SERVING THE NEEDS OF A MARKET: A STRATEGIC ANALYSIS OF THE FLIGHT OPERATIONS ENGINEERING DEPARTMENT WITHIN THE AIRLINE INDUSTRY

by

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ABSTRACT

Over the past decade, the global airline industry has been suffering from negative returns, over-capacity, and extreme competition. This paper develops strategic recommendations on how a new entrant can serve the needs of this industry by implementing a strategy that allows it to differentiate in such an established and saturated market with the goal of disrupting the status quo, gaining market share quickly, and eventually becoming a market leader. First, the airline industry is analyzed in terms of its competitive environment and the factors that influence an airline's financial performance. This analysis leads to the conclusion that the most influential factor in an airline's fiscal performance is its operational efficiency. In order to examine the sources of operational efficiency, focus is then given to the flight operations engineering department within airlines. A series of interviews were conducted to build an understanding of this department's purpose, its activities, and its pain points. Based on this understanding, this paper concludes with strategic recommendations on how to develop and launch a product to service the needs of the flight operations engineering market.

Keywords: Airline Industry; Flight Operations Engineering; Industry Analysis, Market Penetration Strategy.

EXECUTIVE SUMMARY

Today’s global airline industry is suffering from excess capacity and generally little product differentiation. Price-based competition is driven by excess capacity and by the fact that airline tickets are perishable goods and the marginal cost of filling an additional seat is close to zero. These factors have resulted in an extremely competitive environment where bankruptcy and consolidation are common. In order to improve financial returns, airlines must focus on lowering the cost of operations.

The flight operations engineering department within airlines offers the best prospects for cost reduction opportunities for technology-based product innovation. With the business objectives of “first safety, then efficiency”, this department focuses on three main types of activities; measuring and monitoring performance, adjusting and adapting daily operations, and implementing initiatives to increase operational safety and efficiency. New products aimed at this market can enter the market with one of two distinct strategies; compete within the existing value chain that feeds this market, or fulfil a latent need not currently met by existing players.

Through a series of industry interviews, this project analyzes the flight operations engineering department within the airline industry to provide a set of strategic recommendations for a new product serving the needs of this market.

DEDICATION

I would like to dedicate this project to my family, Fereshteh, Sina, Ava, and Greg for their amazing support through the years. You believed in me when I doubted, encouraged me through the difficulties, and picked me up when I stumbled. I have made it this far because you were by my side every step of the way. Thank you.

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I would also like to thank the industry leaders who so generously offered their time and expertise. I am humbled and amazed by your kindness.

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GLOSSARY

FAA	The Federal Aviation Administration is an agency of the United States Department of Transportation (DoT). The purpose of this agency is to regulate and oversee all aspects of commercial aviation in the United States.
ICAO	The International Civil Aviation Organization is an agency of the United Nations. Similar to the United States FAA, they are in charge of creating the rules of commercial aviations. However, individual countries must chose to adopt those rules and regulate themselves.
NextGen	The Next Generation Air Transportation System is a massive undertaking of the United States' FAA. It aims to implement a new national airspace system throughout the United States that is primarily based on PBN technologies with the purpose of addressing problems such as airspace congestion and limited access. It is similar to Europe's SESAR program.
PBN	Performance Based Navigation is ICAO's newest form of navigation that uses GPS-based navigation equipment on board of the aircraft to determine aircraft position rather than ground-based navigation aids. There are two types of PBN Procedures; RNAV (Area Navigation)and RNP (Required Navigation Performance).
SESAR	The Single European Sky ATM Research is an EU (European Union) program with the purpose of changing to European airspace. Their plan is to implement PBN based procedures throughout Europe to overcome problems such as congestion and limited access.

1: INTRODUCTION

On October 24th 1978, United States president Jimmy Carter signed the Airline Deregulation Act. Prior to this act, the US airline industry was governed by a system of government control that treated air transportation like a regulated utility. In this system, five presidential appointees on the Civil Aeronautics Board (CAB) decided exactly where an airline could fly and how much it could charge. Deregulation promotes a purely competitive system that relies on market forces to determine price and quantity of flight services (Robson, 1998)Since 1978, airline industries have been deregulated (or close to it) in almost all areas of the globe. For example, European Union's final stage of deregulation took effect in April 1997, allowing an airline from one member state to fly passengers within another member's domestic market (Standford University: Aircraft Aerodynamics and Design Group, 2005).

Because of deregulation, the airline industry has been experiencing increased competition, excess capacity, and diminishing returns. In particular, in the past decade most airlines have been generating little or negative returns. The increasing price of fuel is further aggravating the situation. The resulting poor performance has lead to an unprecedented rate of bankruptcies and consolidations (TheDeal.com, 2010).

This paper analyzes the aviation industry, identifies current problem areas and gaps, and builds strategic recommendation for serving this industry. In order to do so, the next chapter provides a brief overview of a few of the most popular current strategic theories. The following chapter analyzes the airline industry as a whole. From this analysis, it is recommended that the primary means of improving returns in the currently suffering airline industry is by reducing costs through increased operational efficiency. As a result, the paper delves deeper into the airlines' flight operations engineering department and analyzes them as a market segment. The two sections following the industry analysis build an understanding of the internal situation of this market and the external value chain that feeds it. Most of the information in these two chapters is based on a series of informal interviews. Finally, the paper examines a hypothetical product and provides strategic recommendations on how to best serve this market with such a new product.

2: THEORY

This section provides a review of some of the more relevant literature that is used through this project. These theories provide an understanding of how a new entrant can implement a strategy that allows it to differentiate in an established and saturated industry with the goal of disrupting the status quo, gaining market share quickly, and eventually becoming a market leader. This understanding will be used to help structure the specific industry problem, identify relevant issues, potential risks, and decision criteria and propose solutions.

First, Porter's Five Forces (Porter, 2008) theory is introduced as probably the most popular method for analysing a given industry and understanding the important forces that affect that industry. Next, the more recent theories of disruptive innovation (Christensen, 1997) and blue ocean strategy (Kim & Mauborgne, 2004) are introduced. Then, we look at more practical research on new product introductions; the pitfalls, recommendations, and main areas of concern.

2.1 Porter's Five Forces (Porter, 2008)

Porter's five forces is widely considered as the leading framework for analyzing the competitiveness of an industry. In Porter's opinion, the purpose of strategy is to understand and best respond to the competitive forces within an industry. For the purposes of this paper, this framework is used to develop an overall understanding of the value chain that feeds the flight operations engineering department within the airline industry, its competitive nature, and the prevailing forces. Such understanding is crucial to developing a strategy that achieves industry leadership. This section provides a basic overview of the framework and concludes with a short analysis of the problems and pitfalls of this framework when used within the aviation industry.

As shown in Figure 1, Porter's framework presumes that the nature of competitive interactions within an industry is shaped by five major forces: the threat of entry, the bargaining power of suppliers, the bargaining power of buyers, the threat of substitutes, and the rivalry among existing competitors.

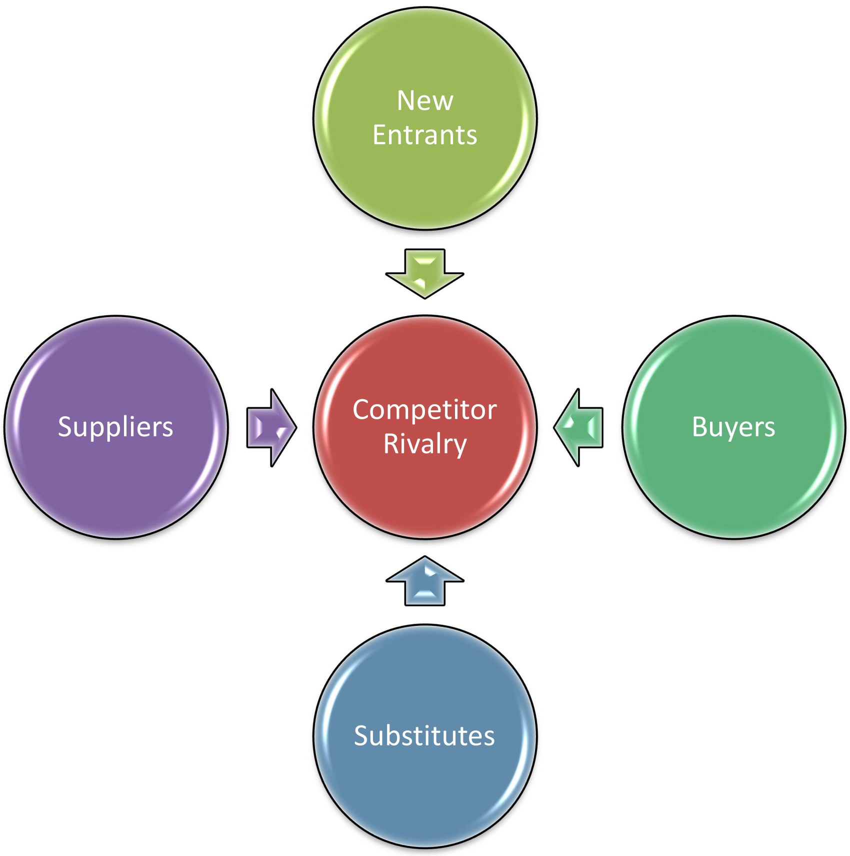


Figure 1 - Porter's Five Forces adapted from (Porter, 2008)

Each of these five forces has a different magnitude in different industries. The strongest force or forces determine the profitability of a given industry and are the most important in strategy formulation. The competitive landscape section of this paper will look at each of these forces in some detail and determine their implications for the flight operations engineering function of the aviation industry.

It is useful at this time to mention that this framework has some shortcomings that are especially relevant to the analysis in this paper. Mainly, as an economist, Porter's framework is predicated in a capitalist view of perfect market and competition. His framework assumes that all players within a specific industry have equal access to resources, competencies, and information. As a result, it ignores the effects of regulations, government interventions, and international barriers; all of which are especially prevalent in the aviation industry. Furthermore, given the global nature of the aviation industry, it ignores the fact that the players will have access to varying levels of capital, information, and technical resources.

2.2 Christensen's Disruptive Innovation (Christensen, 1997)

Christensen classifies technology in two groups: sustaining technology and disruptive technology. The basic idea is that an existing market values a product on a few specific criteria of performance. For example, within the disk drive market, at the time 15 inch drives were dominant, the main performance criteria were capacity, cost per megabyte, and access time. Christensen defines a sustaining technology as a technology that creates improvements in the performance criteria valued by the existing market. On the other hand, disruptive technology offers improvements on performance criteria not currently valued by the existing mainstream market, usually at a cost of deterioration in some or all of the the currently valued performance criteria. For example, at the time of introduction, the 8-inch disk drives offered smaller capacity, cost more per megabyte and were much slower than the then-dominant 15-inch disk drives. However, the new 8-inch disk drives were much smaller and weighed significantly less – two performance criteria that were not valued by the mainstream market at the time of introduction.

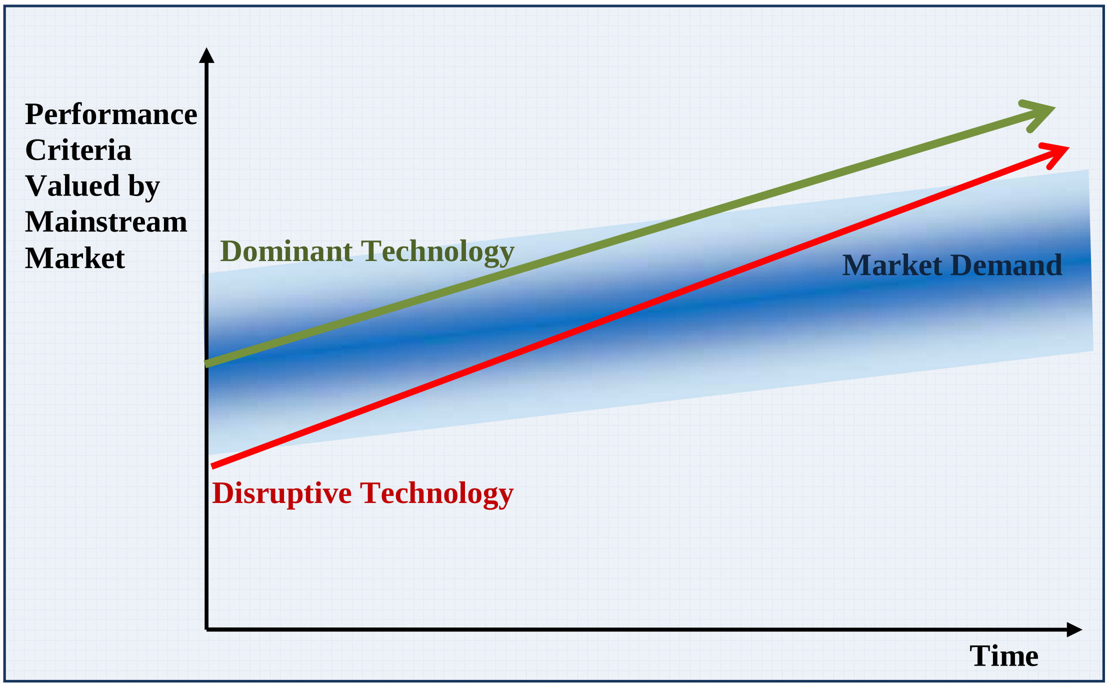


Figure 2 - Disruptive Technology Performance Trajectory over Time (Christensen, 1997)

The main difference between sustaining and disruptive technology is their strategical impact. As demonstrated in Figure 2, sustaining technology allows the firm to move "up market" to sell to customers with higher needs and therefore, charge a premium. The immediate profit margins tend to be larger, however, in the long run, as the firm over-serves the mainstream market, volumes become smaller or margins shrink and overall revenue may eventually begin to shrink. On the other hand, when first introduced, disruptive technologies usually do not meet the needs of the mainstream market based on the primary performance criteria that is valued. Rather, the firm must find a niche market that values the secondary performance criteria. Therefore, at the time of introduction, both margins and volumes will be lower. However, over time, two shifts happen. First, the disruptive technology improves on the primary performance criteria, and while not necessarily reaching the performance of the incumbent technology, it begins to meet the needs of the mainstream market. Second, the mainstream market begins to value the secondary performance criteria offered by the disruptive technology. As a result, the disruptive technology eventually replaces the incumbent technology within the mainstream market. Such disruptive technology can be used in a disruptive business model whereby a new player can enter at the low-end of the market through a niche segment and rapidly grow towards the mainstream to eventually replace (or disrupt) the established major players.

Christensen’s model of disruptive technology has been criticised for being mostly retrospective and descriptive rather than predictive or prescriptive (Danneels, 2004). Furthermore, Christensen has been accused of cherry picking successful cases of disruption without considering those “disruptive technologies” that have failed to disrupt. As a result, Danneels argues that at this stage of research, this theory can’t be used to make predictions of which technologies will disrupt, to make prescriptive guidelines, or suggest activities that a firm can perform to ensure successful disruption.

For the purposes of this paper, however, Christensen’s work on disruptive technology provides some interesting strategic insight. When entering an existing market with a new product, a firm can use two distinct strategies. The firm can enter with a product based on a “sustaining technology” that outperforms the incumbent products on performance criteria currently valued by the mainstream market. We call this strategy an "upper market attack" which could probably expect higher initial margins, larger initial market segment, and quicker market adoption. On the other hand, research suggests that it is much easier for existing players to emulate the sustaining technology; therefore, it is less likely for the firm to become a dominant player or to achieve long-term market or price leadership with this strategy.

The second strategy is to enter the market with a product based on "disruptive technology" that outperforms the dominant technology on a secondary set of performance criteria. Using such strategy the firm would target the low end of the market, or an underserved niche market segment, or a new market segment not targeted by the incumbent players. This is a "lower market attack" strategy that usually begins by targeting a smaller market segment and expects a slower adoption rate and a longer timeline to achieve return on investments. On the other hand, Christensen's research suggests that it is much more likely for the new entrant to successfully disrupt the incumbent market leaders and replace them using this strategy.

2.3 Blue Ocean Strategy (Kim & Mauborgne, 2004)

The basic concept of this theory is that there are two kinds of spaces in the business world. Existing markets constitute what Kim and Mauborgne have termed "red oceans". In such a space the competitive landscape is well understood, market segments have well defined boundaries, and products have well defined performance criteria that the customers know how to value, and therefore are priced accordingly. In such markets the nature of competition is based on providing lower prices for the established performance criteria, revenue growth comes from "stealing" customers from competitors, and as such, these markets become commoditized over time.

New markets or industries currently not served and therefore untouched by competition are termed “blue oceans”. In such markets, the challenge is to create demand rather than to compete for it. Kim and Mauborgne contend that there are two ways of creating blue oceans: give rise to a completely new industry (as EBay did with the online auction industry) or create a blue ocean from within a red ocean by altering the boundaries of an existing industry (as “Cirque du Soleil” did within the circus industry).

For the purposes of this paper, Kim and Mauborgne’s blue ocean strategy is in effect very similar to Christensen’s disruptive innovation strategy. By offering a product that is based on new performance criteria a firm can grow the boundaries of its industry by offering value to a market segment that is either currently underserved or not served at all. The benefit of Kim and Mauborgne’s work is their ability to link this strategy to concrete firm activities that can be managed and measured to create shareholder value.

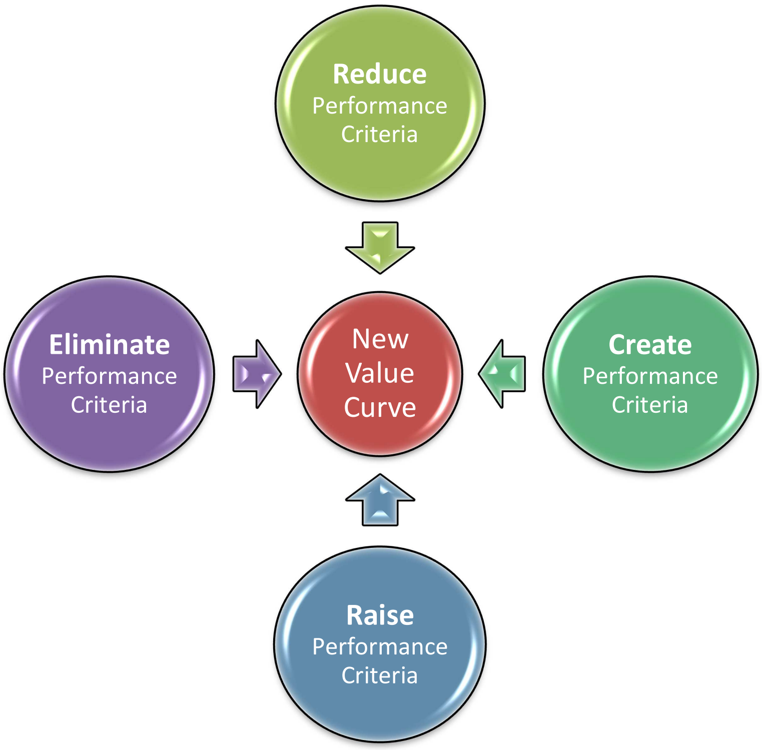


Figure 3 - The Four Action Framework adapted from (W. Chan & Mauborgne, 2005)

Based on their research, Chan & Mauborgne identified four main characteristics of blue oceans; make the competition irrelevant by changing the value criteria, create and capture new demand, break the value / cost trade-off, and align firm activities to the pursuit of differentiation and low cost simultaneously. In their 2005 article, they further extend their theory with the "Four Action Framework" depicted in Figure 3. This framework recommends systematically eliminating or reducing performance criteria that has little value to the customer and is high cost, and instead creating or raising performance criteria that is valued by the customer. In this way, the firm can create a new value curve that simultaneously differentiates the product from competitors and offers a cost advantage.

