia.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This context will elaborate on the methods of conducting preliminary studies on identify and validate different types of fuel saving techniques among airliners in Malaysia. Firstly, data collection will be carried out to identify different fuel saving techniques globally through books and journal articles. After throughly understand on numerous fuel saving techniques practice globally, survey will be conducting to collect data on fuel saving techniques being practice by Malaysia airliners. Finally, interview will be done to validate the fuel saving techniques and aviation indrustry impacts. In achieving the objectives of the thesis, the methodology of this research has been decided and agreed upon.

The flowchart below represents the Research Flow:

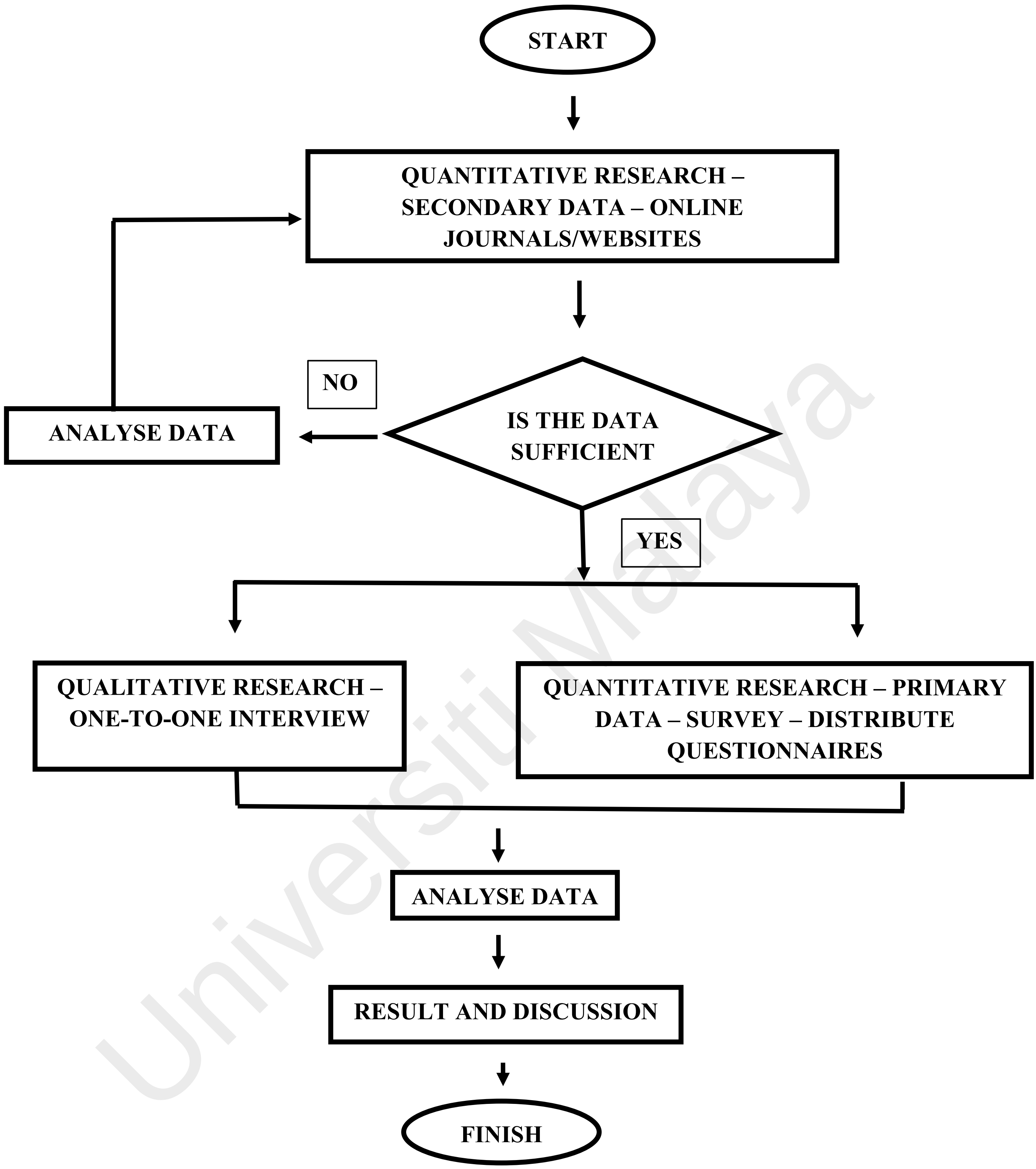


FIGURE 3.1: Research Flow

3.2 Data Collection Method

Data collection is the process of gathering and measuring information which will provide major elements and basic statistical research data. It also enables to answer research questions and evaluate the outcomes. While data collection methods vary by discipline, the emphasis on ensuring accurate and honest collection remains the same for this research (NIU, 2005) For this research, there are two methods that had been utilized to collect data for the analysis which is quantitative and qualitative as discussed below:

I. **Quantitative Research**: This method will be seeking on unbiased measurement, statistical, mathematical, and numerical. The goal of this method is to determine the influence of independent variable on dependent ones (Wanjiku, May 2020). It has to get tested and confirm the theories and assumptions throughout this research. This involved primary and secondary data. Primary data will be collected directly from main sources through survey with closed-ended questions. The secondary data will be acquired from journals and websites of airlines annual report all over the world. Quantitative research method can gather informative data in a numerous way which is through graph, tables of raw data or numerical data. (Ahmad et al, 2019) Primary data will be presented through survey method. From survey we can confirm on history and current fuel saving method and techniques that been practicing in Malaysia. The questionnaires can be form in structured and unstructured depends on research design (Roopa & Menta Satya, 2012). For this survey certain group of peoples from different airliners and also Maintenance Repair Organization (MRO) in Malaysia which currently operating to fulfill the research scopes. Chosen survey respondents have the knowledge and experience in flight and planning operations. But before starting the survey, construction of questionnaires will be done by collecting more informative data on fuel saving techniques that being practice around the world with evidence. This can be utilized through secondary data to accomplish that requirements.

