Exam 3 Report- Interactive Application

Maddie LaBrake, Julie Rose, Laura Wilcox

 The 747-400 is one of the most commonly used aircraft for commercial flights. It holds 416 passengers, has the longest range without refueling (7,670 km), and can fly at higher altitude because it is much lighter then the previous models. The average cost to fly and maintain this plane is approximately $25,000 per hour. With flight times from JFK to LAX ranging from 5 ½ hours to 6 ½ , the cost of the flight can be approximately around $137,500-$162,500. There are many different ways to reduce the cost of the flights such as altering altitude, change of speed, increase or decrease in weight, and possibly changing the model of plane all together. The hard part of doing this; however, is keeping the customers satisfied with their flight experience.

One option to make commercial flying more cost efficient is to change the model of the airplane. The basic model of the 747 is the 747-400. According to Boeing, the 747 model holds 416 passengers, has 4-engine technology, and has a range of about 8,000 nmi. This design has been around since 1966 and has dominated the commercial flying industry with its capacity, efficiency, and ability to travel across the pacific. However, in 1990 a new commercial plane was introduced: the 777x. This modern and luxurious plane has room for 317-396 (depending on the model) and an approximate range of 8,500 nmi. The 777x is quickly replacing the 747x for various reasons. The 777x is designed with twin engine technology, which cuts costs for commercial airlines (Boeing). For a national flight, such as JFK to LAX, 4-engine technology is not necessary. The 777x and its twin engines are more than capable of inexpensively flying almost the same amount of passengers across the nation. The cost to fly the 777x based on fuel is about $9,000 per hour, while the 747x costs about $13,000 in fuel per hour (Boeing 747 vs 777- which is best?). This plane is proudly designed to combat the rising fuel prices with better fuel efficiency and a long range. For the purpose of this specific flight to LAX from JFK, the 777x is a cheaper, more efficient plane. However, the 747x is still more efficient for longer ranges, because it has a larger capacity for more fuel and its 4 engines. The physical benefits behind the 777x are drastically more efficient than the 747. The battle between air resistance and efficiency is ongoing, but the 777x design is able to maximize efficiency mainly through the wingspan. Boeing extended the wingspan of the 777x by 72 meters when compared to other commercial models. Out of those 72 meters, 7 of those are “folded down” during flight to increase fuel efficiency. As learned in class, air resistance depends on speed and surface area. The longer wings in this design over shorter and wider wings in previous designs reduces the surface area in flight. This longer length then eliminates wake turbulence on the wing tips, therefore creating a less resistant flight which saves money. More specifically, when the surface area is decreased, the acceleration is then able to increase at a more rapid rate, allowing the plane to hit a “cruise” speed faster. These specially designed wings “fold up” when entering gates at airports, because they are too long to fit, unlike any other plane.

Commercial aircraft have specific regulations to follow, in particular, regarding the cruising altitude. This range for a is typically around 31,000 to 38,000 feet or 9.49 to 11.58 Kilometers for a 747-400 commercial plane. This number is subject to change based off of the specific model being used. One option to reduce the cost of flights is to reduce the cruising altitude by 10%. This would leave the range of the cruising altitude around 27,900 to 34,200 feet, or 8.49 to 10.41 Kilometers (How High do Planes Fly?). The cruising altitude is the height a plane will stay for the majority of its flight. This height; however, depends on a few different factors. Things like weather, air resistance, and weight of the plane play a significant role in the efficiency of a plane’s flight. As a general rule of thumb, the higher altitude the plane reaches, the more efficient the flight will be, as there is less air resistance and less gravity pulling it down the higher the plane goes. The heavier the taxi weight, or full weight of a loaded plane, the more difficult it is to reach higher altitudes. Another one of these affecting factors is air resistance, which can include inclement weather. When flying from JFK to LAX, the weather will drastically changed based on the time of year. On the east coast, “all four seasons” could be experienced in one day. However, as the plane moves west, the weather and air will get dryer. The plane will fly over the midwest, through the desert, and into California, where the weather is relatively stable as compared to the east coast, so the air resistance will change as the flight progresses. Air resistance is important to understand using Newton’s First Law. It is stated: “Objects in motion tend to stay in motion, and objects at rest tend to stay at rest with the same speed and in the same direction unless acted upon by an unbalanced force.” This is true for planes because if there were no air resistance working against the plane, it would be easy for a plane to fly fast and efficiently from JFK to LAX. However, because there is air resistance, the object (the plane) has an unbalanced force acting on it, making the fast and efficient flight more difficult. There are four forces acting on a plane when it is on its course. The forces are thrust, weight, lift, and drag (Forces on an Airplane). These forces work together to create a vector for the plane. This, for example, is when wind is coming at the plane from different directions and moves the plane slightly off course. This information is extremely vital for airports to keep track of. All in all, keeping the plane at the highest possible cruising altitude (not reducing it by 10%) is best because the higher the plane’s cruising altitude is, the less air resistance there will be, allowing the plane to fly more efficiently.

 The weight of a plane affects its speed, time it takes during lift off, and fuel efficiency. The average cruising speed of a 747 is 940 km/h once it reaches its optimum altitude of around 10 km (1989 - 2010 Boeing 747-400). Commercial planes fly lower than private jets because the altitude is safer for a larger majority of people. Another reason why planes don’t fly higher is due to the [weight of the aircraft](https://www.travelandleisure.com/airlines-airports/how-airplanes-fly) is because the more a plane weighs, the harder it is to get to a certain altitude. The weight of a 747-400 can vary between 333,400-439,985 kg depending on how large of a range the plane needs to have (Boeing 747). With jet fuel weighing approximately 0.8 kg/L, and the plane’s ability to hold around 19,000 L, at least 15,000 kg of the weight comes from fuel. Newton’s 3rd Law applies here because it says for every action, there is an opposite and equal reaction. The more a plane weighs, the more force is required to get the aircraft off the ground and at the same time, there is a greater pull of gravity acting on the aircraft. There is a larger resistance on this model of plane during acceleration and take off as well. Once the 747 reaches its cruising altitude, there are several factors that affect fuel efficiency.In relationship to vectors, it is visible that any wind affects the speed and direction of the plane. If there is a large wind speed and in an opposing direction to the planes flight path, it can drastically alter the path of the aircraft, pushing it off course and making flight time longer. The greater air resistance burns more fuel and in turn costs more money. If there was a way to only fly during perfect conditions with only still air, that would save the company money on fuel. In turn, if the wind is blowing the same direction of the plane, the speed of the aircraft would increase.

There are many options to make flights more cost efficient and satisfactory for customers. The physics and designs applied to planes are top priority in making a more efficient and cost effective flight for both customers and employees in the commercial flying industry. However, the model, weight, air resistance and weather are the most compelling aspects in cutting the costs.

Sources:

<https://www.grc.nasa.gov/www/k-12/airplane/forces.html>

<http://time.com/5309905/how-high-do-planes-fly/>

<https://simpleflying.com/the-boeing-777x-vs-the-boeing-747-what-plane-is-best/> (Boeing 747 vs 777- which is best?)

<https://www.boeing.com/commercial/777/#/customers>

<https://centreforaviation.com/analysis/reports/boeings-747-aircraft-fleet-the-original-jumbo-overtaken-by-the-777-413338>

<https://www.popsci.com/boeing-777x-folding-wingtips>

<https://www.topspeed.com/aviation/aviation-reviews/boeing/1989-2010-boeing-747-400-ar85805.html> (1989 - 2010 Boeing 747-400)

<https://en.wikipedia.org/wiki/Boeing_747-400> (Boeing 747)