Later sections of this paper will used the four action framework to recommend a product based on new value curve and demonstrate how that product would be both differentiated and competitively priced within the existing flight operations engineering sector of the aviation industry.

2.4 New Product Development

The typical product development process is depicted in Figure 4 below.

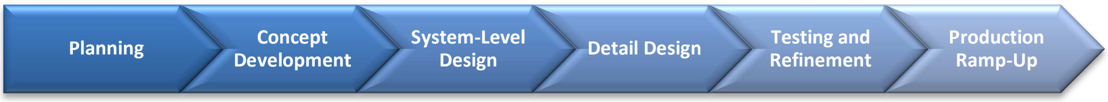


Figure 4 - General Product Development Process (Ulrich & Eppinger, 2008)

In most product-oriented companies, this process is very well defined, measured, and continuously improved. The basic idea is that during the first stage of this process (the Planning stage), the market segment and its needs, the technology platform, and the product's strategic purpose are formally defined and approved. At the end of every subsequent stage, more refined product concepts are generated and tested through market research techniques such as customer surveys, conjoint analysis, and focus groups. The purpose of these tests is to analyze the extent to which the more refined product concepts meet the market segment needs and the product's strategic purpose as defined in the planning stage.

Furthermore, in most companies this product development process takes the form of a funnel as shown in Figure 5 below.

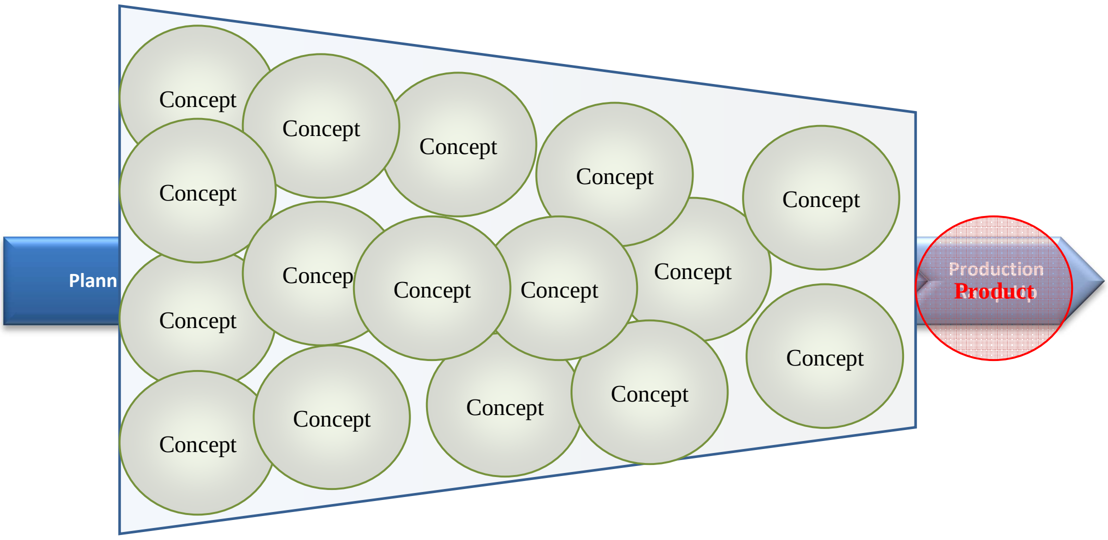


Figure 5 - Product Concept Funnel

As concepts are tested through market research techniques, product concepts are combined or eliminated, until there is only one left at the production stage.

This process works well for incremental innovations where the new product uses proven technology and is designed as an improved version of an existing product with a well-defined market. On the other hand, when the new product is based on discontinuous or radical innovations, this proven incremental process seems to fail. (Lynn, Morone, & Paulson, 1996). This failure is associated with three main aspects of discontinuous innovation that is fundamentally different from incremental innovations. First, products based on discontinuous innovations use new technology that is untested and still developing. Many aspects of the technology may be unknown or improving, and therefore, there is a large risk associated with the uncertainty of the evolving technology. Second, since the technology has not been used in any existing products, the market for the technology is undefined. There is, therefore, another large risk associated with finding the unmet market need for the evolving technology, and having to create a market demand for the unique characteristics of the discontinuous technology and the new product using it. Finally, the new discontinuous technology often creates new possibilities that tend to have their own side effects – political, social, economical, or environmental. As society realizes the repercussions of these side effects, political and legal changes cause large and hard to predict shifts in the competitive landscapes.

Therefore, discontinuous innovations are associated with three large unknowns – technology, market, and timing – that create high risks and require a process that is considerably more flexible than the traditional product development process. (Lynn, Morone, & Paulson, 1996) The main problem with the traditional product development process is that in a discontinuous environment of uncertainty and change, it attempts to identify the market segment and strategic goals of the product at the start, and evaluates product concepts and progress against these preset goals. This is not only counterproductive, it can be highly misleading, forcing the new product development in a direction that will produce poor outcomes or result in the premature termination of high-potential new products.

Figure 6 below depicts the “probe and learn” process used by Motorola that overcomes many of the shortfalls of the standard new product development process for discontinuous innovations.

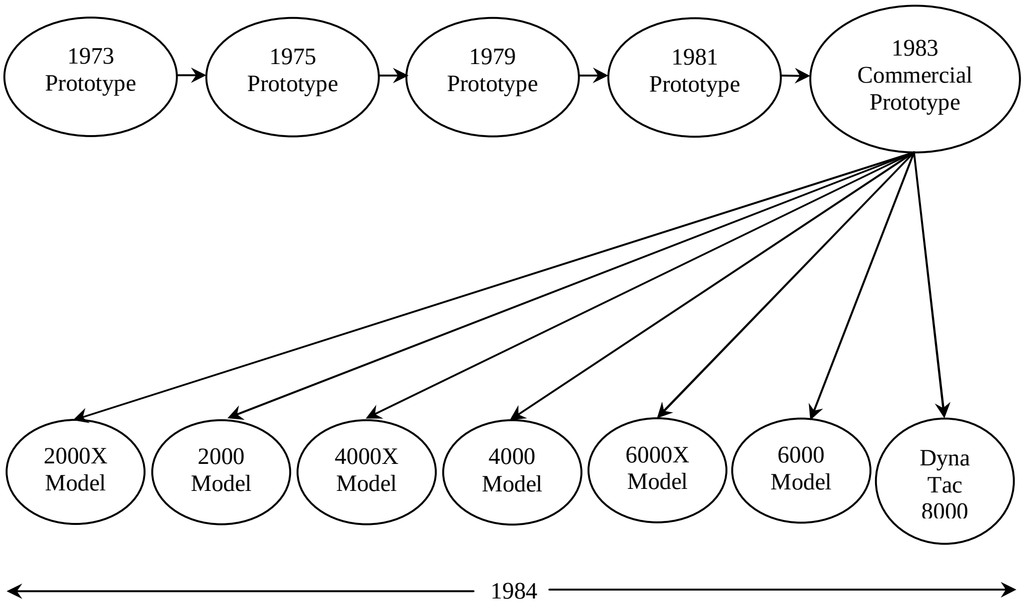


Figure 6 - Motorola Probe and Lean Process: Portable Product Development adapted from (Lynn, Morone, & Paulson, 1996)

As depicted in the above diagram, the probe and learn process involves creating a functioning "prototype" product that is released to the market with the sole purpose of learning from the market. The success of each prototype is measured by the amount of knowledge gained rather than traditional business success criteria such as returns generated. It isn't until the final portable products were released in 1984 that thenew product's success were measured using traditional business success criteria.

The probe and learn product development process can be viewed as "series of market experiments" where the first version and first development decisions are not important in themselves, but the learning and subsequent models are. In this model, the idea is to start probing a potential market with an immature version of the product as a vehicle for learning about the technology (whether and how it needs to evolve and scale), about the market (which applications, market segments, and product features are most receptive), and about exogenous factors such as government agencies and regulations.

The success of the probe and learn process is based on two important factors. First, the company needs to ensure that a proper feedback system is in place that allows learning to occur. Second, the company needs to have a long-term vision and resources available to allow an iterative process of product introduction. At each stage, the "prototype" product is an "approximation" of the winning combination of product features and target market.

Finally, it should be mentioned that discontinuous innovations are much riskier undertakings than incremental innovations. While incremental innovations can be good for the short term, discontinuous innovations do not produce short term results and may or may not be good for the long term. Furthermore, most companies lack the proper management incentives to promote such long-term undertakings as managers may move on prior to the introduction of the final product or investors do not have the patience to wait for uncertain returns.

2.5 Main Area of Concern

For the purpose of this project, the main area of concern is to decide whether it is better to enter the flight operations engineering market through a disruptive product, a discontinuous product, or an incremental product. It is further important to decide whether to attempt a blue ocean strategy of creating a new market segment, or to introduce a product that will compete in an existing market segment based on existing performance criteria by offering superior value.

The answer to the above questions requires a thorough understanding of the industry and the major forces affecting the competitive landscape, as well as the market segment with its current pain points, performance criteria, and decision process. The next two sections of this paper build this understanding, while the last few sections build a strategic model that combines the above theories to suggest the most effective combination of product and marketing strategy.

3: AIRLINE INDUSTRY ANALYSIS

This section provides a brief analysis of the global airline industry. In order to do so, it begins by building an understanding of the general airline structure, the industry's size, the trends within the industry, and airline classification. It will then conclude with a financial analysis of airline revenues, costs, and overall operating profit margins over the past decade.

3.1 Method

The analysis in this section is based on secondary industry data provided by industry research firms such as Datamonitor or university research programs such as the global airline industry program at the Massachusetts Institute of Technology.

3.2 Airline Structure

Most airlines operate through the following major functional groups (Air Transport Association of America, 2007):

- **Operations** includes flight planning, aircraft maintenance, and all aspects of day to day airline operations
- **Sales & Marketing** includes capacity planning, bundling, and pricing
- **Reservations & Ticketing** usually includes website maintenance and ecommerce

- **Management, Administration, and Labour Relations** which can be a major undertaking in large unionized airlines

See Appendix 3: Airline Structure Example of the corporate structure of Air Canada, a major international airline.

Figure 7 below shows the average operating income of airlines in the United States. Refer to Appendix 4: US Airline Data 2000-2008, for the details of the numbers used.

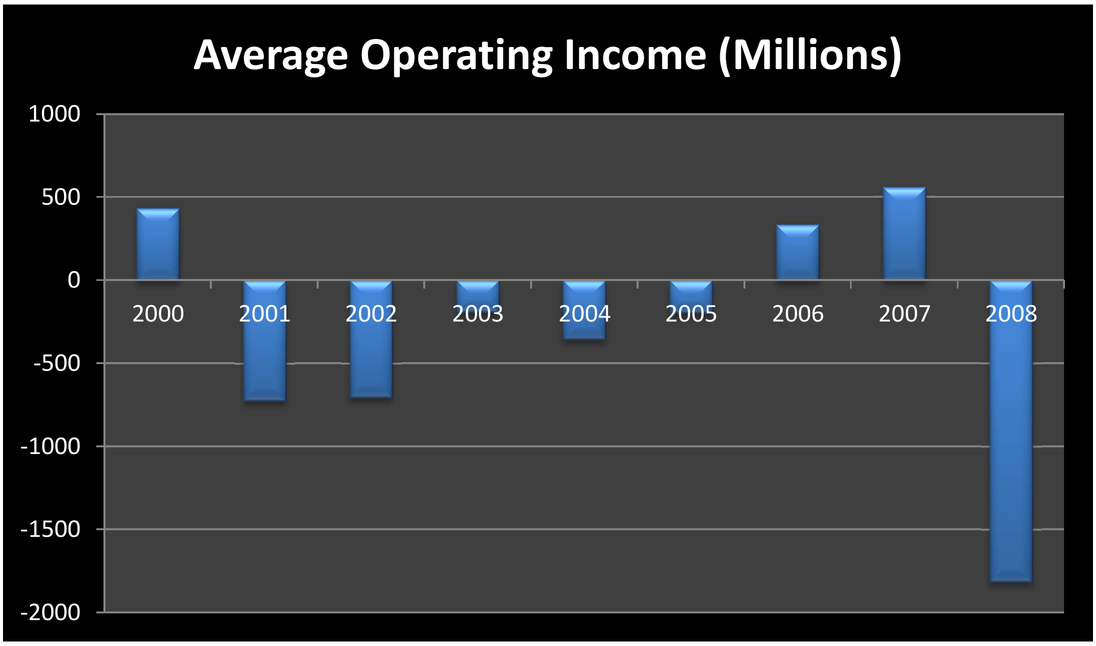


Figure 7 - Average Airline Operating Income in the US[1] (Massachusetts Institute of Technology, 2009)

As depicted in this graph, airlines in general have been suffering due to high operating cost in relation to revenue. As further discussed in the

[1] These numbers are average across 15 airlines of different sizes based in the United States.

section, cost of fuel is the single largest operating expense. As shown in Figure 8 below, a rapid rise in the price of jet fuel in 2008 is the main factor associated with the major losses that airlines incurred in that year.

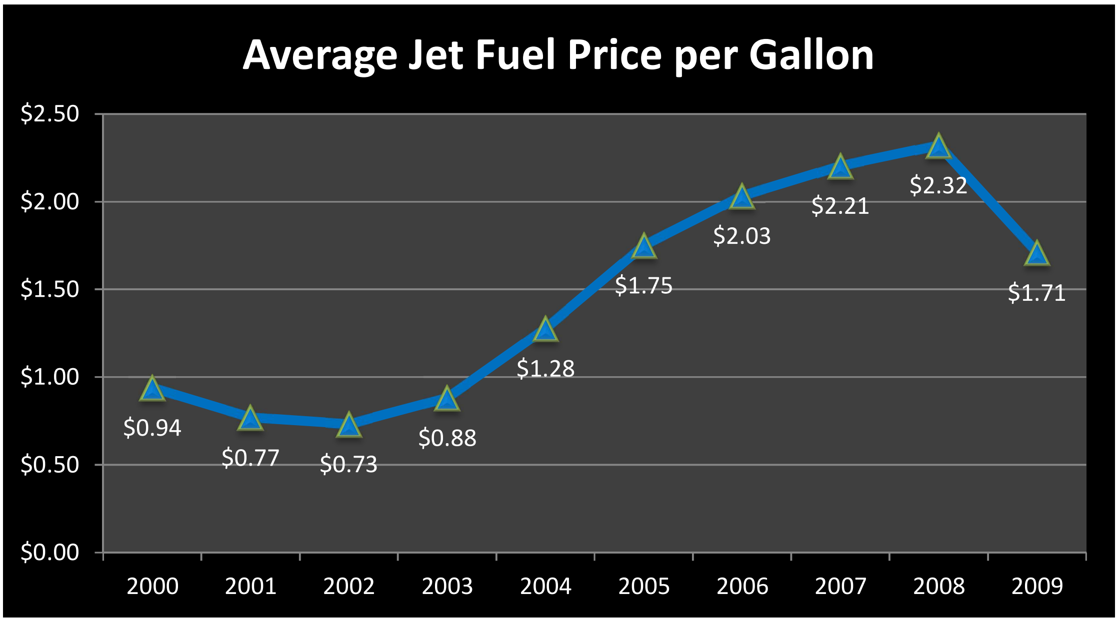


Figure 8 - Average Jet Fuel Price (LA, USA) (United States Government, Department of Energy, Federal Statistics, 2010)

3.3 Industry Size and Trends

In 2008, the global airline industry reached a value of $467.4 billion and a volume of 2.1 billion passengers. In that year, this industry grew by 6.3% in value and 1.8% in volume. By 2013, it is estimated that the global airline industry will reach a value of $609.3 billion (an increase of 30.4% since 2008) and a volume of 2.6 billion passengers (an increase of 23.6% since 2008). (Datamonitor, 2009)

As shown in Table 1 below, in recent years, in the United States, the cost of flight operations has been between 40 and 50 % of operating revenue. Since the industry of interest for this project is the flight operations engineering, then globally, the size of this industry can be estimated at between $187 and $233 billion per year and growing at approximately the same rate as the airline industry at 6.3% annually.

	98	99	00	01	02	03	04	05	06	07	08
System Total Operating Revenue $ Billions	$82	$86	$94	$83	$78	$82	$93	$104	$115	$122	$130
Total Fuel Expense $ Billions	$7	$8	$12	$12	$10	$11	$16	$24	$28	$30	$42
Transport Related Expenses $ Billions	$2	$3	$3	$4	$4	$8	$13	$16	$17	$18	$21
Operating Expense as % Revenue	12%	12%	17%	19%	18%	23%	32%	38%	39%	39%	49%

Table 1 - Flight Operations Engineering as Percentage of Operating Revenue[2] (Massachusetts Institute of Technology, 2009)

The global airline industry can be segmented in many different ways. The most common segmentation is geographical or domestic / international. The relative size of each of these segments is shown in Figure 9.

[2] These numbers are average across 15 airlines of different sizes based in the United States.