II. **Qualitative Research**: This type of research method is to gather in-depth insights and also understand through thoughts and experiences from particular group. Interview method seeks to cover both a factual and a meaning level in this research project (Kvale, 1996). This involved interview which will consist of open-ended questions. Qualitative research method is needed to define in-depth insights for the research studies. This method has the limitation for this research study by recruit one interviewee. As this method will be focused on one individual to complete on unsolved questions from previous method which can be done through one-to-one interview method. Interview method will avoid the embellishment and maintain the integrity of the research content as well (Canary, 2019)

Basically, this research required both quantitative and qualitative method because it has the answers in a different way to fulfill the research objectives. Although it has many things to do but it is mainly to gather the exact data that required for my research study. It's always the best idea to start with a survey part first to find out the overall trends and followed by the interview to understand the reasons behind the trends. This both methods won't be in critical way, actually they can work better together (Ahmad et al, 2019)

3.2.1 Quantitative Data Collection and Analysis

3.2.1.1 Literature Research Analysis

Secondary data is a research technique which acquired by sitting at desk and collecting the existing data that collected by others which is similar to online desk research (Secondary Research, 15 January 2021). Secondary data was collected from airliner organization's databases, websites, libraries or newspaper journals, among other sources which known as secondary data analysis. (Allen, 2017). Moreover, some data is usually recorded during flight via a data flight recording system known as the black box which is placed in the aircraft by the airlines. Some of the parameters recorded are the motion as well as fuel consumption of the aircraft. There are some parts of electronic databases selection from University of Malaya library was utilized for example like Science Direct and SAGE publication were used to search for relevant journals. On the other part of secondary data collection which analyses on fuel saving techniques globally and internally by using libraries, books, journals, articles, web pages, blogs, etc. Secondary data analysis utilized in literature review as discussed earlier. The fundamental to secondary data analysis is to apply theoretical knowledge and conceptual skills to utilize existing data for the research study (Johnston, 2014). However, this data was not directly provided by the airliners in figures due to intellectual property or other unforeseen reasons but some graphs were provided that were used as secondary data for analysis. Online sources like websites and journals help to find out more on fuel saving techniques. Moreover, annual reports from some airliners around the world were helpful in literature review part. From that it's easy to gather more information on fuel saving calculations and techniques which very helpful on comparing to current practices. Through secondary data, 19 fuel saving techniques were extracted from the reading of existing researchers. This was discussed and summarized in section 2.4, Table 2.5. These techniques were used to develop the survey questionnaires. Besides that, secondary data collection is crucial in developing survey questionnaires for this research study.

3.2.1.2 Survey Development

Primary data is a type of data that is collected by researchers from main sources like survey, experiment, etc. (Formplus, December 2020). But for this research required survey method to gather information under group of individuals. Surveys is one of the great tool for this research as they are cost effective, flexible, and allows to collect data from a very large group (Pressbooks, June 2020). Survey will be in the form of closed ended questions in this research study. Respondent's answer will be limited to the fixed set of responses (Roopa & Menta Satya, 2012). Questionnaires was develop using techniques generated from literature review to keep the respondents focused on the purpose of the research study. A set of questionnaires were distributed to a number of Malaysian airliners that includes mostly the passenger airliners as well as a Maintenance Repair Organization; Sepang Aircraft Engineering.

The questionnaire established in this survey was further examined by consulting the supervisor, Associate Professor Dr. Salwa Hanim Binti Abdul Rashid, Captain and License Aircraft Engineer from Company A. The survey questionnaires about aircraft operations which is more technical based questions. This will be covering the current airliner workers that involve in flight and planning the aircraft operations which can lead to main points. Flight operations support is to coordinate all these technical and operational factors such as the weather, overflight permits, route planning, aircraft performance, airport facilities, the aircraft's technical condition or fuel requirements (Cargolux, 28 September 2020). Planning operation support department helps the operators to evaluate their need in terms of resource which leads to major requirements and demand which leads to material management (Papakostas et al, 2009) Based on the respondent answers, the survey results can be achieve the second objective. Quantity range of respondents are within 15-20 from each airline. Through secondary research, 19 fuel saving techniques were extracted from the reading of existing researchers. This was discussed and summarized in section 2.4, Table 2.5. These techniques were used to develop the survey questionnaires. The survey questionnaires will be shown in appendix A and appendix B. Respondents were encouraged to add any supporting document related to the questions if required. This survey designed in such a way to understand the fuel saving techniques that being practice by the respondent's company.

I. Construction of Survey Questionnaires

Questionnaires must have precise purpose that related to our research objectives. The questions were in the form of Likert Scale, bipolar question (yes or no) and multiple-choice questions.

Likert Scale**:** it is a psychometric scale commonly used in questionnaires and is the most widely used scale in survey research (Taherdoost, 2019) When responding to a Likert questionnaire item, respondents specify their level of agreement to a statement. The format of a typical five-level Likert item is as shown below:

STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE

Bipolar Question: is a type of question which needs either positive or negative response to a statement. In this project, respondents showed their agreement to the statement by answering "Yes" and denying or not supporting the statement by answering "No".

YES	NO

Respondents were required to tick either one of the choices as shown in the figure above. This provides with consistent data that easy to conclude the results. Ranking question: is a type question that needs the respondent to rank the answer choices from the worst to the best possible.

3.2.2 Qualitative Analysis

3.2.2.1 Interview Data

Qualitative research method involves a descriptive judgment using concept and experience instead of graph, tables, or numbers to get confirmations on certain things that need to get answer. Higher response rates can easily clarify the questions if it's over respondent selection, more complex questionnaire and easier to motivate respondents. (Roopa & Menta Satya, 2012) One of the research objectives can be done through one-to-one interview. This method will answer the questions "why" and also bring the depth of understanding to the questions. Interview were carried out with Captain from Flight Operations division at Company A to be the interviewee who directly involve in formulation and implementation fuel saving initiatives. The interview was conduction in Company A office meeting room, and it took between 30 minutes to hours to complete in May 2021. There will be open-ended questions will distribute to the interviewee. is experience in managing and implementing fuel saving initiatives for AirAsia provided us with the necessary information regarding the fuel saving initiatives formulation and implementation. The interview questions will be attached as Appendix C and the letter of acknowledgment will keep in as record due to private and confidential. Throughout his experience in managing and implementing fuel saving initiatives for Malaysian Airlines provided us with the necessary information regarding the fuel saving techniques and implementation. Based on his point of view, it can possibly gather more information related to an industrial environment exposure pertaining to a current issue that is impact of increasing fuel prices on the aviation industries. Throughout this method the study able to bring the research that are wide-reaching and deep insights. From this, it can extrapolate the experience thought process, analyzing, and estimating in-depth perspective in fuel saving implementations. The interview we're recorded in written format as there will be no permission on recording. In data analysis, data collected through interviews was classified and simplified according to the data source.

3.3 List of Airline Operators in Malaysia

Below is a list of airline operators that are currently operating in Malaysia. The survey questionnaires will distribute to below airlines flight and planning department workers and this will be focused on mainly passenger airlines.

1. Air Asia
2. Malindo Air
3. Firefly
4. Raya Airways
5. Air Asia X
6. Malaysia Airlines
7. MASwings

However, an addition to this list is one of the largest Maintenance Repair Organization (MRO's): Sepang Aircraft Engineering (SAE). The questionnaires regarding planning and maintenance activities that are carried out on an aircraft will be distributed to SAE in order to analyze fuel saving from a different perspective.

3.4 Summary

Research method could be either with quantitative and qualitative; or quantitative or qualitative independently which depends upon needed and it will plays a greater role in future research (Jamshed, 2014). As show in research flow, online journals and websites provide way to find the fuel saving techniques around the globe. But additional data collection further required to validate on fuel saving technique implementation among airliners in Malaysia by conducting the survey and interview. Data analysis and reporting results from survey were identified as important phase to achieve the objectives of the research. The outcome of interview and survey analysis report of fuel saving techniques among airliners in Malaysia will be reflected in results and discussion.

CHAPTER 4: RESULTS & DISCUSSION

4.1 Introduction

This chapter is dedicated to give detail explanations about the results obtained from the survey conducted on 7 airlines operator including maintenance repair organization in Malaysia. Based on the survey questionnaire analysis, along with the analysis on graphical representations provided by Malaysian Airliners. This research concludes the various techniques practiced by airliners in Malaysia and also shows how those techniques have proven to be efficient in saving fuel. A total of 65 responses were received, which correlates to an overall response rate of 100% which means all the target airlines had answered the survey questionnaires. The research objectives to be met are separately analyzed with respected to collected information.

4.2 Survey Result for Techniques of Fuel Saving Practice by Airliners in Malaysia

4.2.1 Flight Operations

TABLE 4.1: Analysis of Flight Operations among airliners in Malaysia

TECHNIQUES	MASWINGS	RAYA AIRWAYS	FIREFLY	AIR ASIA	MAS	MALINDO AIR	AIR ASIA X
Practice of Noise Abatement Departure Procedure 1	✓	✓	✓	✓	✓	✓	✓

The aircraft accelerated to a particular climb speed as soon as the flaps are completely retracted	✓	✓	✓	✓	✓	✓	✓
Measures taken on optimization of flight planning with respect to route planning	✓	✓	✓	✓	✓	✓	✓
The thrust reversers deployed upon landing?	✓	✓	✓	✓	✓	✓	✓
Lightweight plates and utensils were used for flight catering	✓	✓	✓	✓	✓	✓	✓
The aircraft been supplied with service items one way instead of round trip	✓	✓	✓	✓	✓	✓	✓
The aircraft route designed in such a way to allow the aircraft to take the nearest route as possible	✓	✓	✓	✓	✓	✓	✓
The aircraft choose any course within an allowable range of areas	✓	✓	✓	✓	✓	✓	✓
Th aircrafts with blended winglets	✓	✓	✓	✓	✓	✓	✓

The continuous descent approach (CDA) been used during landing	✓	✓	✓		✓	✓	✓
The landing gear deployed at stated time or earlier	✓	✓		✓	✓	✓	✓
The practice of Noise Abatement Departure Procedure 2	✓		✓	✓	✓	✓	✓
Auxiliary Power Unit usage on ground before flight	✓		✓		✓	✓	✓
The aircraft depend solely on braking upon landing	✓		✓		✓	✓	✓
Aircraft taxied with single engine running		✓		✓			
The contingency fuel carried on board		✓					
The aircraft engines turned off during certain intervals of the taxiing and parking process				✓			
The aircraft taxied using all engines							
The aircraft follow a specific given route							
Total	**14**	**13**	**13**	**13**	**14**	**14**	**14**

The above table shows survey result of the different techniques that used by various airliners in Malaysia. Further, will be discussed how each technique can contribute to fuel savings. The Noise Abatement procedures allow aircraft to retract the flaps and accelerate at a lower altitude with flaps retracted. This reduces drag and improves aircraft efficiency, reducing fuel consumption and lowering exhaust emissions. It can be seen majority of the airlines are practicing these procedures.

By having winglets on the aircraft has been known to save fuel and majority of airliners are having aircraft types that have blended winglets. Nowadays almost all the commercial airliners having the winglets in a different design. Aviation industry does have several different modifications in wingtips. As we know winglets main purpose is in reducing drag and improving fuel efficiency. On the other hand, the use of thrust reversers also reduces fuel as it aids in braking hence reducing exertion on the engine power. It can be seen that all airliners have been practiced.

Weight is a major contribution to fuel consumption, it can be seen that majority of airliners go to the extent of reducing the weight of their utensils and plates which is also a good approach. Maintain the proper weight is extremely important in balancing act, if we don’t practice proper weight and balance calculation it can lead to critical stage to the flight planning.

If the aircraft is given a specified route and is unable to deviate from it due to any unforeseen reasons, this may result in excess fuel burn and cause wastage. Therefore, it can be seen that most airliners allow the aircraft to choose its specific course of route and hence, allowing fuel to be saved.

As the pilot changes from the different levels of altitude, additional engine power would be required to maintain constant speed. This additional power means additional fuel burned (CDA, 2006). On the contrary, a continuous descent approach (CDA) is a method of descending the aircraft for landing where the aircraft maintains a high altitude for a longer period of time rather than descending to various levels. This ensures that lesser fuel is burned as less engine thrust is required (CDA, 2006). Most airliners have implemented this technique because it has great effect in fuel saving and also carbon emissions.

Landing gear deployment is necessary at stated time in the Standard Operating Procedures (SOP); this is because if the landing gear is deployed at an earlier time it will just add to aerodrag which in turn increases fuel consumption. It can be seen majority of the airlines are practicing these procedures. The usage of Auxiliary Power Unit on ground should be minimized by the use of ground power unit and this is seen in the case of Raya Airways, this airline was established in November 1993 as Transmile Air (Raya Airways, 21 May 2021) as well for Air Asia.

The advantage of running the aircraft on a single-engine while taxiing contributes greatly since with only one engine running fuel burns only for that particular engine. However, it can be seen that not many airliners are practicing such a technique. Although, it was discovered that Raya Airways does practice this method for their 3 engine aircrafts.

Contingency fuel is extra fuel carried on board as back up fuel. However, it is advised that enough back up fuel should be calculated as per each flight. As shown in the results, Raya Airways carries more than required contingency fuel as this amount depends on how much the Airline requires rather than individual calculations of each flight before it get prepared.

Finally, the focus is on shuts off the engine at specific intervals of taxing and parking process. From the survey result, it can also be seen that Air Asia is the only airline that often shuts off the engine at specific intervals of taxing and parking process and uses other alternatives such as use of tow truck to aid in moving the aircraft around incase needed for other services.