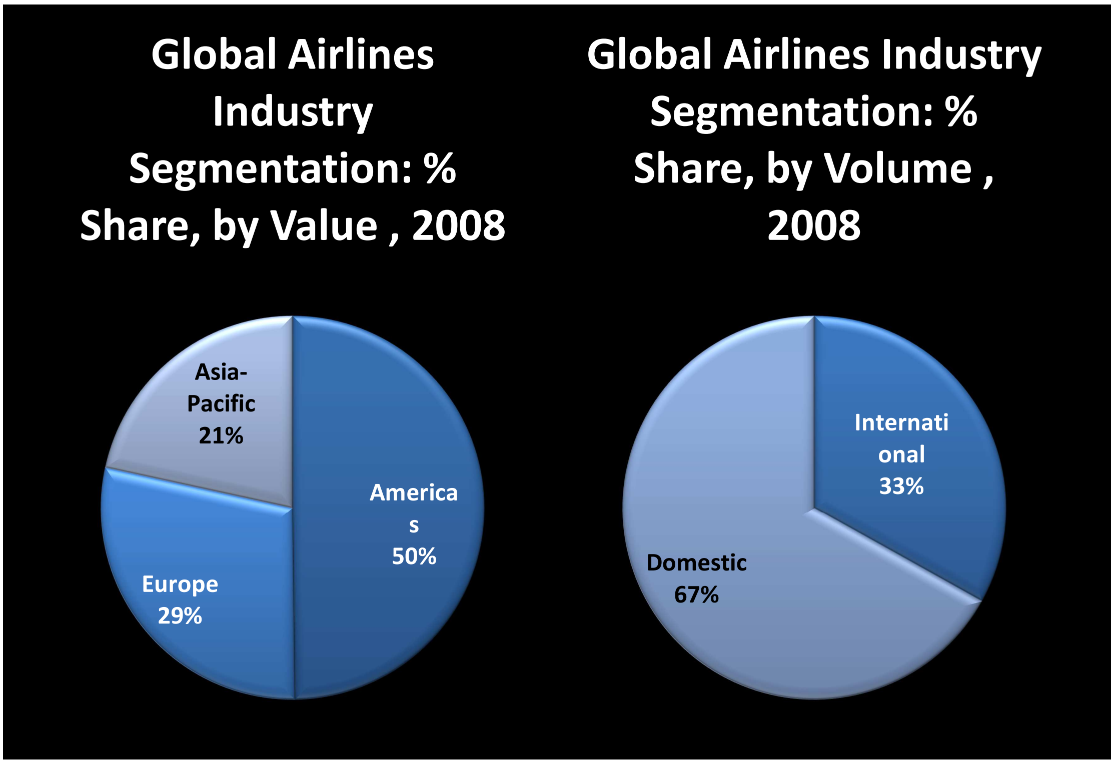


Figure 9 - Global Airline Industry Segmentation (Datamonitor, 2009)

3.4 Airline Classification

There are numerous ways of classifying commercial passenger airlines. The United State's department of transportation (DoT) classifies airlines based on annual operating revenues in three categories: major, national, and regional (United States Department of Transportation, 2004). Major airlines such as Alaska Air, American Airlines, and United Airlines, generate annual operating revenues above $1 Billion. National airlines have annual operating revenues between $100 Million and $1 Billion. Some examples of national airlines are AirTran, JetBlue, and Midwest Express. Finally, regional airlines have annual operating revenues below $100 Million and are the fastest growing and most profitable segment since deregulation. Regional airlines in the United

States include SkyWest Airlines, American Eagle Airlines, and Atlantic Southeast Airlines.

Another common classification of airlines is based on their business model into three categories:network carriers, low cost carriers, and regional carriers. In this model network carriers are large airlines flying internationally and usually affiliated with a specific country (for example Air Canada). Also known as “Trunk Carriers”, these airlines usually operate at an international level, and make use of “hub and spoke” routes (see Appendix 1: Hub and Spoke Networks). Like Air Canada, they mostly existed prior to deregulation and have since had to struggle to maintain a viable hub and spoke business model. On the other hand, the low cost carriers (such as WestJet) tend to be newer airlines, flying more direct routes, and maintaining better profit margins. These airlines operate both regional and long-haul international flights. Finally, regional airlines are the smaller airlines with lighter aircraft that fly within very specific and small regions. These airlines usually provide additional capacity to the large network airlines in their specific regions.

For the purpose of this paper, this latter classification is used since an airline’s business model and corporate structure is more relevant to the analysis than annual operating revenues.

3.5 Financial Analysis

This section analyses the revenue / cost structure and examines the decision criteria, process, and lifecycle within commercial airlines.

Globally, the airline industry is suffering from low margins, consolidation and bankruptcy. This has been attributed to three main factors: economic downturn, rising cost of fuel, and overcapacity.

In general, airline profitability is closely related to economic growth (GDP) (Taneja, 2005). The second factor affecting airline profitability is significant excess capacity in the market (Robson, 1998). In the 1980s, when western economy was booming, the airline industry experienced a large growth in demand. During this time, airlines began to increase capacity drastically as they were counting on continued growth. However, because this continued growth did not materialize, there is currently a large excess capacity in the industry resulting in lowered prices and margins. (Robson, 1998)

Finally, the single largest cost of airline operation is fuel consumption. In the United States, in 2008, airlines spent on average between 34% to 70% of passenger revenue directly on fuel. (Massachusetts Institute of Technology, 2009)

3.5.1 Revenue Breakdown

As mentioned in the previous sections, airlines can be classified into network carriers, low cost carriers, and others such as regional carriers. Figure 10 below shows the average operating revenue per available seat mile for the airlines in the United States.

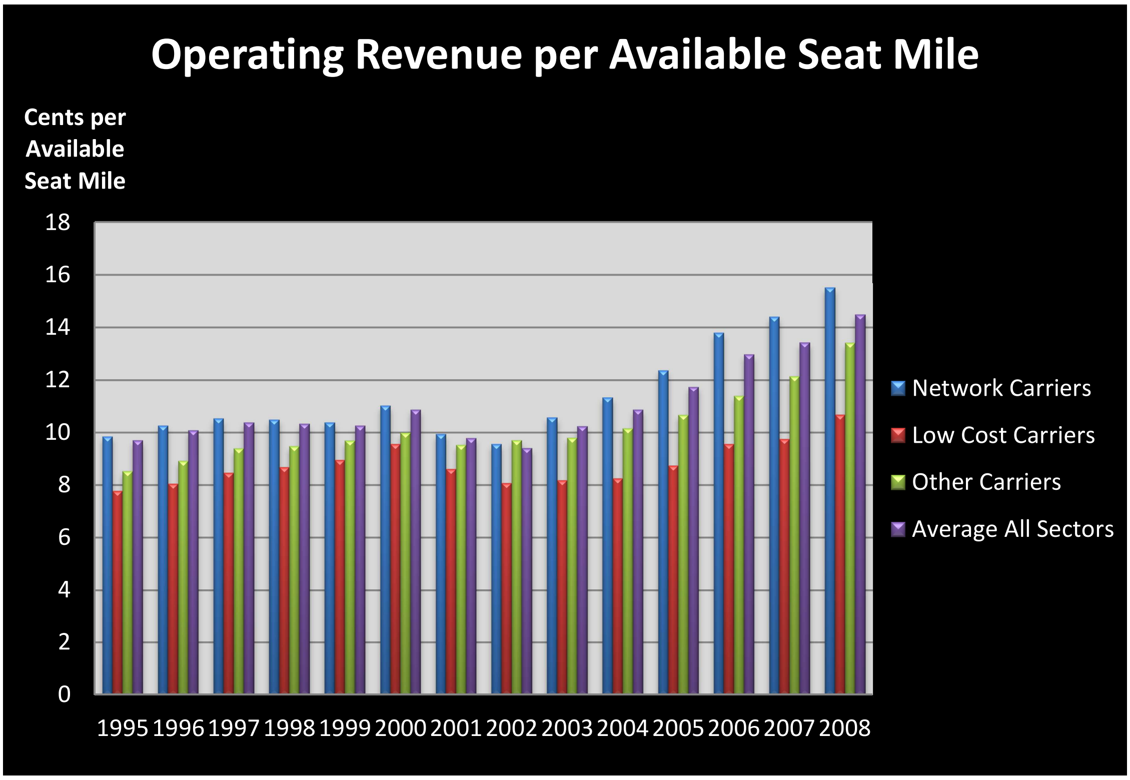


Figure 10 - Average United States Airline Operating Revenue per Available Seat Mile (Massachusetts Institute of Technology, 2009)

As can be seen in the above figure, in general, network carriers generate approximately 20% more revenue per available seat mile than other types of carriers. On average, low cost carriers generate the least amount of revenue per available seat mile. This data is as expected since low cost carriers tend to have much lower prices than the network carriers and make up in their margins by reducing cost as will discussed in the next section.

Airlines generate operating revenue through different sources. These sources can be classified into passenger, cargo, transport related, and others. Figure 11, Figure 12, and Figure 13 below depict the revenue breakdown for each of the network, low cost, and other airline sectors in the United States.

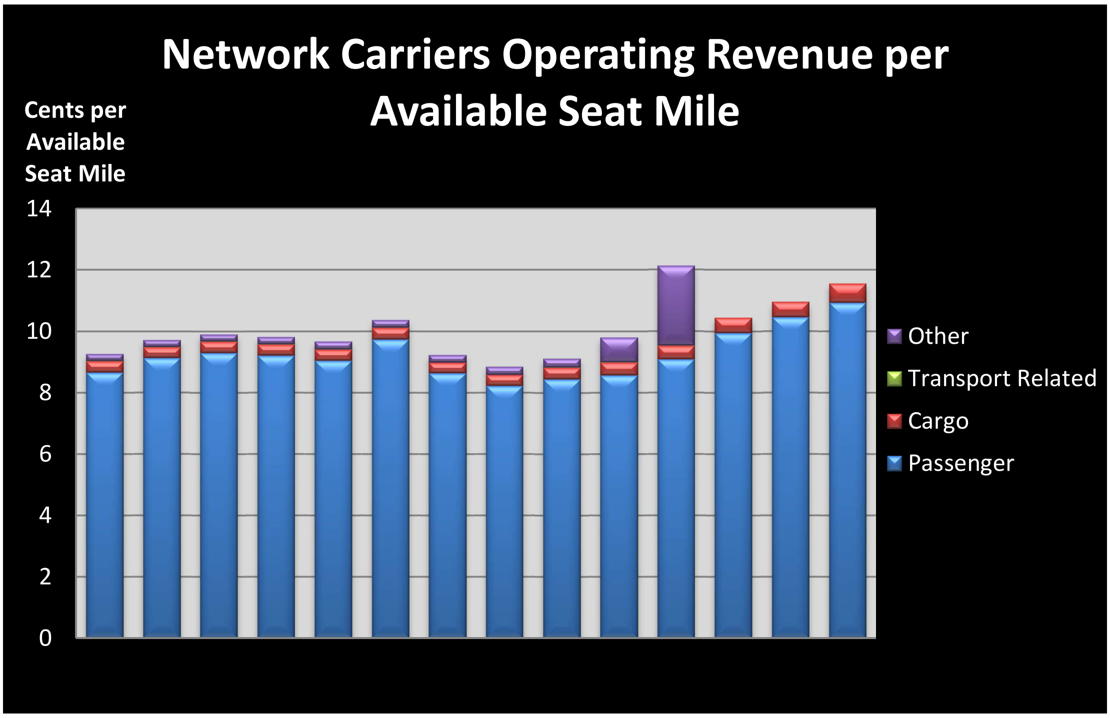


Figure 11 - Average US Network Carrier Revenue Breakdown (Massachusetts Institute of Technology, 2009)

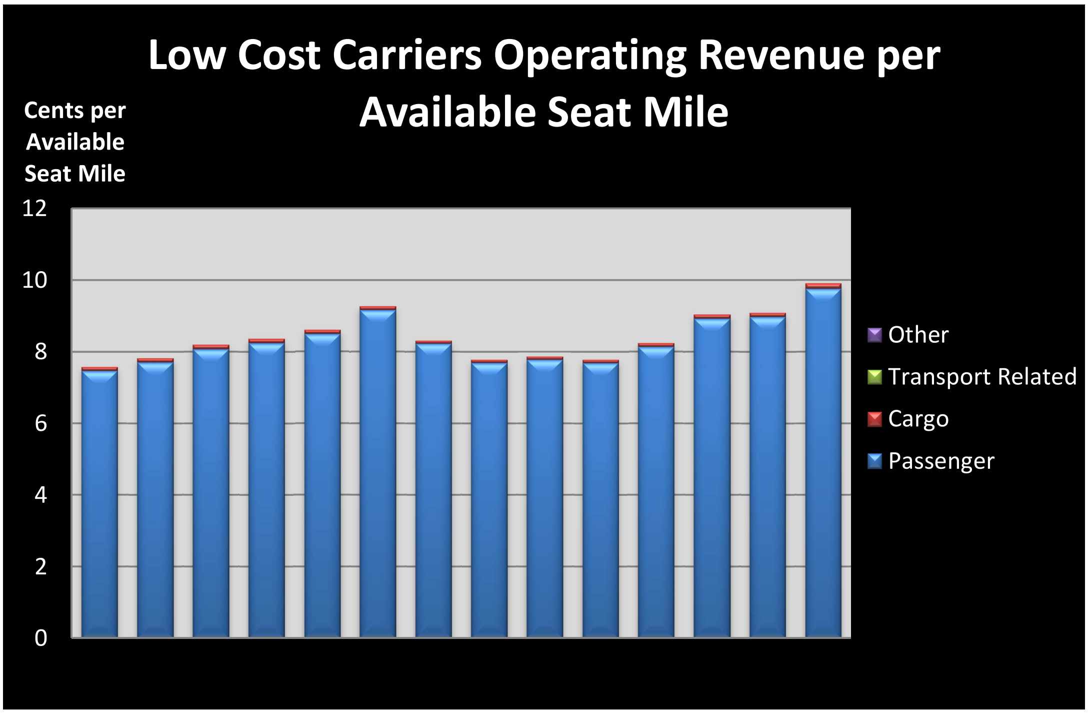


Figure 12 - Average US Low Cost Carrier Revenue Breakdown (Massachusetts Institute of Technology, 2009)

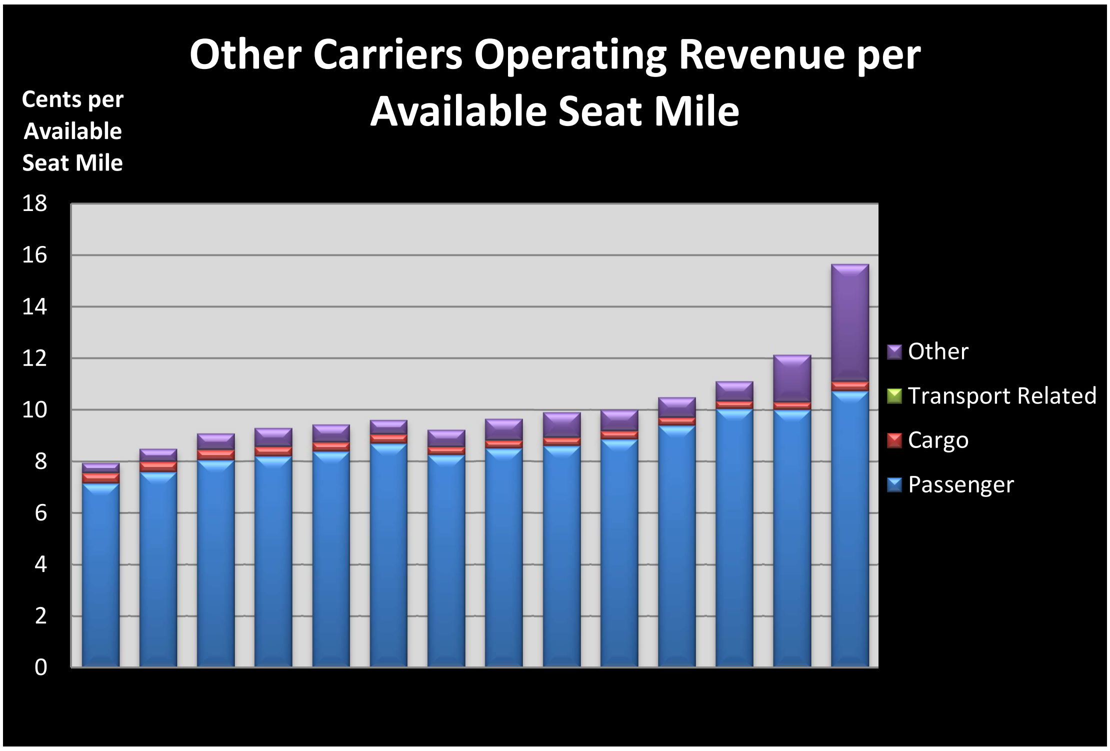


Figure 13 - Average US Other Carriers Revenue Breakdown (Massachusetts Institute of Technology, 2009)

As can be seen in the above graphs, airlines earn revenue from two major sources outside of passenger revenue: transport related and cargo revenue. Both of these sources of revenue have been growing in proportion of the past few years, and should be looked at in more details.

First, the US Department of Transportation defines "transport-related revenue" as:

"Ancillary fees include baggage fees, reservation change fees and miscellaneous operating revenue, including pet transportation, sale of frequent flyer award miles to airline business partners and standby passenger fees. Revenue from seating assignments and on-board sales of food, drink, pillows, blankets, entertainment, or any other ancillary items are reported as Transport Related Revenue and cannot be identified separately."

(US DOT (Department of Transportation) - RITA - Research and Innovative Technology Administration, 2010)

Figure 14 and Figure 15 below show the transport related revenue per available seat mile (cents and percentage of overall revenue respectively) for each airline category.