4.2.2 Planning Operations

TABLE 4.2: Analysis of Planning Operations among airliners in Malaysia

TECHNIQUES	SAE	MASWINGS	RAYA AIRWAYS	FIREFLY	AIR ASIA	MAS	MALINDO AIR	AIR ASIA X
The aircraft tires changed to a lighter composition	✓	✓	✓	✓	✓	✓	✓	✓
The cost index calculated according to particular aircraft and its respective flight	✓	✓	✓	✓	✓	✓	✓	✓
The load containers normally made of aluminum extrusions and/or composite side and roof panels	✓	✓	✓	✓	✓	✓	✓	✓
The aircraft frequently checked for any protrusions that may result in increased aerodrag	✓	✓	✓	✓	✓	✓	✓	✓
The introduction of RNAV been used	✓	✓	✓	✓	✓	✓	✓	✓
Standard practice to check the exterior of aircraft for any abnormalities	✓	✓	✓	✓	✓	✓	✓	✓

Improvements in structure that reduces air resistance and therefore reduce drag formation	✓	✓	✓	✓	✓	✓	✓	✓
The flight management systems (FMS) functions take wind conditions into consideration	✓		✓	✓	✓	✓	✓	✓
The ground power unit (GPU) given priority over the Auxiliary power unit (APU)		✓	✓	✓	✓	✓		✓
The aircraft tires use revolutionary reinforced radial construction; high modulus cord is used rather than the nylon cord	✓				✓	✓		✓
The engine undergoes water wash frequently					✓	✓		✓
A lot of contingency fuel is carried on board every flight			✓					
There are more than required catering items								

usually on board each flight								
The construction of aircraft tires modified in lighter way								
There is common cost index for both domestic and international flights								
The aircraft weight managed by placing the center of gravity of the aircraft closer to rear of the fuselage								
Total	**9**	**8**	**10**	**9**	**11**	**11**	**8**	**11**

The above table shows the different techniques used by various airliners in Malaysia as well as an addition of one of the biggest MRO; Sepang Aircraft Engineering. Further, will be discussed how each technique can contribute to fuel savings.

As mentioned before, weight plays a major role in consumption of fuel. There are many ways this can be overcome. It is known that aircraft tires may be in various compositions. In order to save fuel, many of the airliners utilized tires that are of a lighter composition. This was achieved without jeopardizing the safety of the aircraft.

A technique that reduces fuel burn often requires more trip time. One way of determining this is the Cost Index (CI). This is the ratio of the time-related cost of an airplane operation and the cost of fuel. Entering zero for the CI results in maximum range airspeed and minimum trip fuel. On the other hand, if the maximum value for CI is entered, a minimum time speed schedule is derived. This speed schedule calls for maximum flight speeds and ignores the cost of fuel. However, to get the best results for CI the airliner should calculate it individually for every flight and not keep a common CI for every flight. In this way fuel is consumed appropriately. From the results, it can be seen that all airlines have implemented this technique.

Other than the tire composition, the usage of aluminum extrusions and composite panels for load containers also contribute to reduced weight. This is because, generally in terms of weight, aluminum and composites are far lighter than steel. The results show that most airliners are using load containers of lighter materials which are a good practice.

It is known that drag is the enemy of fuel consumption. A higher drag often leads to more fuel being consumed. Therefore, it can be seen that all airliners have a regular practice of checking the aircraft exterior for abnormalities or any form of protrusions of any kind that may add to drag. RNAV stands for Radio Navigation. This system allows for better navigation and also allows the aircraft to choose the optimum course of route. This in turn allows for better and shorter planned routes hence reducing fuel consumption. From the results, it can be seen that all airlines have implemented this practice of the usage of RNAV.

Flight Management System (FMS) play a major role in flight planning. The decision on how much contingency fuel is to be carried, or which course of route an aircraft takes is made here. One of the other factors to be considered in flight planning is the wind direction. By knowing the wind direction, the aircraft can be made to take a course on which it does not need to overcome the effects of wind and can avoid headwind. It can be seen that all airlines represented above have their FMS taking into considerations wind direction.

The use of Ground Power Unit (GPU) often helps in reduced fuel consumption because the Auxiliary Power Unit (APU) is used less. From the results, it can be seen that majority of the airliners are carrying out this practice of giving priority to the GPU over the APU.

Engine wash is one of the best technique to contribute to fuel consumption as mention earlier (Cummins, 2020) This is because by washing the engine frequently, dirt and other debris known as FOD(foreign object damages) is removed hence allowing the engine to operate to its maximum efficiency with minimum fuel burnt. Therefore, it can be seen in Malaysia Airline, Air Asia and Air Asia X have implemented this technique. Malaysia Airlines have signed up five-year agreement with Ecopower engine water wash service, from this they able to reduces fuel up to 1.2% fuel by doing it regular basis.

Nowadays most of the aircraft tires are constructed in lighter way to increase on safety improvements and also fuel consumption although it requires extreme load and high pressures. Aircraft tires are important component in aviation, therefore airliners must stay up to date with latest invention. Based on the survey result, all the airlines not being practice modifying the aircraft tires construction in lighter way.

A more forward center of gravity requires a nose pitching moment that is obtained by reduced tail plane lift which is in turn compensated for by more wing lift. This creates more induced drag and leads to an increase in fuel consumption. Therefore, it is better to have the center of gravity as rearward as possible. When this happens, dynamic stability of the aircraft is reduced and hence fuel consumption is reduced. It is seen that none of the airliners practice this method of placing the center of gravity rearward.

As a conclusion, majority airlines in Malaysia practice to have most of the fuel saving techniques as stated in survey questionnaire. Respondents from flight and planning operations department manage to confirm on fuel saving techniques that implemented by airliners in Malaysia. However, there is some lacking in developing the techniques as discussed earlier. This need improvements to increase more fuel savings in future.

4.2.3 Other Techniques Practice by Airliners in Malaysia

Based on survey result, there are few fuel saving technique implementation provided by the respondents from the selected airliners which not in the list. As Captain said, Malaysia Airlines has joined with 28 other airlines around the world on implements SkyBreathe® software to reduce CO2 emission of the fleets and improves fuel savings. From this they able to get benefit in understanding the fuel efficiency through all phases of a flight on achieving the fuel saving targets. On the other side, Air Asia Group has implemented OptiClimb software which save climbing fuel this will represents a fleetwide carbon footprint reduction. It is similar concept as Malaysia Airlines through use of flight data but mainly on optimizing climb profile, these minor changes can give significant effects on fuel savings. On the other side, Air Asia X has implemented Electronic Flight Bag (EFB) which replace 55kg of manuals on board, this enables to save up to 8kg of fuel sector and also reducing the fuel consumptions. All the airlines in Malaysia have been trained and practice for Sustainable Aviation Fuel (SAF) system which is clean substitute for petroleum known as alternate fuel initiatives. It is produced from sustainable resources such as waste oils, agri-residues or non-fossil CO2. This can be blended with jet fuel that which doesn't require special infrastructure or equipment changes. But as for now this system still in discussion due to some reason. Above techniques will be summarized as in table below:

TABLE 4.3: Other Techniques Practice by Airliners in Malaysia

Additional Techniques	OptiClimb Software
	SkyBreathe® Software
	Electronic Flight Bag (EFB)
	Sustainable Aviation Fuel (SAF)