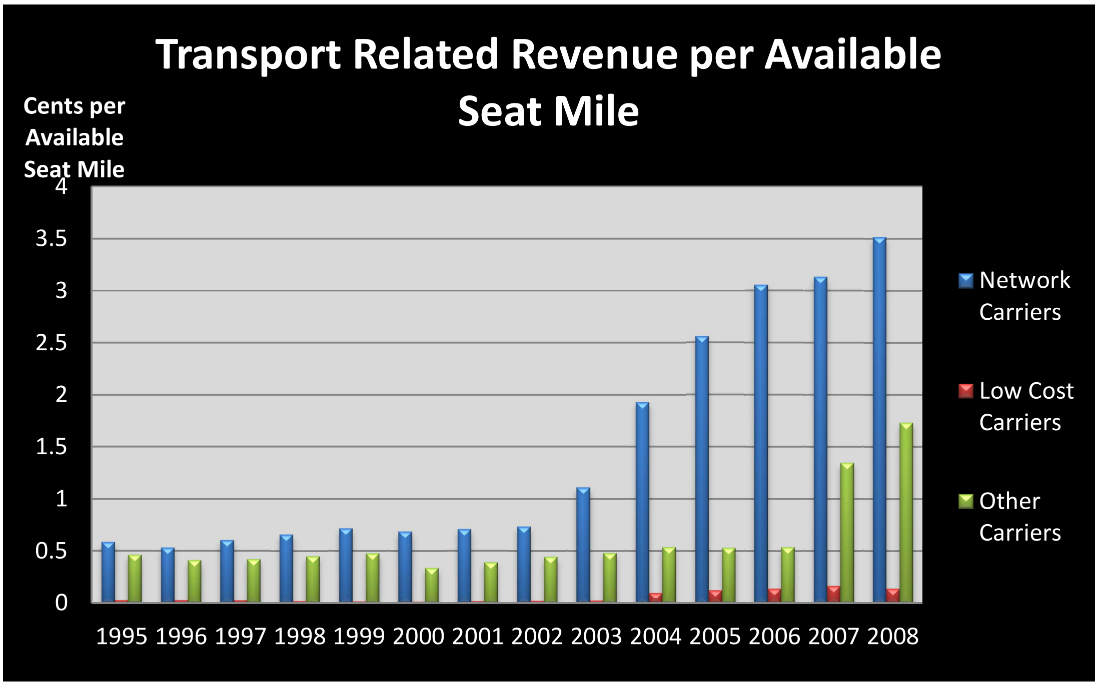


Figure 14 - Transport Related Revenue per Airline Category (Massachusetts Institute of Technology, 2009)

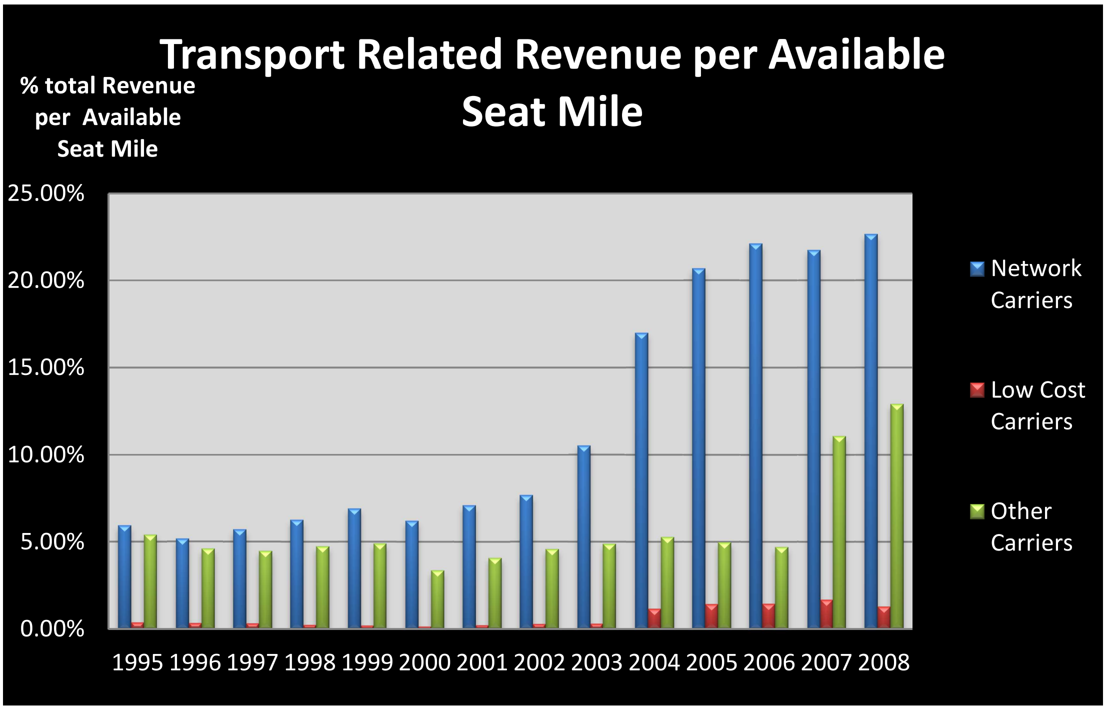


Figure 15 - Transport Related Revenue as a Percentage of Overall Revenue (Massachusetts Institute of Technology, 2009)

Since this category seems hard to classify and unrelated to flight path and fuel consumption, it will not be explored any further in this project. Similarly, Figure 16 and Figure 17 below depict the cargo revenue for each of the airline categories. As shown in these graphs while the absolute revenue from cargo has been increasing in network carriers in 2002, as a percentage of overall revenue, it is staying relatively constant. The other interesting trend is that this type of revenue is decreasing in the "other carriers" airline category.

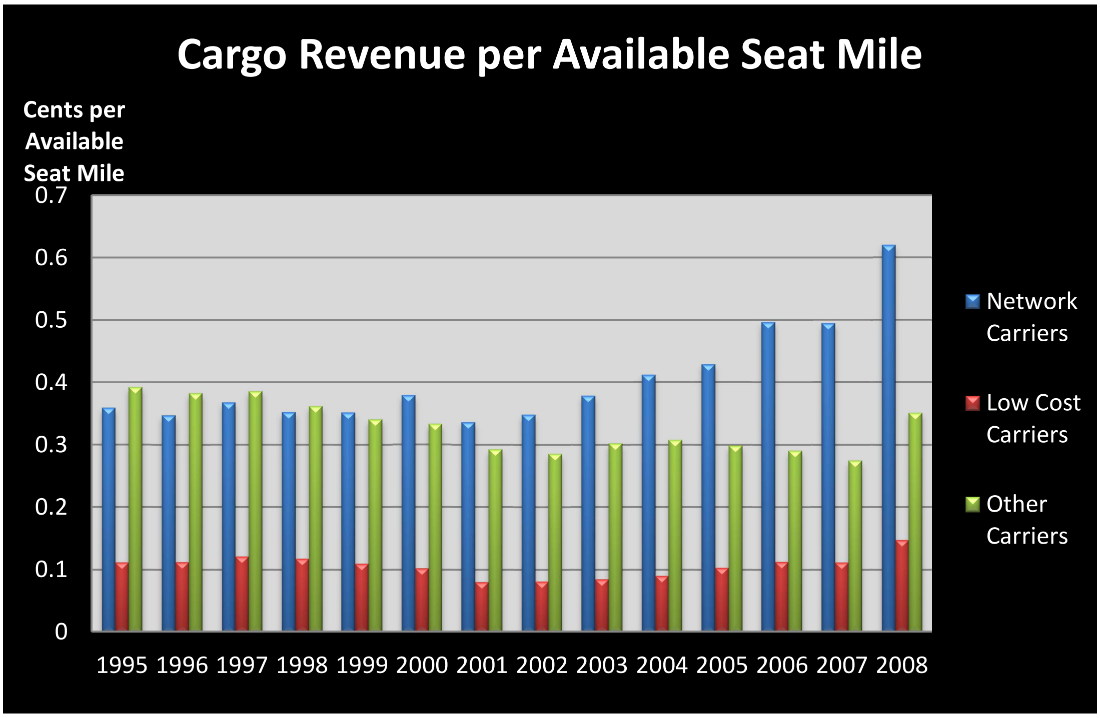


Figure 16 - Cargo Revenue per Airline Category (Massachusetts Institute of Technology, 2009)

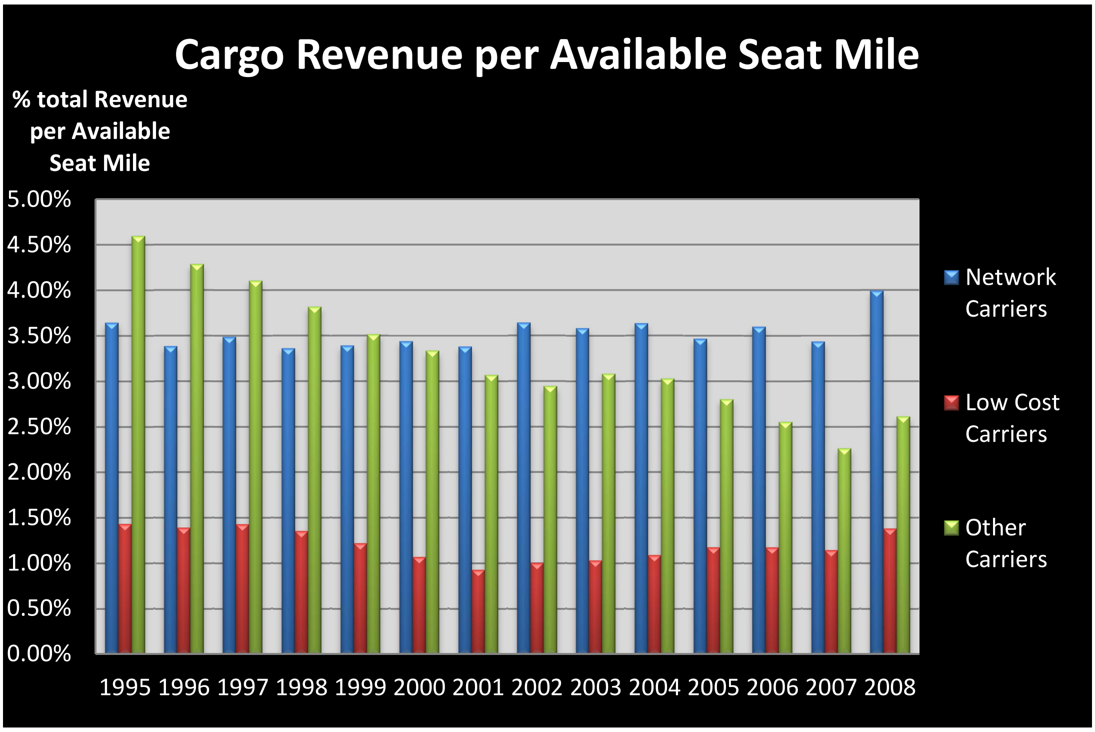


Figure 17 - Cargo Revenue as Percentage of Overall Revenue (Massachusetts Institute of Technology, 2009)

As shown in the above graphs a portion of all commercial airline operating revenue comes from carrying cargo. In recent years, network carriers have a higher percentage of their revenue from carrying cargo than other types of airlines. In general, the amount of cargo that an aircraft will carry is determined by the desired take-off weight of the aircraft. At the time of departure, the pilot takes into account the current weather conditions and the designed “one-engine-out” safety procedure to determine the desired take-off weight and speed. This take-off weight will then determine the amount of cargo that the aircraft will carry.

Therefore, increased accuracy of the obstacle and terrain data can lead to lowered clearance surfaces, which in turn can reduce the climbing rate of the aircraft, result in additional cargo capacity, and allow the airline to increase operating revenue. Another way of increasing cargo capacity is to offer the pilot more accurate tools for last minute adjustments and calculations. This would not only increase consistency and safety, but also allow the pilot to decrease safety buffers, which would potentially increase the calculated desired weight, cargo capacity, and lead to increased operating revenue.

3.5.2 Cost Breakdown

Figure 18 below shows the average operating expense of airlines in the United States broken down based on the sub segments identified previously.

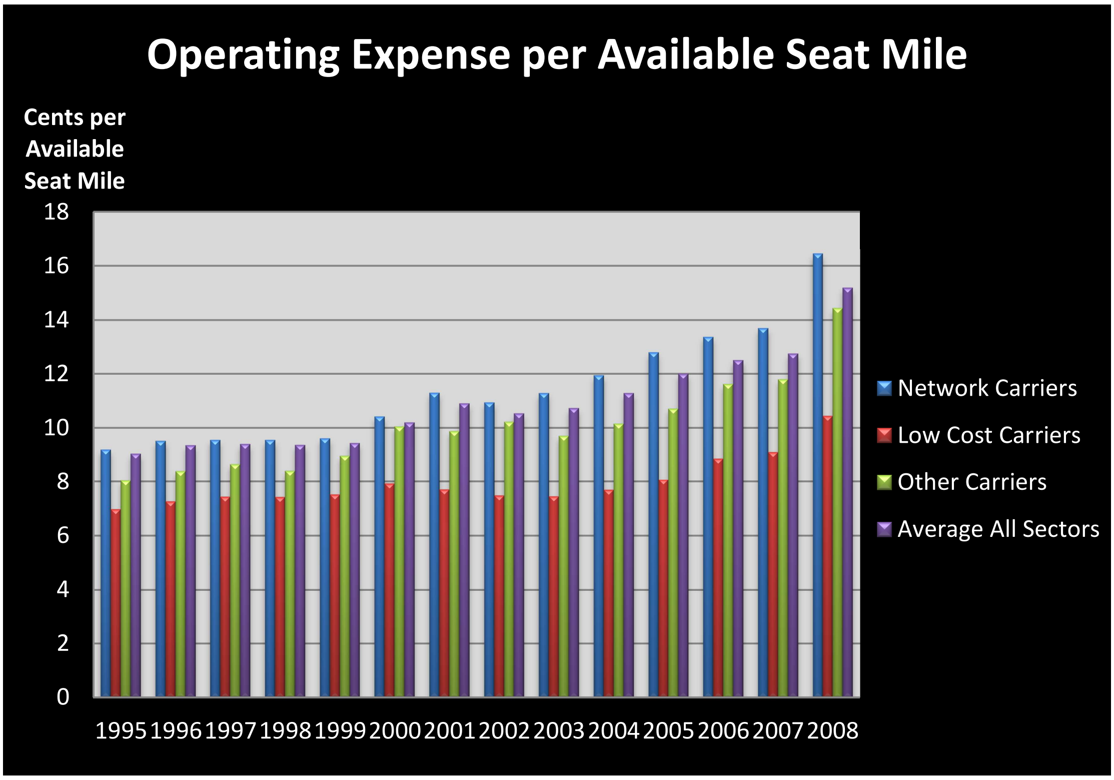


Figure 18 - Average US Airline Operating Expense (Massachusetts Institute of Technology, 2009)

As can be seen from the above graph, low cost carriers have much lower operating expenses than any other type of commercial airline. In fact, on average, the operating expense of low cost carriers in the years 1995 to 2008 has been about 12% lower than the operating cost of network carriers. (Massachusetts Institute of Technology, 2009)

Airline operating costs can be grouped into three major areas: fuel, labour, and others (which includes aircraft maintenance, management, and administrative costs). Figure 19, Figure 20, and Figure 21 below depict the relative operating costs in each of the major segments.

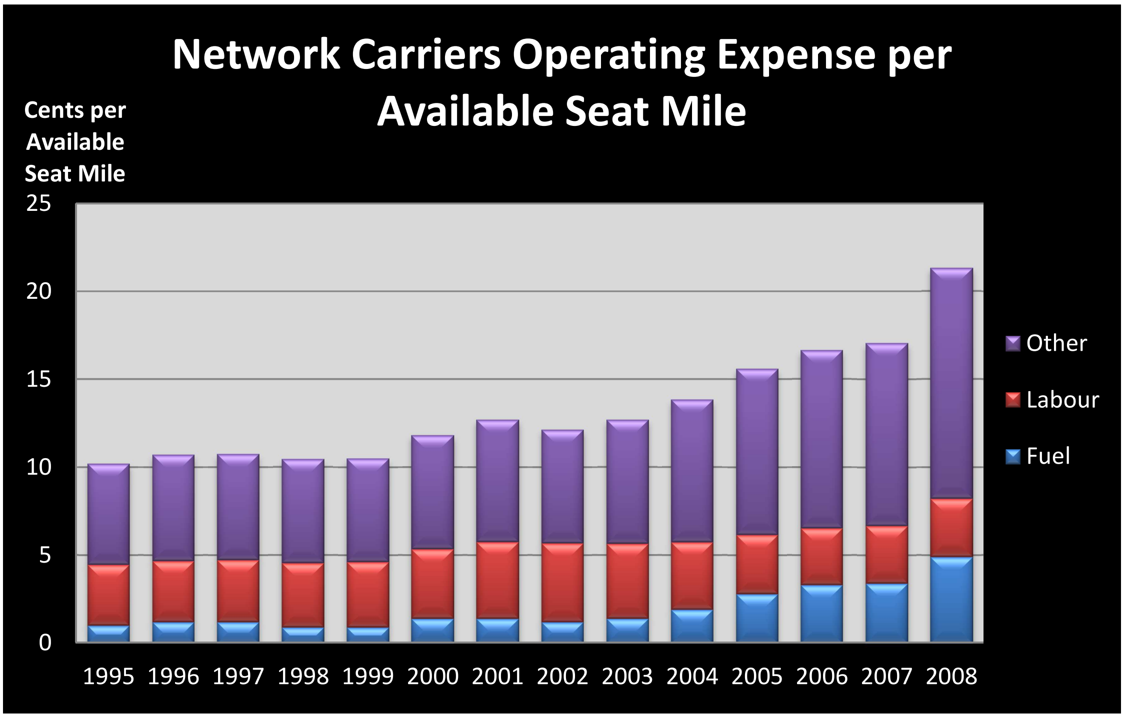


Figure 19 - Average US Network Carriers Cost Breakdown (Massachusetts Institute of Technology, 2009)

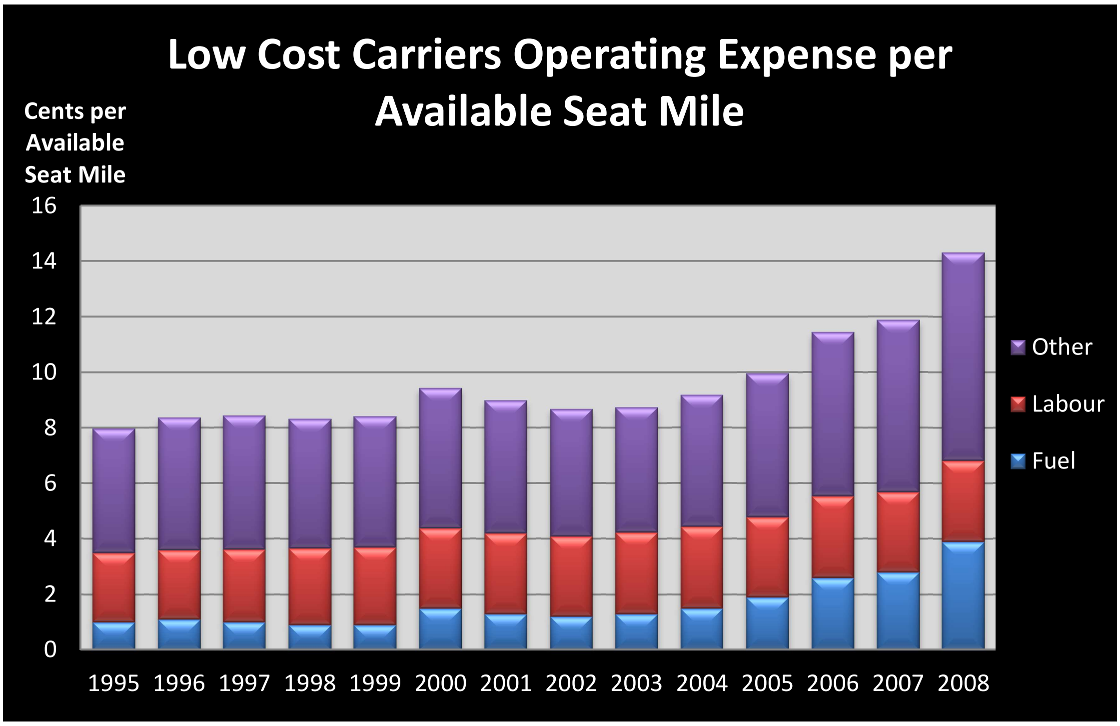


Figure 20 - Average US Low Cost Carriers Cost Breakdown (Massachusetts Institute of Technology, 2009)

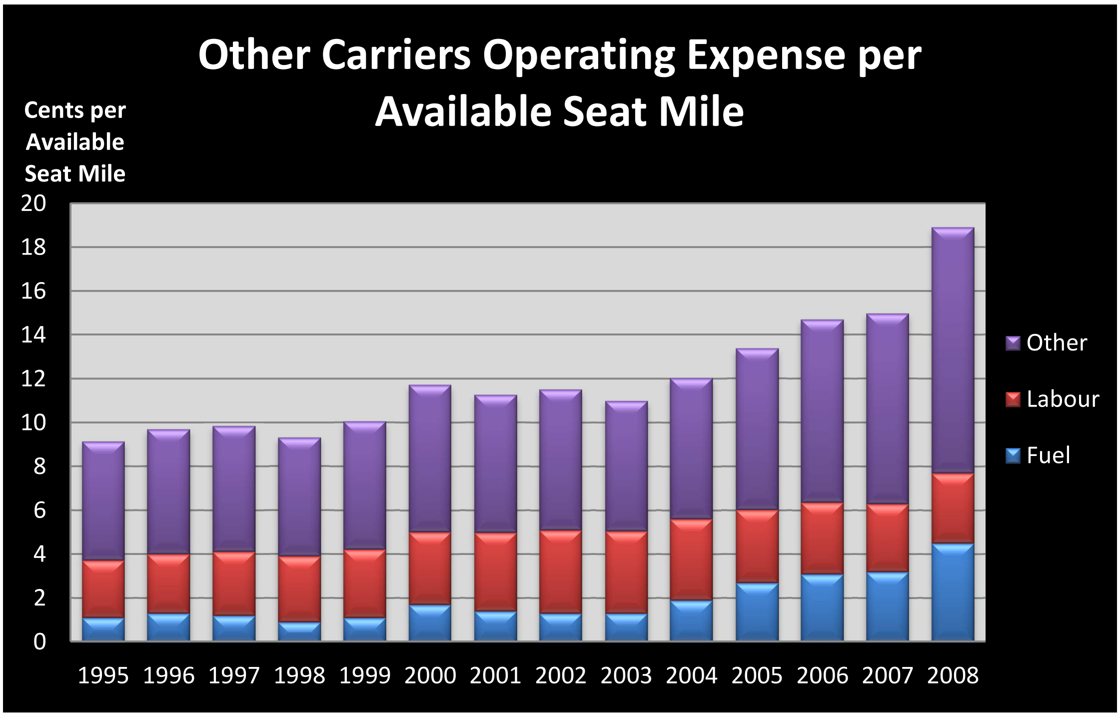


Figure 21 - Average US Other Carriers Cost Breakdown (Massachusetts Institute of Technology, 2009)

As shown in the above graphs, fuel is a major factor in airlines' operating costs in all segments of the market. The 2008 increase in the price of Jet Fuel drastically increased the operating costs of airlines in all segments resulting in negative profit margins for practically all major US airlines. Furthermore, as environmental concerns are growing around the globe, countries are putting into effect more stringent fuel restrictions and programs such as carbon taxing. In the near future, these regulatory efforts will further increase the airlines' cost of fuel consumption.

As shown in Figure 22 below, the fuel consumption per available seat mile is almost the same for each of the airline categories. The interesting trend however is there seems to be a consistent attempt across all airline categories to reduce the rate of fuel consumption since 2002.

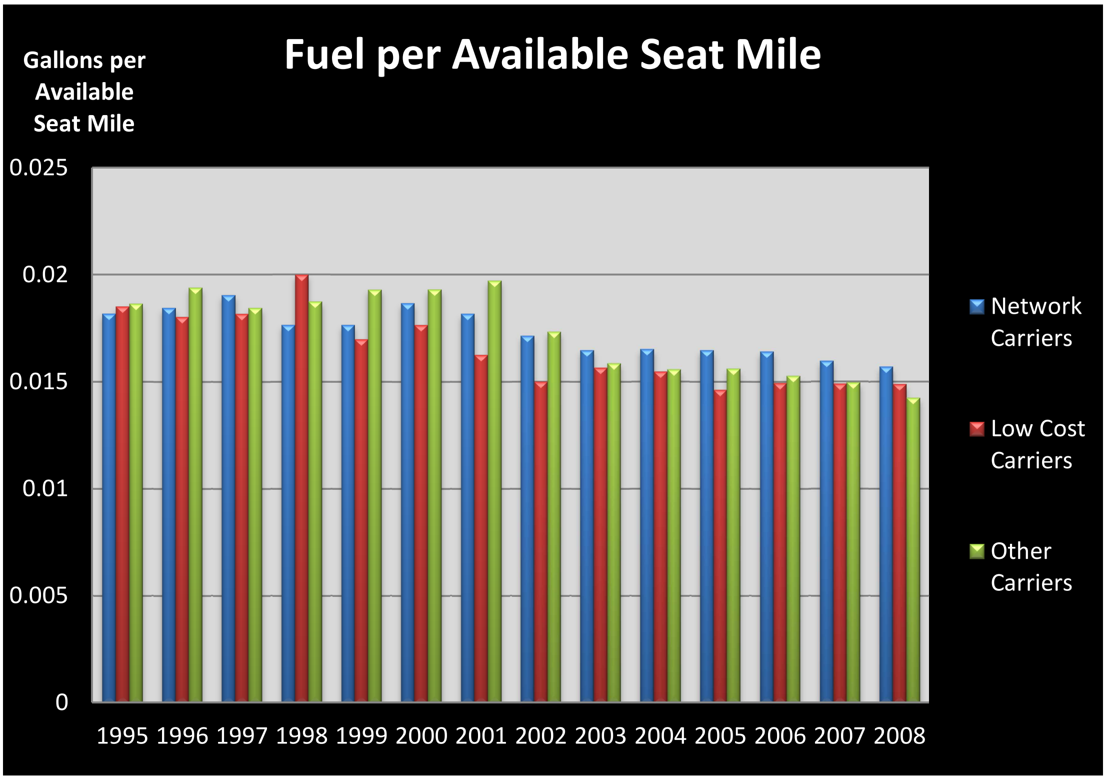


Figure 22 - Fuel Consumption per Airline Category (Massachusetts Institute of Technology, 2009)

The main factors affecting aircraft fuel consumption are flight path and duration, aircraft weight, and aircraft climb rate. More accurate obstacle and terrain information used in more tailored procedures can result in shorter flight paths and smaller climb rates, both of which would decrease the rate of fuel consumption and thereby the overall airline operating cost. Furthermore, increasing last minute pilot evaluation accuracy could decrease the necessary take-off speed, also resulting in less fuel consumption and lowered operating costs.

3.5.3 Operating Profit Margins

Figure 23 below shows the operating revenues and expenses per available seat mile of airlines in the US between the years 1995 and 2008.

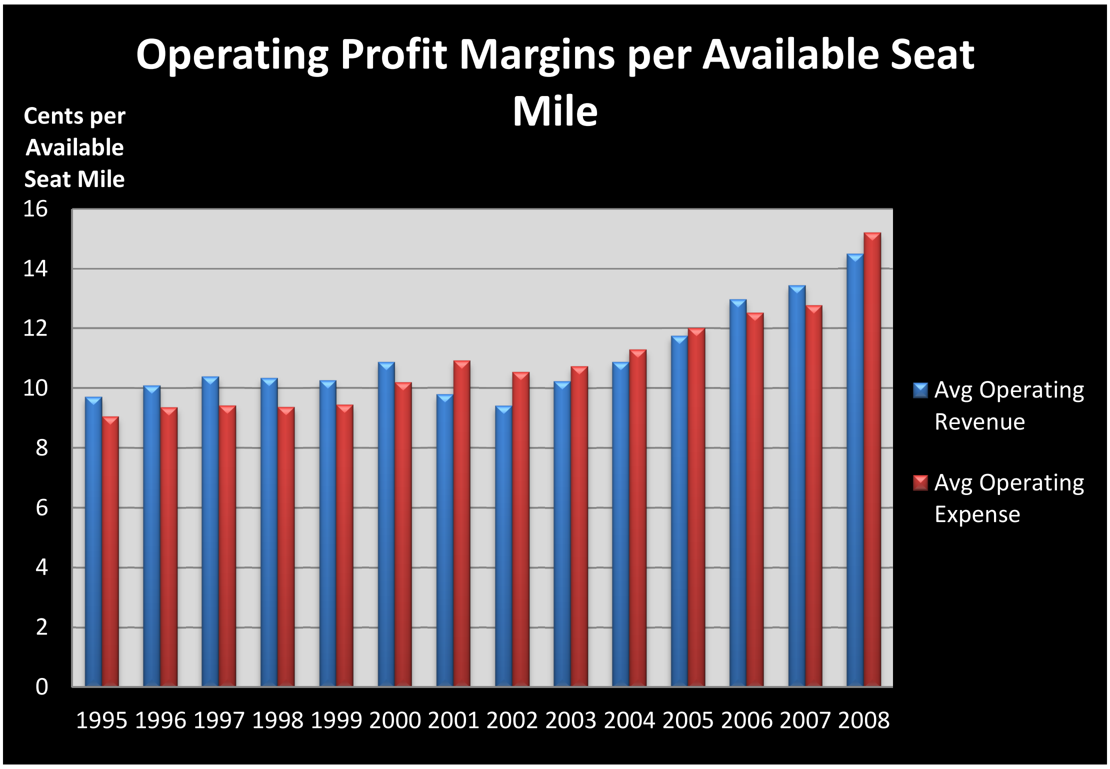


Figure 23 - Average US Airline Operating Revenue and Expense (Massachusetts Institute of Technology, 2009)

The two major trends can be observed in the above graph. First, both operating revenues and expenses have been increasing over time. The second trend of interest is that in terms of profit margins as shown in Figure 24 below.

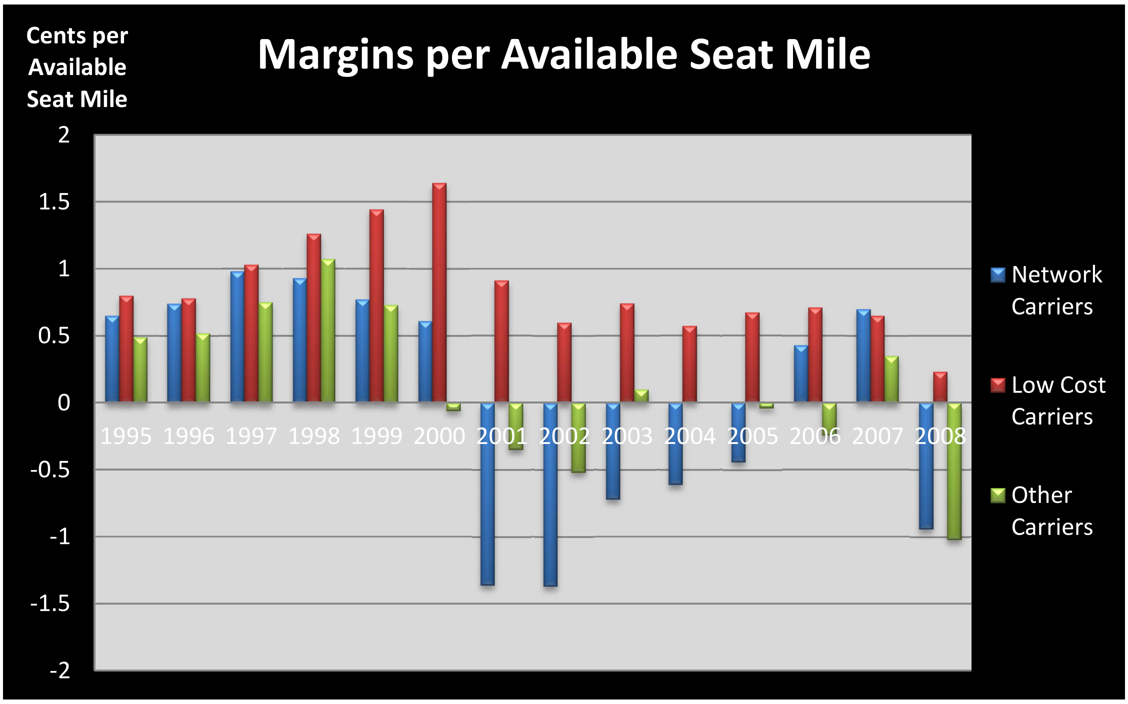


Figure 24 - Airline Operating Margine per Airline Category (Massachusetts Institute of Technology, 2009)

As can be seen in the above graphs airline profitability has been quite poor since 1995 and possibly before. Interestingly, low cost carriers have been able to maintain profitability while network carriers have been incurring losses since 2001. In general, however, for most airlines, current operating revenues barely cover operating expenses, and a good proportion of the time, they don't - resulting in operating losses.

It is obvious that in terms of airline operations, at this point in time, airlines need to focus on increasing operating profitability. While a lot of attention is given to industry trends in terms of growth potential, the current situation within the airline industry suggests that there needs to be a strong focus on achieving operating profitability within existing markets.

4: FLIGHT OPERATIONS ENGINEERING MARKET

This section takes a deeper look at the flight operations engineering department of airlines. It begins with an analysis of the business objectives of this department and is followed by a discussion of the decision criteria and the change process within this department.

4.1 Method

There is little significant secondary data available for the analysis in this section, and the little that is available is dated and no longer relevant. As a result, the analysis in the section is based on interviews. Appendix 6: Interviews, explains the interviewing methodology, interview questions, lists the interviewees and summarizes the interview results. This section will use these interview results to build an understanding of the flight operations engineering market.

4.2 Business Objectives

In terms of objectives, flight operations engineering's primary focus is airline safety, and then, efficiency without compromising safety. In order to create efficiencies within the airline industry, this department must also overcome the challenges associated with working within such a highly regulated environment.

In order to achieve these objectives, this department's daily activities revolve around three types of activities; measuring, adapting to the latest information, and implementing initiatives.

Measuring the right things and increase accuracy in what they measure is a main focus of this department. Most modern airlines have automated systems on board the aircraft that records around 40 different parameters throughout every single flight. Upon landing, this data is automatically downloaded to their overall flight management system. Furthermore, the latest weather and runway conditions are also continuously updated. The accuracy and relevance of the data that is measure have a few purposes. First, increased accuracy usually results in better predictability, which in turn decreases risk and increases safety. Secondly, better knowledge usually results in the ability to minimize buffers and margins, which in turn decreases cost and increases efficiency. Finally, information increases knowledge which can be used to plan new initiatives and do things that were previously not possible.

The second type of activities performed by this department involves continuously updating daily operations based on the latest current information. For example, prior to each flight the dispatcher will decide the aircraft's exact flight procedure, takeoff weight, and fuel reserve. These decisions are tailored to the specific aircraft based on the information measured about its past performance. The decisions also depend on the latest weather and runway information at the time of departure. Another example of continuous monitoring and adapting of operation concerns NOTAMs (Notice To Air Men). NOTAMs are basically released by regulatory bodies to warn of an impending change at an airport. For example, a NOTAM can describe that a specific navigational aid will not be operational at a specific airport for a specific time, or it can describe that a new facility is build within the vicinity of the aerodrome. The flight operations engineering department continuously monitors NOTAMs and adapts their daily operations to ensure safety and maximum efficiency given the changes at each airport.

The third type of activity performed by the flight operations engineering department involves proposing and implementing operational initiatives. The purpose of these activities is to either provide improvement in the above two types of activities or to increase operational safety and / or efficiency. In order to do this, the department first builds a purely theoretical business case of the form “if we do a, we are probably going to see b”. Then they design a an experiment that would require a relatively small initial investment and little interruption of current operations to test whether doing “a” really results in “b”. Based on the results of these experiments, they will build a full business case and request higher management approval for the initiative. This department is then responsible for implementing the initiative, measuring the change, and reporting the results.

While all three of these types of activities are performed at all destinations and for all flights, this department tends to spend a lot more resources on what they identify as “performance challenged airports”. Performance challenged airports have a combination of shorter runways, higher altitudes, warmer average temperatures, and mountainous geographical areas. At such airports, airline operations tend to be limited by aircraft performance and suffer from high inefficiencies.

4.3 Decision Criteria

The single most important factor in any airline’s decision process is the business case. For airlines, the challenge in making a business case revolves around being able to prove the case. Proving relies on the ability to measure accurately and reliably the impact of the required investment.

The ability to measure performance seems to be one of the major challenges of the flight operations engineering department. On any single flight, there are a lot of factors affecting fuel burn such as wind, temperature, barometric pressure, weather patterns, aircraft weight, drag, flight path, air traffic controller instructions, pilot decisions, and so on. (see section Factors affecting Fuel Burn). Today, most modern airlines have an ACMS (Aircraft Monitoring System) function that automatically records 40 parameters or more on every flight. This information is very detailed and specific.

When the information is used to monitor a specific aircraft, it can be very useful in providing near real-time information on issues that could be a safety concern and in allowing flight operations to be tailored to the specifics of the actual aircraft in order to increase safety and efficiency. However, at the aggregate level, there are major challenges in using this data to determine the actual value generated by a specific investment or initiative. The main reason quoted for these challenges was that there are simply too many parameters and too many variables creating too much noise. When asked about what is measured and monitored at the aggregate level, common answers included looking at the overall fuel burn from last year, adapting it for major changes such as new destination, and comparing it to this year's fuel bill. Almost all interviewer expressed that looking at the data at any other level of granularity could be misleading.

In terms of decision criteria, a logical deduction that there are efficiencies to be gained in a specific area is usually enough to initiate in a relatively small investment in an experiment that proves the business case. The harder part is designing an experiment that requires little upfront investment, creates negligible operational disruption, and can provide results that can be extrapolated to the larger business case.

In terms of decision makers, it seems that most such business cases are initiated by middle management or at the level of the director of the flight operations engineering department. Upper management must agree to the initial investment and will definitely have to approve the final investment. Once the business case is approved, the change is usually “pushed down” through the airline operations. In all interviews, all examples of changes given were initiated and implemented in a top-down fashion.