4.3 The Efficiency of Fuel Saving Techniques Operated by Malaysia Airlines

This section will discover on to assess how efficient are the fuel saving techniques that are being implemented among airliners in Malaysia. In order to analyze how efficient are the fuel saving techniques, the main airline operator to focus is Malaysia Airlines. Malaysia Airlines has been awarded as best airlines and this airline shows great performance among the rest (The Star, 2019) As the Malaysia Airlines is the main airline operator in Malaysia, they had shown their desire beyond the expectation and also went through a lot of fuel saving improvements over the years (See & Rashid, 2016) Malaysia Airlines has total 43 fuel saving initiatives that set up to 200 million target savings in 2018. (January, 2018) As we focus on fuel saving techniques efficiency let's begin with the number of fleets that currently operating. Malaysia Airlines fleet consists of the following aircraft types:

TABLE 4.4: Total fleet for Malaysian Airline's Operations as of 31 December 2019 (Malaysia Airlines fleet, 2020)

Fleet Types	Number of aircraft in Malaysia Airlines Operations
B747-400P	14
B777-200	17
A350-900	6
A330-300	5
A330-200	6
A380-800	6

B737-800	16
B737-400	37
ATR72-500	19
TOTAL	**128**

From the table shown above, it can be seen that majority of fleet is of the B747-400P, B777-200, B737-800, B737-400 and ATR72-500 aircraft types. Therefore, the significant reduction in fuel usage is contributed by these aircraft types although some minor reductions are provided by the other aircraft types as well. Before explaining how each of the majority of fleets contribute to fuel saving, below are some figures showing the overall fleet efficiency of all fleets in Malaysia Airlines.

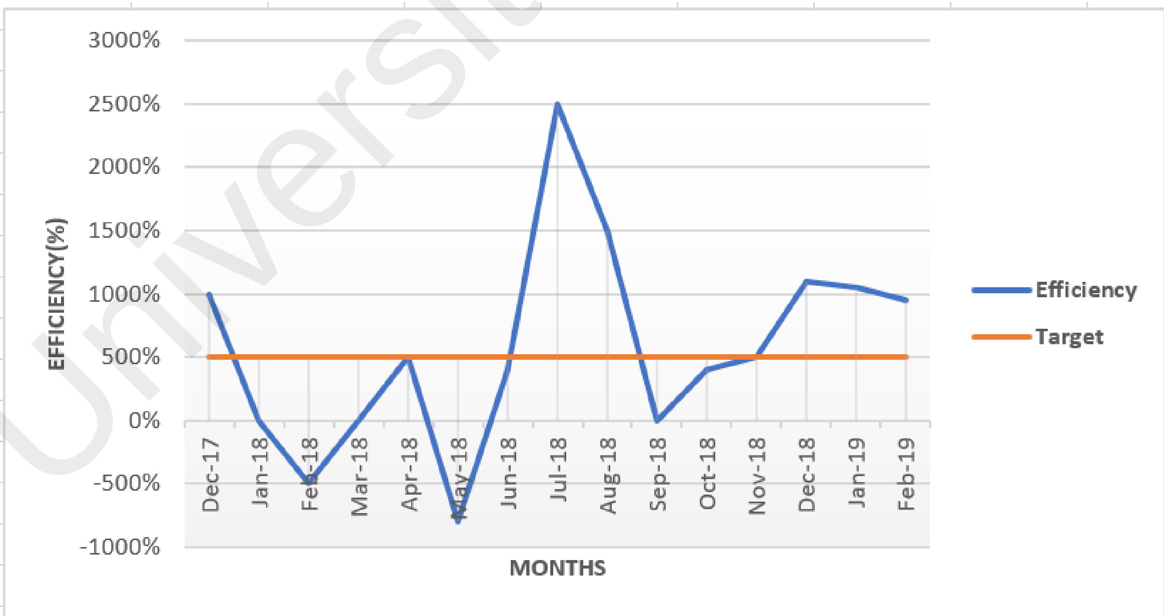


FIGURE 4.1: Overall fleet efficiency

The above figure shows the overall efficiency of all the fleets functional at Malaysia Airlines. The red horizontal line represents the target efficiency as predicted for the year 2017 as well as 2019. It can be seen that the efficiency of all fleets had not been close to expectations since only towards the end of 2018 and beginning of 2019. This could be due to various reasons. That being, the introduction of Boeing 737-800 as stated in the Malaysia Airlines Annual Report 2016.

The Boeing 737-800 as depicted next contributes to fuel saving greatly by the use of its winglets. This graph however is one of the ways to show how well efficiency of all fleets had been achieved. Another graph is the planned fuel compared to the actual fuel consumed.

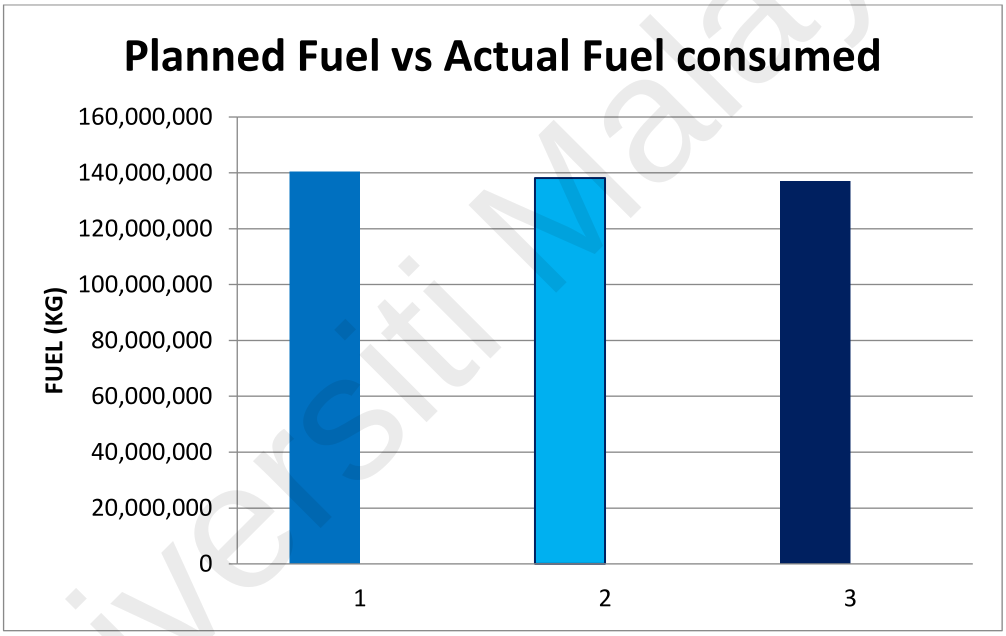


FIGURE 4.2: Planned fuel vs Actual fuel consumed (Marcus Burzlaff, 2017)

Budgeted fuel – 140,446,716

Planned fuel – 138,143,006

Actual fuel consumed – 137,002,658

The above graph as mentioned shows the comparison between planned fuel and actual fuel consumed for the month of August 2019. (Marcus Burzlaff, 2017). The first bar to the left represents the budgeted fuel, this is how much fuel has been allocated for that particular month. The next bar represents the planned fuel. This planned fuel is estimated during flight planning.

Flight planning involves two safety-critical aspects: fuel calculation, to ensure that the aircraft can safely reach the destination, and compliance with air traffic control requirements, to minimise the risk of mid-air collision. In addition, flight planners normally wish to minimise flight cost by appropriate choice of route, height, and speed, and by loading the minimum necessary fuel on board. On the other hand, the next bar represents the actual consumed fuel that month.

By looking at the graph, it can be seen that the actual fuel consumption is not only less than the budgeted amount but also as close to the forecasted usage. The percentage difference between the actual fuel consumption and the planned fuel:

$$= \frac{Planned\ Fuel - Actual\ Fuel}{Planned\ Fuel} \times 100\% = \frac{138{,}143{,}006 - 137{,}002{,}658}{138{,}143{,}006} \times 100\%$$

$$= 0.83\%$$

The above calculation shows that the percentage difference between the planned fuel and actual fuel was 0.83%. This means that Malaysia Airlines, through the implementation of various fuel saving techniques managed to save 0.83%. Although this graph shows the savings in the month of August 2019 only, a smiliar trend has been experienced for the remaining months as well.

The other thing that can be deduced from the graph is that, the planned fuel as well as the actual fuel appeared to be much lower than the stated budgeted fuel. This too is an added advantage showing the efforts of the airline operator in terms of fuel saving.

The percentage difference in this case is:

$$\frac{Budgeted\ Fuel - Actual\ Fuel}{Budgeted\ Fuel} \times 100\% = \frac{140{,}446{,}716 - 137{,}002.658}{140{,}446{,}716} \times 100\%$$

$$= 2.45\%$$

This percentage difference shows that Malaysia Airlines saved 2.45% fuel compared to what they had budgeted for. As shown in the analysis of the previous objective, Malaysia Airlines adopts various techniques on fuel saving. These techniques are practiced by the present fleets. Below are some of the fleets that are currently being operated in Malaysia Airlines.

B737-400

FIGURE 4.3: B737-400 Malaysia Airlines (Malaysia Airline Fleets, 2021)

The major fuel contributions by a B737-400 lie within its featured CFM56 turbofan engines, which yield significant gains in fuel economy and as well as reduction in noise. The CFM56 turbofan engine contributes to fuel saving due to its construction of being a two-spool high bypass engine and hence offering a high power to fuel consumption (Brady, 2020)

ATR 72

FIGURE 4.4: ATR 72 Malaysia Airlines (Malaysia Airline Fleets, 2021)

The ATR 72 is globally well known for its economic and ecological characteristics. This aircraft is used by MASwings and provides a great deal of reduced fuel consumptions through various aspects. The ATR 72 has the highest composite utilization in a regional aircraft which allows it to have a light structure. Less weight leads to having less fuel burnt compared to heavier structured aircraft. Other than this high tech engines and propellers, advanced aerodynamics, low drag airframe, structural efficiency all contributes to reduced fuel consumptions on this aircraft. (Vedant & Somesh, 2015)

B777-200

FIGURE 4.5: B777-200 Malaysian Airlines (Malaysia Airline Fleets, 2021)

On the other hand, the Boeing 777-200 holds the third highest fleet type consisting of 17 aircrafts. The B777-200 efficiency can be seen in the graph below. This is the trend the B777-200 holds over the years of 2008 – 2019.

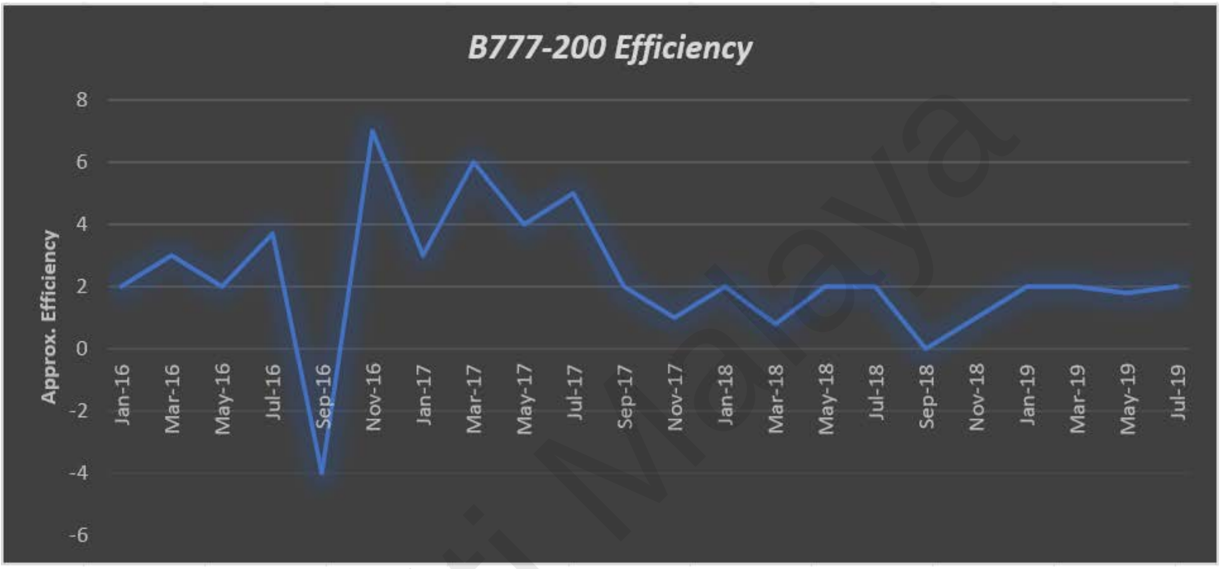


FIGURE 4.6: B777-200 Efficiency (Broderick et al, 2020)

It can be seen that there had been major fluctuations in the year 2016. However, as said by Captain, after the implementations of some new fuel saving techniques that have been stated in the earlier part of the analysis, B777-200 performance stabilized. This can be seen by the constant pattern seen towards the end of the year 2017 and starting of the year 2019.

B737-800

FIGURE 4.7: B737-800 Malaysia Airlines (Malaysia Airline Fleets, 2021)

"In addition, compared to the existing older aircraft that are in operation today, the B737-800 and A330- 300 are equipped with newer technology, are more fuel-efficient and cheaper to maintain – factors that will contribute to the Company's cost reduction initiatives."- Tengku Dato' Sri Azmil Zahruddin bin Raja Abdul Aziz (Managing Director and Chief Executive Officer Malaysia Airlines) as Captain mention.

The B737-800 has the best added feature among all B737's and that is the advantage of having winglets. The graph shows the difference between an aircraft with winglets and one without winglets as tested on the B737-800 carried out by Boeing.