4.4 Change Process

Once the business case is approved, the extent and speed of adoption depends largely on the airline structure. The smaller, flatter, and more agile airlines tend to adopt a “just do it” culture. In such cultures adoptions is much quicker and they are more likely to invest in even the smallest gains if they believe in the business case. In larger more unionized airlines, the next question is the impact on the unions, crews, and so on. It’s not necessarily that adoption will not happen, but rather it is a longer process. If the efficiencies offered are small, the cost of going through that process may be larger than the perceived efficiencies, and therefore, adoption may not happen. As a result, smaller and more agile airlines are more likely to make investments that have smaller returns, as long as they believe in the validity of the business case.

The process and duration of the actual implementation depends on a few factors. First, it depends on how many external entities need to be involved in the change. A change that involves buying form a third party will usually require a bidding a process and time for the third party to deliver the desired parts. A change requires regulatory approval is largely dependent on the country, the mandates of the authorities, and their knowledge of the technology. For example, approving new RNP procedures is highly dependent on the authority's mandate to facilitate such approvals and their familiarity with RNP technology.

Internally, the change process depends on the extent of the change and the size of the airline. If aircrafts need to be upgraded, then the change will happen through the airplane's preset maintenance schedule. The size and diversity of the fleet will have a large impact on the duration of this change. If training is required, depending on the type of training, for example, classroom, simulator, or online training, then the crew needs to be trained in small groups to allow continuing daily airline operations.

In general, however, all changes described through the interviews took a minimum of one year to implement. Many of the bigger changes were planned into a five-year plan.

Once the change is implemented, it will be integrated into the other two types of activities performed by the flight operations engineering department; namely measuring performance and adapting daily operations. The gains from the change are continuously measured, reported to upper management, and used to measure the success of the initiative.

4.5 Conclusion

A diverse set of criteria can be used to segment the global airline industry. The most common segmentation involves segmenting based on geographic location, type of service (cargo, passenger, etc), type of operations (local, regional, international, etc), size of operations, and fleet type. Based on the interviews performed, this section recommends a different approach to segmenting the flight operations engineering market within the global airline industry.

The first and most important factor based on which this market should be segmented is the airline's overall operational maturity. It is important to acknowledge that airline, like most other commercial ventures, will first and foremost invest in what they perceive as have the largest return for the smallest investment. Airlines with immature operations are most likely to find the largest returns in other parts of their operations such as schedule, labour, and equipment upgrade.

The second most important factor that should be considered when segmenting the flight operations engineering market is the airline's structure and culture. This will dependent largely on the type of product or service offered. Larger, more hierarchical airlines are more likely to adopt bigger projects and projects that have low impact on existing crew and operations. On the other hand, smaller, flatter airlines are more likely to adopt smaller projects and are usually more friendly to changing existing processes and airline operations.

The final factor that should be considered is the type of airline operations as it will result in a different magnitude and prioritization of problems. The characteristic to consider is highly dependent on the type of product or service. For example airlines that operate internationally are much more susceptible to currency and fuel hedging. As the cost of jet fuel and the value of currencies change at different rates in different countries, the operational cost of international airlines changes relative to one another. As a result, in a very short time span, these changes can become a source of competitive advantage or disadvantage allowing one international operator to undercut the rest of the market over the same route.

Another differentiating factor in the type of airline operations is airlines that fly mostly the longer distances as opposed to airlines that fly shorter routes. As described in the Factors affecting Fuel Burn section of Appendix 6: Interviews, the majority of the fuel consumed during a single flight occurs during take-off and climbing. When looking at average fuel consumed per distance (miles or kilometres), airlines that fly the longer distances seem to have better fuel efficiency per kilometre than airlines flying the shorter distances. As a result, if the product or service offered where to decrease fuel consumption during the take-off or climbing stages of the flight, airlines flying the shorter distance will experience a much better return and can be offered a stronger business case than those flying the longer routes.

A third example of a differentiating factor in the type of airline operations is the diversity of destinations. Airlines that operate at similar airports and in similar regions of the world require much less diversity in their fleet. Airlines such as WestJet and Southwest are operating a single aircraft type fleet. This offers them flexibilities in schedule, since all aircraft and all crew can fly to all destinations, which results in cost efficiencies in scheduling and labour. However, this flexibility has a side effect of limiting the types of experiments that can be designed to prove business cases. In such cases, it is impractical to implement a change to a few select aircraft or to train only a few crewmembers. The side effects of trying to schedule operations so that those few crewmembers are always flying those few aircraft at the selected destinations would make the experiment very costly and practically impossible.

As a result of the interviews, it is the recommendation of this paper that geographical location is in general not a good segmentation category for this market. Geographical location would only matter when regulatory approval is necessary for the suggested changes. If the change involves new technology and requires training the regulatory bodies in order to gain approval, interviewers suggested that a local airline who is the largest operator at a specific airport has the strongest chance at gaining such approval. Foreign operators and small operator are not likely to get access to a lot of time and resources from local regulatory bodies.

5: FLIGHT OPS ENGINEERING VALUE CHAIN

This section looks at the value chain that feed the needs of the flight operations engineering department. A competitive analysis is performed to determine the competitive environments for each of the main sectors that offer services to the flight operations engineering department. This understanding is then used in the next section to provide recommendations for new product development and market penetration strategies.

5.1 Value Chain

Within an airline's operation function, the flight operations engineering department is in charge of planning the details of the daily airline flight paths and procedures, and improving flight performance.

In order to understand the activities of the flight operations engineering group, we need to provide a short description of a typical flight procedure. A few days prior to each scheduled flight, the pilot receives a "pre-flight briefing" package. Based on the expected weather conditions, this package specifies not only the aircraft and flight path, but also such details as take-off weight and speed, optimal fuel necessary, and flight time. Hours before the actual flight, the pilot picks up the final "flight release" package and all the "NOTAM" (Notice to Airmen) associated with the flight route. At the time of flight, based on the actual conditions, the pilot will make all final decisions such as weight, fuel, flight path, and take-off speed.

In order to build the pre-flight briefing package, the flight operations engineering department has already built a set of predefined flight procedures. Each flight is divided into three parts: take-off, enroute, and landing. Each part of the flight will have associated flight procedures and charts for each aircraft type flown by that airline. In addition to the desired flight paths, there will also be safety procedures which are also the main drivers of the maximum take-off weight and the required take-off speed.

Figure 25 below depicts some of the inputs into flight operations engineering. This group selects the procedures, and is also in charge of monitoring and improving airline flight operations performance. Performance activities can be divided into two groups. First is the "static performance" analysis which involves looking at the existing set of procedures to improve performance. Typically, the goal would be to provide a noticeable improvement through a major change in one area (for example by changing the entire flight path to go between the mountains rather than around the mountains). The second type of performance improvement is through "dynamic performance" analysis, which would involve providing the pilots with more precise tools that allow more precise last minute optimization based on the actual weather conditions. This increased accuracy would allow the pilots to reduce the "buffers" that are added for safety, provide more consistency, and improve performance by small factors on every flight that would add up across many flights.

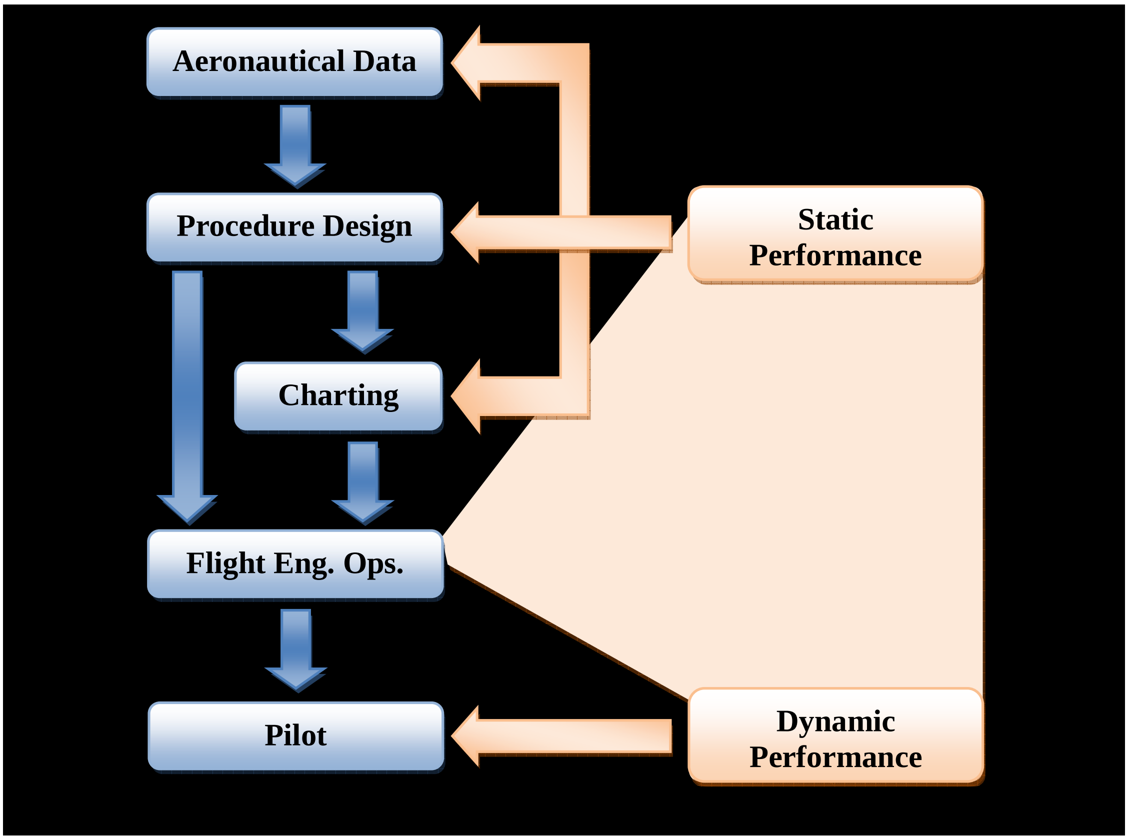


Figure 25 - Airline Flight Operations Engineering Value Chain (Wass, 2010)

Aeronautical data includes any physical and geographical data necessary for commercial flight. This includes obstacle data, terrain data, and data about navigational aids. Since commercial airlines fly very high en route altitudes, the data of interest to airlines is at the departure and arrival airports. This data can be owned and provided by a variety of parties depending on the country. Usually the data is owned by some type of government agency or by individual airports, considered “public” in nature, and provided for use close to free of charge. However, this public data tends to be too inaccurate to create the most efficient flight path. Increasing the accuracy involves incurring measurement costs on an on-going basis as construction occurs. To avoid these costs, safety buffers are added to the height of these obstacles that can be as large or even larger than the estimated obstacle height. The result is higher operational cost per flight due to the increased obstacle clearance that leads to a higher aircraft flight path, increased flight time, and fuel consumption.

The aeronautical data chart is then used to produce a number of standard flight procedures. Flight arrival and departure procedures calculate the safest and most effective flight path to and from each runway at an airport. There are many procedures for each airport to accomodate factors such as runway, direction of the wind, type of aircraft, and aircraft capabilities. Airlines can chose to fly "public procedures" provided by the national agencies or to develop and fly personalized procedures that must be approved by a national agency.

However, before a pilot can fly a procedure, it must be "charted". This activity involves turning the procedure data into a one page "chart" that graphically depicts the flight path and pertinent information. During the flight, the pilot carries a physical form of the procedure chart, which is used to fly the procedure path. The difficulty is that procedures are subject to constant change as aeronautical data and procedure development criteria are updated. As a result, most airlines incur the cost of charting and printing on a regular basis.

Procedure data, schedules, and flight paths are also used to plan daily airline operations and build pre-flight briefing and flight release packages for the pilot. In addition, the flight operations engineering department also has the responsibility to constantly monitor all of these activities and improve the overall performance of the airline's operations. In order to help with this activity, most airlines monitor operation cost at a very granular level through data gathering equipment on the aircraft itself.

Depending on the airline, the different activities in this value chain may be performed internally or outsourced. In general, aeronautical data, and charting are outsourced. On the arrival side, procedure design is mostly outsourced and generic. However on the departure side, most major airlines use tailored procedures, which, depending on the airline, is either done internally or with some consulting help. This difference is due to the fact on the arrival end, in order to ensure airway safety, the airport's air traffic controllers prefer that airlines follow the same generic flight paths rather than allowing airline specific flight paths. On the departure end, however, the airways have been cleared for the aircraft, and therefore, the pilot is given a lot more freedom to use tailored flight paths. Tailored departure flight paths mean more efficient operations on departure than arrival procedures.

Performance optimization is generally done internally as it is very specific to the airline's operations. There is a large array of software tools available to assist with data gathering, performance monitoring, and overall analysis.

Figure 26 below shows the estimated breakdown of the cost of each activity in this value chain to the average airline.

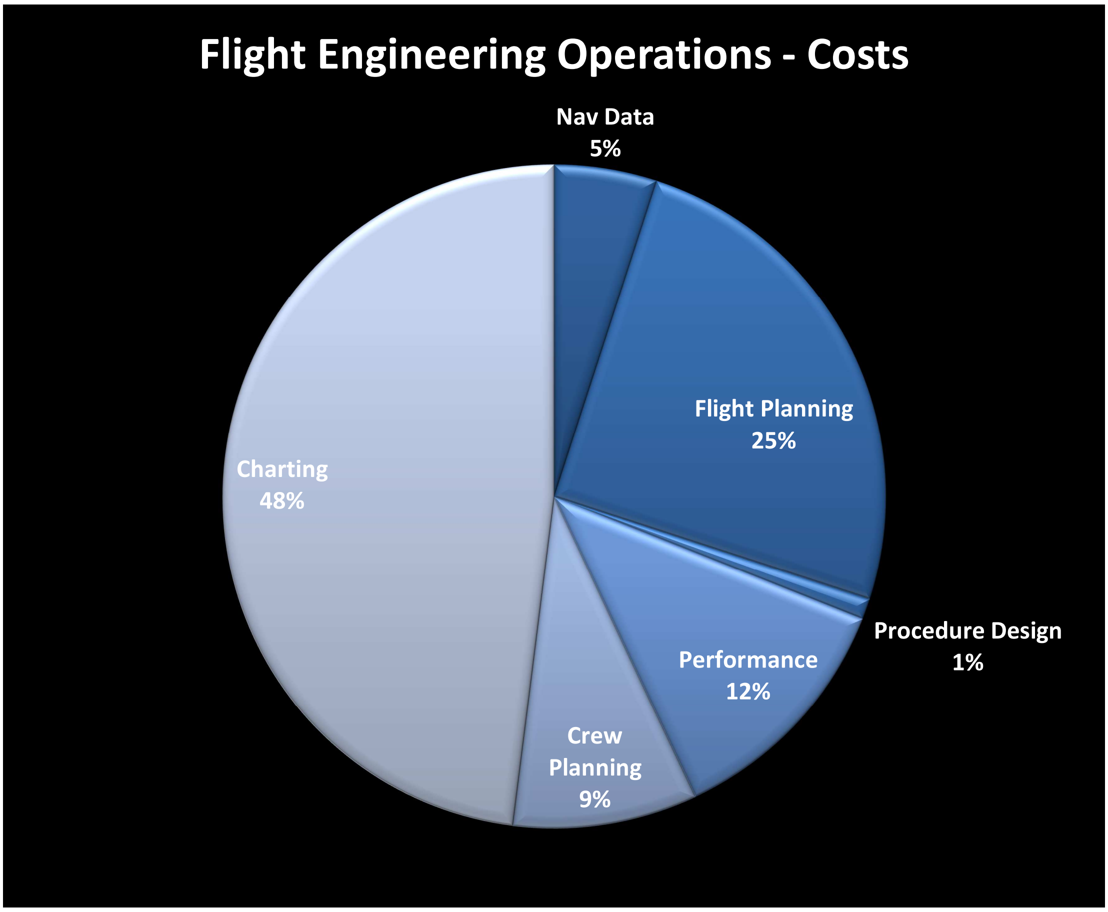


Figure 26 - Airline Flight Operations Engineering Cost (Wass, 2010)

Charting is by far the most expensive activity in airline flight operations engineering. There are two main reasons. First, procedures must be charted on a regular basis and therefore it is a recurring cost. Second, one supplier - Jeppesen has patented the graphical representation of procedure charts that has now become industry standard. As a result, it enjoys monopoly-like power in charting and extracts large rents from the airlines. The next section, **Error! Not a valid bookmark self-reference.**, analyzes the competitive landscape for this overall value chain and Jeppesen's position in more detail.

5.2 Competitive Landscape

This section uses Porter's Five Forces (Porter, 2008) framework (as described in section 2.1) to build an overall understanding of the competitive landscape within the value chain for the flight operations engineering sector of the global aviation industry.

The single most important aspect of any strategic analysis is first how we define our industry. Globally, many different standards, regulatory bodies, and levels of government intervention affect the aviation industry. Furthermore, airlines can be classified in many different ways according to size of operations, flight paths (long haul v. Short haul), or type of airline (low cost / high fare). However, all commercial airlines must perform flight operations engineering in one form or another. This section analyses how each of Porter's five forces are manifested for different types of airlines. In later sections, this analysis is used to decide how to segment the market to develop the most effective market penetration strategy.

5.2.1 Aeronautical Data – Public Agencies

Aeronautical data is mostly considered "public" data and provided close to free of charge by national agencies. Examples of such agencies include the United States Federal Aviation Administration and Canada's Nav Canada agency. The problem, however, is that the data is inaccurate. Safety is assured by adding large accuracy buffers that result in higher flight altitudes, more fuel consumption, and higher airline operating cost.

In some cases, when an airline is considering improving performance through tailored procedures, they can incur the cost of surveying specific areas or obstacles of interest to increase accuracy. While there are companies that attempt to act as aggregators of airline information (for example IAPA's Airport and Obstacle Database (oadb) (IATA, 2004)), this paper doubts the extent to which airlines participate in aggregation. Information sharing is voluntary and the tailored procedures based on this increased accuracy could be considered a source of competitive advantage.

Aeronautical Data	Impact	Comments
Threat of New Entry	Low	There has been no significant new entries in the past decade. Geographical areas are large and local details are constantly changing making collection of accurate data an expensive undertaking. At the same time, less accurate public data and procedures are provided to airlines free of charge. In order to convince airlines to pay for more accurate information, return on investment needs to be proven, which has so far been hard to do.
Power of Supplier	N/A	No suppliers
Power of Buyer	Low	The most procedure designers and airlines are able to do is lobby the government. So far, it has not been very effective.
Threat of Substitutes	Low	The only substitute is for procedure designers and airlines to measure their own data. Since the areas are large and constantly changing, this tends to be an expensive task that

		doesn't provide enough returns for one airline to perform.
Existing Competitor Rivalry	None	Usually this data is provided by a single public agency for each national or geographical area.

Table 2 - Aeronautical Data - Porter's Five Forces Analysis (Porter, 2008)

5.2.2 Procedure Design – Public Agencies / Internal / Consulting

Similar to the Aeronautical data public procedures are provided close to free of charge by public agencies. In Canada and the United States, the same agency that provides access to the public aeronautical data, also provide the public procedures. However, these public procedures tend to be very generic and completely independent of airline or overall flight path. In order to accommodate everyone, they tend to use very large clearance areas resulting in longer flight paths and increase airline operational costs.

In order to gain operational efficiencies, some airlines create tailored procedures. The activity of specialized procedure design is either performed internally or outsourced to third party firms. There are two types of procedure design firms. There are those firms that compete globally and are usually subsidiaries of much larger firms. These types of firms usually consider procedure design as a value added service to the products offered by their parent companies. For example, Naverus (GE Subsidiary), Quovadis (Airbus Subsidiary), and Jeppesen (Boeing Subsidiary) all compete against one another globally. On the other hand, there are lots of smaller firms that compete regionally. In general, both types of firms behave like consultants that help an airline improve multiple areas of performance including procedure design.

If procedure design was divided into three components of approach, departure, and enroute procedures, then airlines use mostly public procedures on the approach side and mostly tailored procedures on the departure side. As described previously, the main reason for this is the air traffic controllers' reluctance to allow tailored flight paths during approaches.

Procedure Design	**Impact**	**Comments**
Threat of New Entry	High	There are few barriers to entry. Companies performing procedure design are similar to consulting firms. Any person or group of people with procedure design experience can start a small firm and provide consulting type services to airlines based on reputation and personal connections.
Power of Supplier	Low	The suppliers are the aeronautical data providers that tend to be public agencies providing the information close to free of charge.
Power of Buyer	High	Airlines are large and have high bargaining power. Procedure designers tend to be much smaller than airlines, regional, and have to compete with the free public procedures.
Threat of Substitutes	High	About 80% of commercial flights use public procedures.
Existing	High	Competition is mostly based on reputation and personal

Competitor Rivalry		connections. Procedure design firms tend to be small.

Table 3 - Procedure Design - Porter's Five Forces Analysis (Porter, 2008)

5.2.3 Charting – Oligopoly

Charting is the process of producing a graphical representation of the procedure. Each firm that produces charts patents the symbols and layout used for this graphical representation. Since pilots are trained and get used to a specific representation, these patents create large switching costs for the airlines, and therefore, large entry barriers for competitors.

As a result, charting is an oligopoly with two main players owning over 90% of the market: Jeppesen (Boeing Subsidiary) and Lido (Lufthansa Subsidiary). Today, Jeppesen's graphical representation has become the industry standard, allowing Jeppesen to enjoy a very large share of this market (estimated at over 70%). (Wass, 2010)

Charting	Impact	Comments
Threat of New Entry	Low	Jeppesen has the patent on the graphical depiction of procedures that has become the industry standard. Since pilots are trained to read that specific depiction, it is very hard for anyone else to compete within this market.
Power of Supplier	Low	Suppliers are public agencies providing public procedures and data this is basically free of charge (about 80% of procedures flown and therefore charted) or a multitude of

		small procedure designers.
Power of Buyer	Low	Even public procedures must be charted before they are used by the pilot. As a result all airlines flying commercially will be needing this service.
Threat of Substitutes	Low	Pilots are trained to use charts to determine flight path. This retraining would be both costly and create safety concerns.
Existing Competitor Rivalry	Low	It's practically a monopoly.

Table 4 - Charting - Porter's Five Forces Analysis (Porter, 2008)

5.2.4 Flight Operations Engineering – Internal

In most airlines, the activities involved in flight operations engineering is performed internally using inputs from the different players in the value chain. Based on these inputs, the flight operations engineering department create the pre-flight briefing and the flight release packages for the pilot. They will then monitor performance and make continuous improvements.

5.2.5 Performance – Internal or Consultants

Airlines continuously monitor and try to improve the performance of their operations. Today all aircraft on most major commercial airlines are equipped with devices that take detailed measurements of aircraft performance, fuel consumption, flight time, and flight path.

Most of the same firms that offer procedure design and charting act as consultants in this area. The idea is that the consulting firm can help improve the overall airline performance by analysing the data and improving the flight paths. There are also a large number of software solutions offered in this area.

Performance	Impact	Comments
Threat of New Entry	High	Cost of entry and entry barriers are low. Consulting firms enter and exit the market regularly.
Power of Supplier	N/A	Airlines supply the data analyzed.
Power of Buyer	High	Consultants must convince the airlines that they will provide efficiencies higher than the cost of hiring them.
Threat of Substitutes	High	Airlines can do this internally.
Existing Competitor Rivalry	Medium	Competition is mostly based on reputation rather than price.

Table 5 - Performance - Porter's Five Forces Analysis (Porter, 2008)

5.2.6 Conclusion

The implications of the competitive landscape are summarized in Figure 27**Error! Reference source not found.** below.

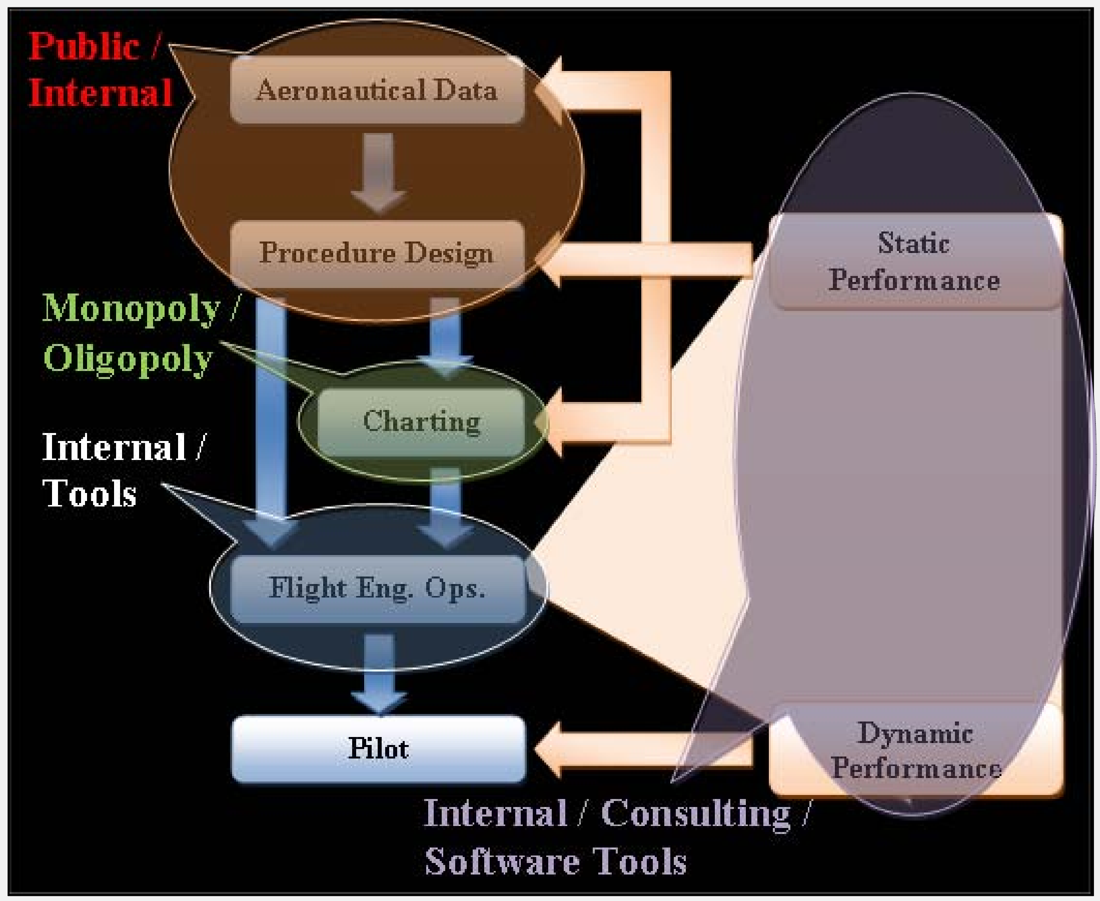


Figure 27 - Competitive Landscape Implications

Since aeronautical data and procedure design are provided in a very generic and non-accurate form by public agencies, the threat of substitutes is high while competition is very low. The challenge in entering the market in this sector, is to convince the airlines that they will experience substantial benefits by paying for data and procedures that are available publicly. As an oligopoly, charting enjoys very high margins, however, entry barriers are very high. The challenge in entering here is overcoming the airline's switching cost in adopting a new graphical format and planning for the threat of large competitor response. Flight operations engineering activities are mostly internal airline activities and entering in this sector would mean providing tools or consulting services. Finally, performance evaluation and enhancement is basically a consulting market with some highly domain specific software tools available.

6: PRODUCT STRATEGY

This section looks at a hypothetical product and recommends product characteristics and marketing strategies for successful market penetration. Because of the strategic nature of this product as well as the limited scope of this paper, the product is only discussed in terms of the characteristics of what it offers to the customer rather than how it will do so.

6.1 Marketing Mix

The term “marketing mix” was first popularized by Borden in his article “The Concept of the Marketing Mix”. (Borden, 1984) While Borden’s marketing mix includes quite a few different ingredients, McCarthy later grouped these into four categories that are today known as the “4 Ps of Marketing” shown in Figure 28 below. (McCarthy, 1978)

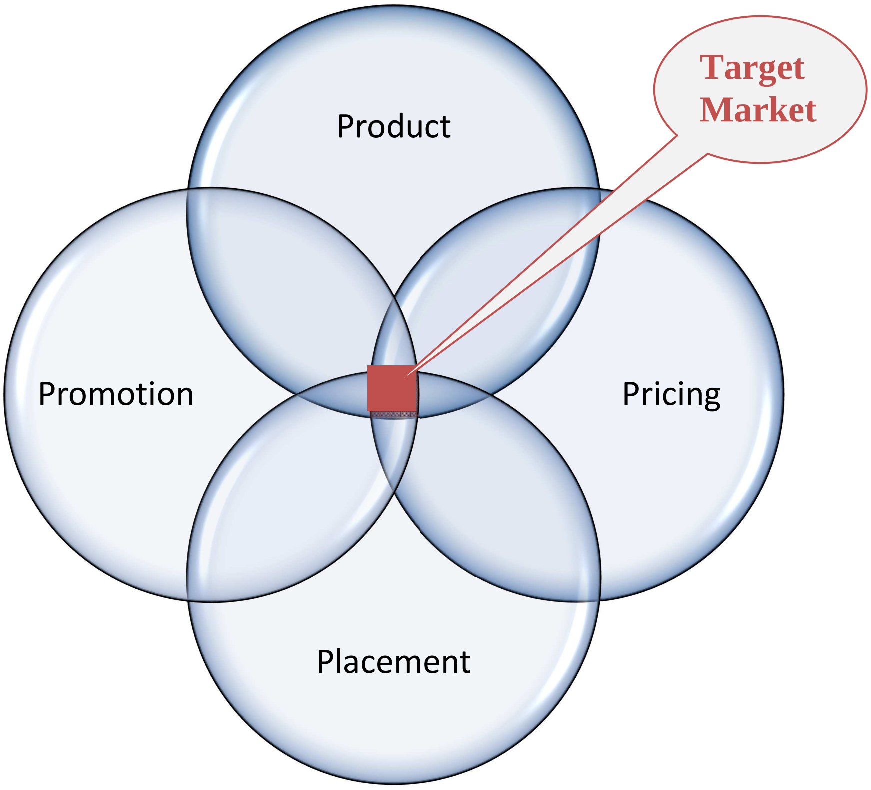


Figure 28 - The 4 Ps of the Marketing Mix adapted from (McCarthy, 1978)

This section describes each of these categories as well the positioning statement for the hypothetical product analyzed.

6.1.1 Product

"Company X" is offering "Product X" as a procedure design tool that would allow airline operators to design and modify operational flight procedures quickly and easily. The basic usage pattern is as follow. The airline operator can create a new or open an existing procedure using Product X and input parameters relating to the conditions at the time of flight. Based on these conditions Product X would re-evaluate the procedure, flag any safety concerns, and suggest efficiency improvements in the procedure. The operator would then respond to these concerns and suggestions to optimize the procedure for actual flight conditions.

Once the operator is satisfied with the procedure, she will then proceed to chart it using Product X. Each airline operator will have one or multiple templates to use for charting purposes. Product X will create a suggested chart using one of the saved templates. The operator will then optimize the chart by adding, removing, and adjusting the size and location of elements on the chart. The idea is to allow the user to customize the chart without affecting the accuracy of the information displayed. As such, actual flight paths and location of physical objects will be drawn to scale by Product X and will not be editable by the operator. On the other hand, cosmetic features such as colour, font, and additional information displayed on the chart will be customizable.

Note that Product X is not meant to replace the flight operations experts, but to give them more control. As such, Product X doesn't create or optimize the procedure or chart. It does the calculations necessary for optimization and provides the tools and capabilities for the expert to perform the optimization and create the resulting chart.

6.1.2 Positioning

"Design and chart flight procedures the way you calculate fuel and take-off weight"

In order to develop the positioning statement, it is necessary to understand the airline operator's usage model prior and post Product X. Figure 29 below depicts how airlines typically interact with their flight procedures.

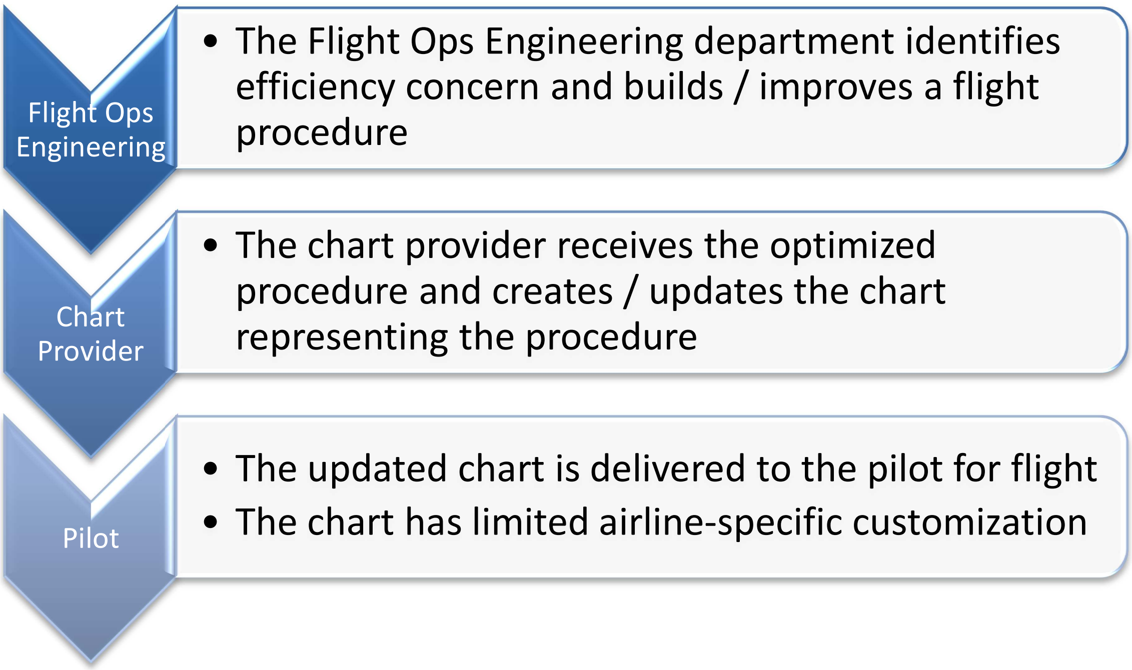


Figure 29 - Usage Pattern Prior to Product X

Once the flight operations engineering department delivers the updated procedure to the chart provider, it takes an average of about 2 months before the updated chart is delivered to the pilot for operational flight. As a result, these procedures are created to be somewhat generic – they will be safe under a wide range of flight conditions. The buffers required to ensure this safety make these procedures less efficient than optimal.

On the other hand, Figure 30 below depicts the usage pattern with Product X.

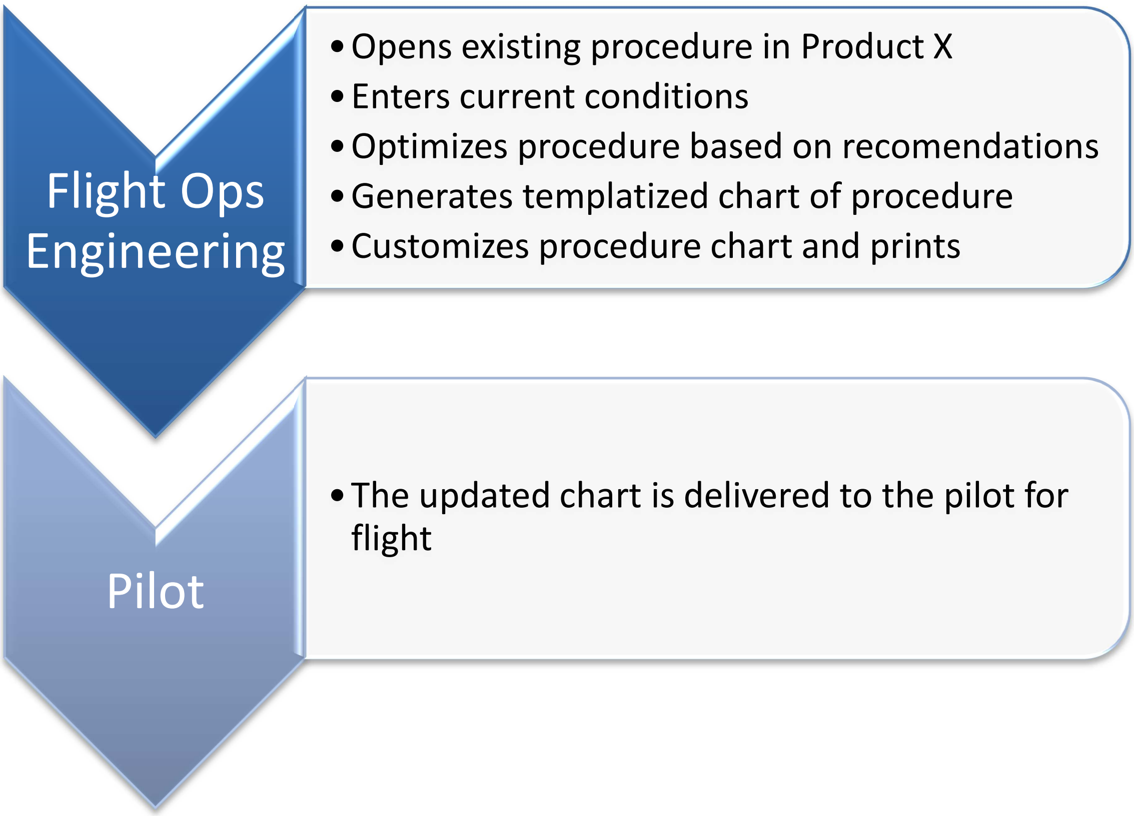


Figure 30 - Usage Pattern with Product X

Using Product X, the airline operator can optimize the flight procedure hours before the flight, rather than requiring months. Now procedures can be adapted to the actually flight conditions and buffers can be safely reduced. This optimization increases airline safety, agility, and efficiency.