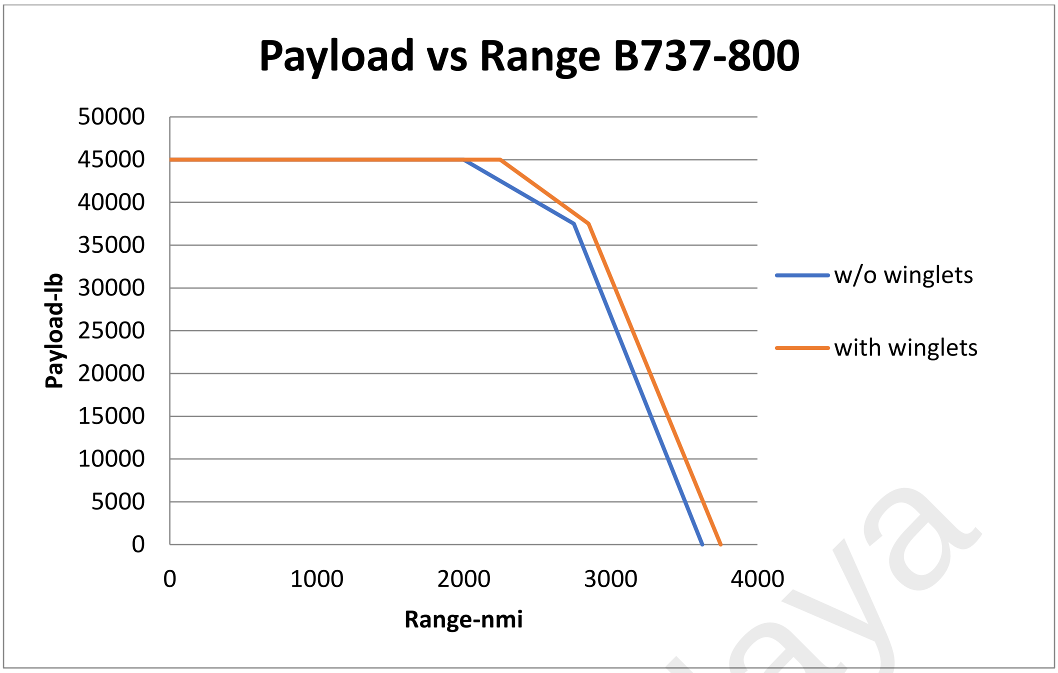


FIGURE 4.8: Payload vs. Range for B737-800 (Shannon Ackert, 2013)

As shown in the graph, an aircraft without winglets would provide lesser nautical miles than an aircraft that has been installed with winglets. Basically, what can be concluded from the graph is that due to the installation of winglets, better aerodynamically stable flight can be experienced and hence this reduces the amount of fuel consumption (Shannon Ackert, 2013).

B747-400

FIGURE 4.9: Boeing 747-400 Malaysia Airlines (Malaysia Airline Fleets, 2021)

The B747-400, which was introduced to service globally in October 1985, was the first Boeing aircraft to include winglets as part of the original design (Guy Norris and Farnborough, 2000). Flight tests on these blended winglets on a Boeing 747-200 have shown fuel savings of about 6-7%. These tests were carried out by Boeing. The blended winglets improve the efficiency of the wing and cut drag by reducing the onset and size of wingtip vortices (Guy Norris and Farnborough, 2000). Malaysia Airlines has B747-400 in both passenger and freight form. There are about 14 B747's currently operating in Malaysia Airlines.

4.4 Impact of Increasing Fuel Price in Aviation Sector from Industrial Environment Perspective

This section is dedicated to give detail explanation on impact of increasing fuel prices in aviation sector pertaining from industrial environment exposure. It has been achieved through the possibility of interviewing Captain, Flight Operations division at Company A. A letter of acknowledgment regarding the interview will keep in record due to private and confidential.

The discussion allowed enlightenment of the factors needed to be considered in a real world situation rather than those read in books and articles. Fuel saving is no doubt a crucial factor to be monitored in the aviation industry. Captain gave us an insight of how the departments support fuel saving techniques implementation and identify problems faced by Malaysia Airlines.

As explained by Captain, the most dominating division that can enhance fuel saving is the planning department. Certain techniques that are implemented for fuel saving may be done on the aircraft itself or on the way it is flown. However, once the aircraft is off the runway no change would affect the fuel consumption. This is why the planning department plays a more important role than the flight operations. This is because, if the planning of flight routing and other issues can be decided upon with proper considerations that the fuel consumption may be optimized or if the maintenance intervals are planned with proper justifications then it can also help to not only reduce fuel consumption but also help the airline economically.

4.5 Contribution of Cost Saving Techniques

Airlines are used to pinching pennies and squeezing every last penny out of their systems and also saved millions of dollars by doing something simple and unnoticed by passengers. Operational cost containment is critical in this hard economic situation for the aviation business. Therefore, the goal of airline is to reduce fuel bill through implementing more efficient procedures and weight reduction measures. One percent fuel savings can be achieved simply by the actions of the crew, or by better management and maintenance of each engine, or even by improved care for the aircraft itself. If an airline focuses on every opportunity to save fuel, these fine-tuning actions will quickly add up to a significant cost savings (Moutoussamy, 2014). Even minor increases in reliability can result in huge cost savings, not to forget on improved safety. Therefore, most of the fuel saving techniques implementation among airliners in Malaysia contributes to cost saving. By adding winglets to certain aircraft, airlines able to save millions of gallons of fuel annually which is equal to millions of dollars saving. The rate of fuel efficiency improvement of new fleets could be increase by using cost-effective emerging technologies. According to the study, using developing cost-effective technologies in a larger-scale deployment might cut new fleet fuel consumption. By implementing cost-effective technology, airlines may lower fuel expenditures by 19 percent from 2025 to 2050, compared to the baseline case (Kharina, Rutherford & Zeinali, 2016). Focused on cost-cutting techniques such as taxing, lighter aircraft tires, variable cost index, thrust reverser usage, load container materials, flight catering items, flight plan optimization, flight management system, noise abatement departure and blended winglets have become an essential practice at incumbent airline.

4.6 Summary of Findings

The chapter concludes all findings that were analyzed based on the results of the survey questionnaires and interview questions. Based on the literature review, numerous techniques have been extracted and used in the questionnaires. These techniques have previously been proven to be successful means of saving fuel. They are focused mostly on ground operations like usage of ground power unit instead of the auxiliary power unit and also taxing the aircraft with single engine. However, for these techniques it was concluded that it is not recommended to taxi the aircraft with a single engine but at the same time it is not necessary to have all engines running. This conclusion was made by Raya Airways.

It was also discovered that majority of the airliners are not implementing techniques like regular engine water wash, the shutting down of engines during taxing and parking process and also common techniques like placing the center of gravity of the aircraft as rearward as possible. Regular engine water wash will promote more efficient engine performance, and this would in turn save fuel. Other than that, as mentioned earlier by placing the center of gravity rearward of the aircraft, the dynamic stability can be reduced and hence the engine would not have to use more than required power to overcome the dynamic stability.

The main goal of this research is to create awareness of the different techniques being implemented in the Malaysia aviation industry. Although there are many ways that are currently being implemented, there are still numerous techniques as mentioned earlier that are yet to be discovered by the airliners to further reduce fuel consumption. 1 or 2 percentage savings could change in billions for the airlines, and it does matters for all the stakeholders.

In future studies, airlines need to examine the issues from larger data samples to increase the generalize the findings. These potential savings from reduced fuel use could be used for other requirements and also, these savings could contribute to the betterment of the airliner financially as well as the environment. This is because with reduced fuel burn the harmful gases that are affecting the environment will be reduced so as to promote a greener healthy environment. These innovations not only making more fuel efficient but also improve the planet by consuming fewer natural resources.

4.7 Summary

Based on quantitative and qualitative research analysis of fuel saving technique practices and impacts in Malaysia, it can be proven that almost all of the airlines in Malaysia implements most of the fuel saving techniques that stated in questionnaires. However, there are some fuel saving techniques that couldn't be implemented due to time limitation, investment and technology. In order to achieve this, airlines must collaborate on technology and getting approval from stakeholder by proving on how they are being implemented within established parameters and with data reasons. Moreover, safety must always come first while optimising future fuel efficiencies. As a result, the safety implications of all techniques must be thoroughly assessed. Survey result shows in 2 different operations that involve knowledge and experience on fuel saving techniques. It can be stated that the most fuel saving techniques has been practiced by the airliners in Malaysia are lighter aircraft tires, variable cost index, thrust reverser usage, load container materials, flight catering items, flight plan optimization, flight management system, noise abatement departure, GPU usage over APU and blended winglets. These techniques gave the effective result for fuel saving. On the other hand, some techniques like contingency fuel, engine water wash, flight routing and aircraft taxi with single engine methods not being used frequently as stated in discussion. This means that airlines in Malaysia still have some lack of guidance on saving the fuel consumptions. There are few fuel saving techniques implementation provided by the respondents from the selected airliners which not in the list. Next part will be discussed on how efficient are those fuel saving techniques that are being implemented among airliners in Malaysia by using online websites and journals data collection and also validate information from Captain. In order to analyze how efficient are the fuel saving techniques, the main airline operator to focus is Malaysia Airlines. The significant reduction in fuel usage is contributed by B747-400P, B777-200, B737-800, B737-400 and ATR72-500 aircraft types although some minor reductions are provided by the other aircraft types as well. Through interview, Captain discussed on impact of increasing fuel price in aviation sector from industrial environment perspective. He also gave us an insight of how the planning and flight departments support fuel saving techniques implementation and identify problems faced by Malaysia Airlines. Recommendation on fuel saving techniques improvements in Malaysia will be discussed as a conclusion of this research.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Recommendations

Further improvements can be made to this research study by introducing a new technique or enhancement of a current techniques. Malaysian airliners must consider the suggestion to use of lighter and slimmer seats so that more passengers can be accommodated fully on the aircraft. This will lead to more reduction in fuel burn as future saving improvements. Additionally, this gets us back to seat pitch, which many people use to estimate how much space they'll have on a certain plane. For now, switching seats takes time, airlines are unable to do so until the planes are in for repair. During this epidemic, numerous airlines can do this when their planes were idle.

Moreover, the airlines in Malaysia are encouraged to use Sustainable Aviation Fuel (SAF) system which known as alternate fuel initiatives since they had been trained and practiced. Aviation global industry's commitment stated to achieve 50% carbon emission reduction by 2050 from bio-fuel production. Moreover, biofuel have been tested by many airliners and researchers, they also recommended to the airlines. (Mohsin et al, 2017) According to IATA, more than 180000 commercial flights using sustainable aviation fuel as in June 2020.

Enhancement of flight route technique is highly recommended for the airlines in Malaysia since the survey result shows absence on that practice. As per U.K researcher, tiny changes to the flight routes could make millions of kilograms of fuel each year which using up to 16% less fuel in the process (Delbert, 2021). This will be an additional bonus part for overall fuel saving contribution. According to the researchers, if all airlines agreed to the adjustments, it would be relatively simple to implement them and then utilise satellite and radar tracking to ensure that all flights remained safe on their slightly altered paths.

Apart from that, Malaysian aviation industry must start using 3D technology, carbon fiber materials and shape memory alloys (SMA), because all these will reduce aircraft weight while increasing customization and overall construction efficiency. Aircraft weight reduction is always the topmost priority to increase fuel efficiency. However, to do this a proper budget is required from stakeholders so that the appropriate facilities can be utilized. Also, a lot of co-operation is needed from the airliners in Malaysia to help in achieving new techniques for fuel saving. This is normally in terms of providing relevant data for analysis. For further improvement of this research, case studies should be conducted on how effective the government's effort on are increasing the fuel saving techniques in Malaysia. This will increase the opportunities to add more fuel saving techniques.

5.2 Conclusion and Future Works

In conclusion, all the four objectives of this research study were achieved. The first objective which is to identify the fuel saving techniques used by airlines globally is achieved and explain in literature review. The second objective to identify the fuel saving techniques being practice among airliners in Malaysia is achieved and discussed in section 4.2. The third objective is to assess how efficient are the fuel saving techniques that are being implemented among airliners in Malaysia is achieved and discussed in section 4.3. The fourth objective is to recommend the fuel saving techniques improvements to be implement by the Malaysian airliners is achieved and discussed in section 5.1. There are 4 fuel saving techniques recommended to increase more fuel saving as in overall for Malaysian airliners which is Sustainable Aviation Fuel (SAF), slimmer and lighter seats, flight routing and 3D technology materials as clearly discussed in section 5.1. The goal of this research was to confirm the different techniques that being practiced by airliners in Malaysia. Through numerous examples within the Malaysian commercial aviation industry, a conclusion can be made that measures are being taken by airliners in Malaysia in order to save fuel. These potential savings from reduced fuel use could be used for other requirements. However, one thing abundantly clear that these savings could improve aircraft efficiency. No wonder the aviation industries future seems so impressive and fascinating. On the other hand, it is the responsibility of airline industry to be more sensitive to high fuel prices as well as addressing air pollutions and noise that affects the humans. Future research must focus on newer techniques production by aviation industries all over the world. The main challenge for future investigations will be the evaluation of the fuel saving technique practices among Malaysian airliners in the light of the impact caused by other than environment. For further improvement of this research, case studies and qualitative research should be conducted on how effective the government's effort on are increasing the fuel saving techniques in Malaysia.

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