This change in usage pattern is similar to how airlines have optimized the calculation of take-off weight and amount of fuel necessary. There was a time when airlines calculated the amount fuel necessary for each flight months prior to the scheduled flights. Since actual flight conditions were unknown at that time, the amount of fuel carried by each aircraft had to be high enough to cover the most pessimistic flight conditions in order to ensure safety. As airlines moved away from that model to adjusting calculations hours prior to flight based on actual flight conditions, they were able to create large efficiencies without compromising safety. Product X allows airline operators to experience efficiencies through a similar shift in flight procedure optimization.

Therefore, the positioning statement for Product X is as follows.

For airline operators **who want** to increase efficiency and agility in flight operations without compromising safety **our product is a** flight procedure design and charting tool **that provides** flight procedure experts the ability to optimize procedures and build customized flight charts **unlike** the traditional model of sending procedures to an external chart provider with a two months turn-around time **we have assembled** the tools necessary to allow internal flight operations experts to create, optimize, and customize flight charts within hours.

6.1.3 Pricing

Three pricing models were considered; one time licence, monthly subscription, pay-per-use. Of these three pricing models, the monthly subscription pricing model is recommended.

From the customer's perspective, the problem with the one-time-licence pricing model is that it creates a high up-front investment at the time of procurement when the actual returns to that specific operator are still unproven. The problem with the pay-per-use model is that the actual cost becomes hard to predict. It becomes a problem from a budgeting and forecasting point of view.

From Company X's perspective, the problem with the one-time-licence pricing model is that it limits recurring revenue and the ability to offer value-added options. The problem with the pay-per-use model is that it creates a disincentive for the customer to use the product and makes it harder to forecast revenues each month.

The monthly-subscription pricing model lowers adoption barriers by decreasing the initial investment required by the airline operators. Costs and revenues are predictable from the perspective of both the customer and Company X. An option to cancel the subscription with a few months' notice would minimize the risk of unfavourable returns for the airline operator and further remove adoption barriers. As Product X is enhanced with value added options over time, this pricing model allows trial pricing, bundling, and segment specific pricing.

In terms of actual price range, Product X should be priced so that adopting airlines can experience positive returns in the same financial reporting period. This will promote further adoption of Product X, both in the airline that has adopted it and throughout the airline industry. Since actual prices should be based on expected returns from the increased efficiencies enabled by Product X, it is extremely hard to predict price ranges at this time and beyond the scope of this paper.

6.1.4 Launch Strategy- Placement, Promotion, and the Role of Early Adopters

The airline industry is characterised by inertia due to high fixed costs and interconnectivity of systems that necessitate standards, while at the same time remaining highly competitive. In such an environment, change is hard to initiate but when the value of a business case is demonstrated, adoption happens quickly. The key to successful product adoption revolves around reputation, relationships, and word of mouth. Company X must start by building a deep relationship with one or two major airlines in the industry. The main goal at this stage is to demonstrate the business value of investing in Product X and to build a reputation around quality, safety, and responsiveness. The choice of early customer is important. They must be an early adopter who is also a credible reference for the majority market.

When the first airline's financial statements demonstrate the efficiencies gained through the adoption of Product X, there will be a large increase in demand for this type of product. It is important for Company X to be ready to grab as large a market share as possible early on. In order to do this, areas such as sales, production, support, and customer adoption must scale quickly. It will be the slowest link in the overall demand generation and fulfilment chain that will determine Company X's overall market share and its ability to be the market leader.

In terms of controlling variable cost and speed of delivery, Product X should be designed to allow each airline to easily customize charts themselves with little involvement from Company X. This can be done by adopting a "mass customization" strategy where desired chart elements are created as independent modules that can be easily added, removed, or cosmetically customized by the airline operator experts. In this case, an additional customer at-most requires the addition of "new modules" and with each new customer the likelihood of such request decreases. Such strategy creates economies of learning where the variable cost of additional customers decreases over time and entry barriers are elevated for would-be competitors.

Furthermore, Company X can prepare to meet market demand through a highly scalable back-end design and a streamlined product adoption process. By the time the efficiency gains of Product X are proven, Company X should have developed a process for the smooth transition of an airline's existing procedures into Product X. This process should document, not only internal activities within Company X, but also the activities and operational changes necessary at the airline operator in order to experience the efficiencies from Product X.

6.2 Market Penetration

There are two dimensions for segmenting the market to increase adoption rate; procedure type and type of airline. In terms of procedure type, Company X should first focus on areas with the lowest barriers of adoption and the highest returns. As depicted in Figure 31 below, the focus should first be safety procedures such as one-engine out, then departure procedures -- leaving en-route and approach procedures for the very end.

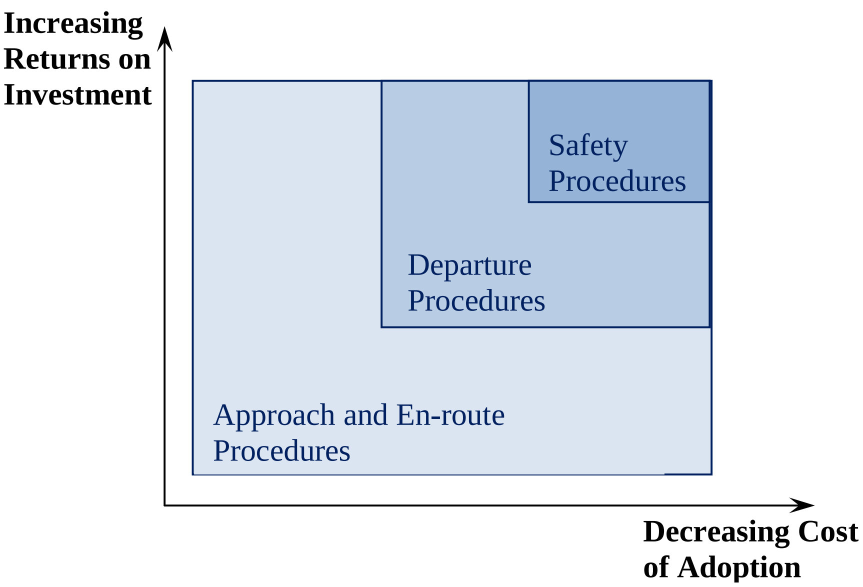


Figure 31 - Product X Procedure Types

In the above diagram, an airline's cost of adoption is based on three factors; existing in-house expertise, necessary regulatory and air traffic controller cooperation, and current airline operations. In terms of in-house expertise, airlines use mostly public approach and en-route procedures, some tailored departure procedures at “problem airports”, and almost all tailored safety procedures such as one-engine out procedures. As a result, airlines have the highest level of in-house expertise in safety procedure development and some expertise is developing departure procedures.

Furthermore, development, optimization, and operational use of safety procedures require the least amount of involvement from regulators and air traffic controllers. Departure procedures require regulatory approval but little involvement from air traffic controllers. On the other hand, approach procedures require both regulatory approval and air traffic controller authorization.

Finally, airlines don’t usually have safety procedures formally charted by their charting company. In most cases, they print a basic version themselves and provide it to the pilot. As a result, such procedures would require the least amount of process and behavioural change from the airline.

Based on these three factors of in-house expertise, third party involvement, and existing airline operations, airlines will experience the lowest cost of adoption with safety procedures and then departure procedures. Other procedure types such as approach and en-route procedures will experience the highest cost of adoption.

The return experienced from each procedure type is based on the airline’s ability to create operational efficiencies by adapting that procedure type to actual flight conditions. Safety procedures are used to calculate the limits of aircraft performance. These procedures dictate the maximum take-off weight and the amount of fuel to be carried by the aircraft at the time of flight. Since these are some of the most important factors in aircraft performance and operational efficiency, returns from safety procedure optimization are likely to be the highest. On the other hand, since the highest rate by far of fuel burn is at take-off and during climbing, optimizing departure procedures is also likely to provide larger efficiencies and higher returns than optimizing approach and en-route procedures.

The second dimension of market segmentation is the type of airline. As discussed in the Conclusion subsection of section 4: Flight Operations Engineering Market, airlines should be segmented first based on operational maturity, then the airline's structure and culture, and finally based on the type of operations and geography. Airlines with mature operations are more likely to spend resources improving efficiencies in flight operations engineering. The airlines' structure and culture will dictate how easily they can change internal processes to create efficiencies based on the capabilities offered by Product X. The type of operations (regional, long-haul, etc) and geographical location will dictate the extent of the impact that such localized efficiencies will have on overall airline costs.

When the market is segmented based on the two dimensions of procedure type and type of airline, a bowling pin market penetration model (Moore, 2002) can be developed as demonstrated in Figure 32 below.

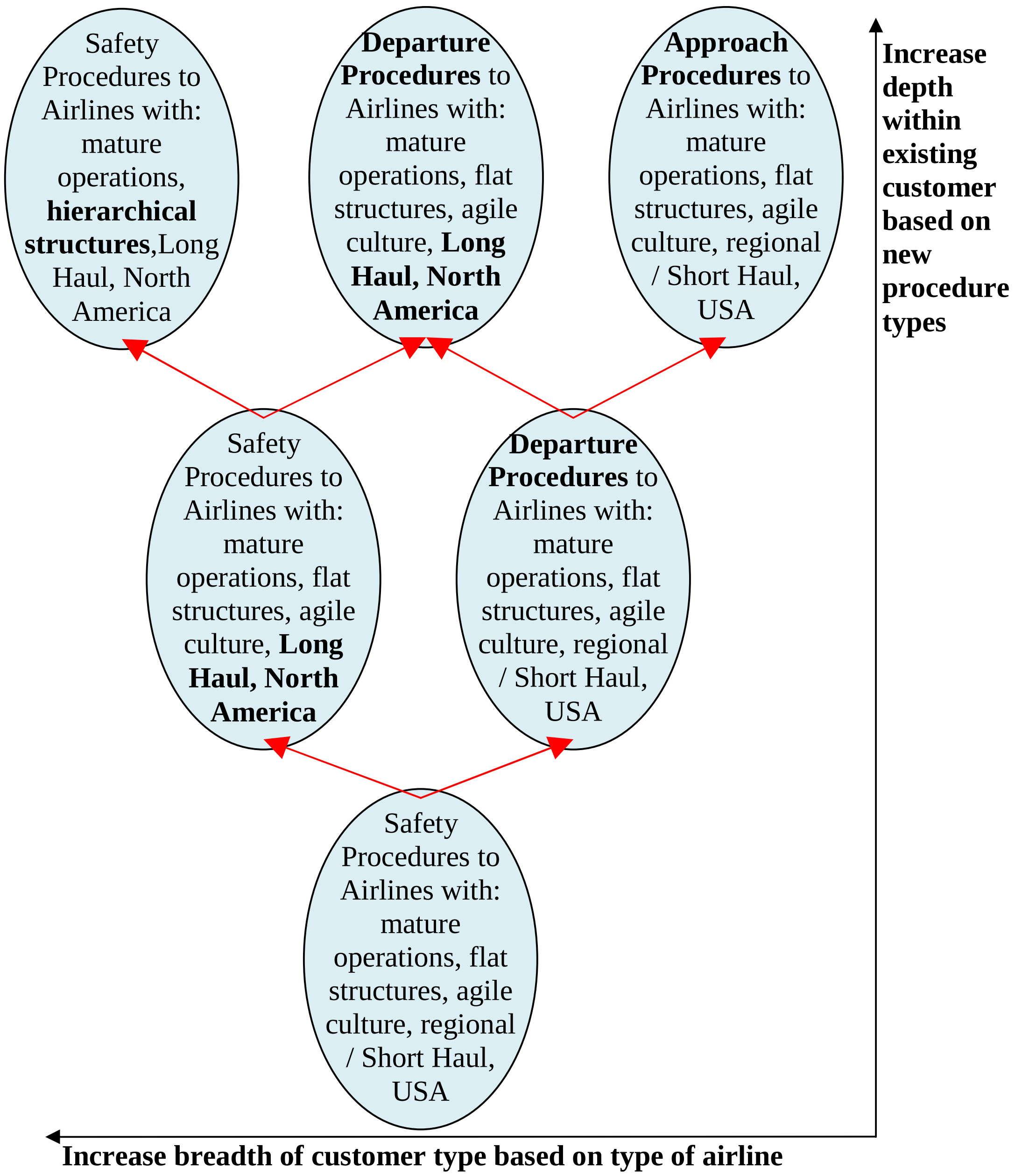


Figure 32 - Market Penetration Strategy

As Company X develops a deeper relationship with its initial customers, it can sell deeper within that company by promoting the adoption of Product X for additional procedure types. Furthermore, as the efficiency gains from the adoption of each procedure type is proven, Company X can increase the breath of its customers by expanding customer types as illustrated in Figure 32 above. In this way, each successful product feature creates an opportunity to engage a new customer, and each success customer relationship creates an opportunity for deeper sales.

6.3 Business Model Disruption

Current charting solutions are evaluated on the dimensions of perceived quality and cost. Perceived quality is based not only on the quality of the information provided, but also the relevancy of the information presented to the airline's operations, the depiction of that information, the ease-of-use in reading it, and the extent to which the depiction has become an industry standard. The cost of the charting solution takes into account the overall cost to the airline, which includes not only the cost of acquiring the charts, but also the cost of maintenance and renewal.

Product X offers airlines new dimensions of responsiveness, agility, and control in procedure development and charting that existing offerings are unable to provide. By changing turn-around time from months to hours, it allows airlines to use in-house expertise to tailor procedures to daily flight conditions. On the other hand, as a new player in this market, Product X will not compare well on the existing dimensions of valuation. While the new dimensions offered by Product X allows airline operators to create efficiencies in flight operations, the lack of the value added services currently offered by existing charting companies can be a significant draw back.

With respect the Christensen's disruptive technology model introduced in section 2.2, Figure 34 below illustrates the current market conditions and Product X's possible trajectory.

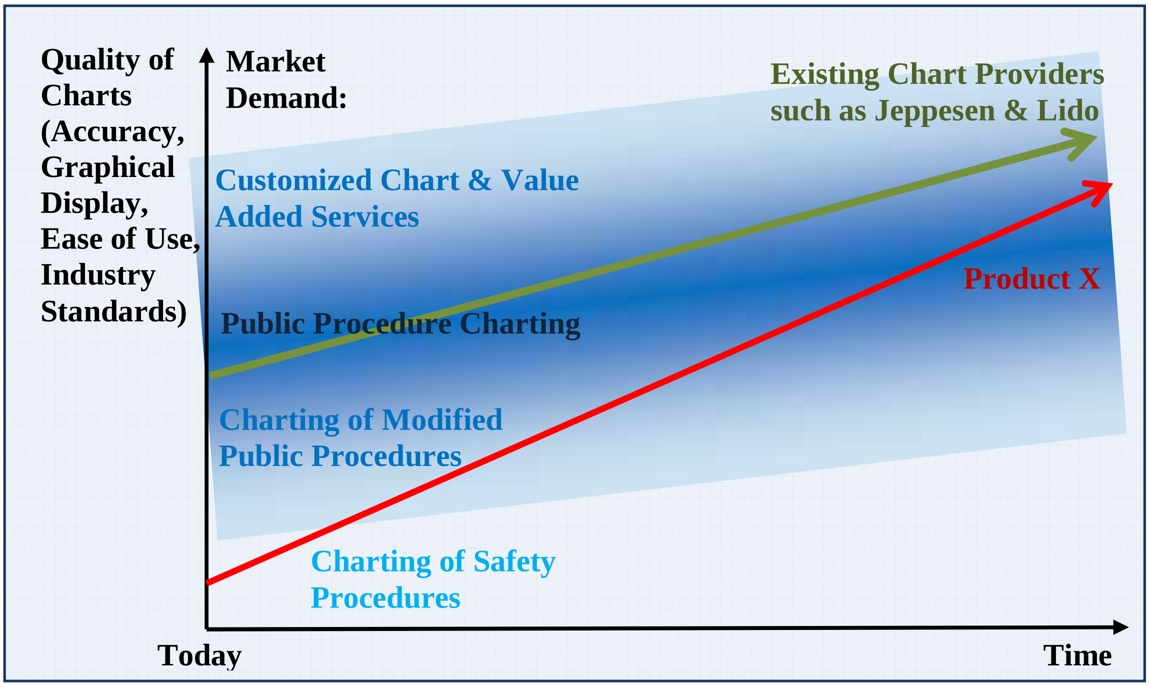


Figure 33 – Product X's Possible Disruption Trajectory (Christensen, 1997)

If we consider charting as the overall market, then the mainstream market is currently interested in charting public procedures. Existing players such as Jeppesen and Lido are moving higher in the market by providing value-added services such as the delivery and replacement of charts on board operational aircrafts and minor customization of charts. However, current providers are not satisfying the market for truly tailored procedures such as safety procedures. Airlines tend to create crude versions of these charts (often no more than a set of instructions) and provide that to the pilots.

In this model, Product X has the potential to disrupt this market by entering at the lower end of the market to satisfy the needs related to charting safety procedures. Since these procedures are not usually formally charted, Product X will not be taking market share away from existing players – at least not at first. Since the market is small, large competitors are not likely to be interested or threatened. As the charting capabilities of Product X improves over time, airlines are more likely to use it for other charting needs, especially if they are already using it in-house. Furthermore, as airlines experience the value of the agility and control offered by Product X, they are more likely to value these criteria in all their charting needs. In this way, Product X begins to move upstream and disrupt the mainstream market.

Next, if we look at Product X from the Blue Ocean Strategy introduced in section 2.3, we can compare Product X's value curve to that of existing offerings as shown in Figure 34.

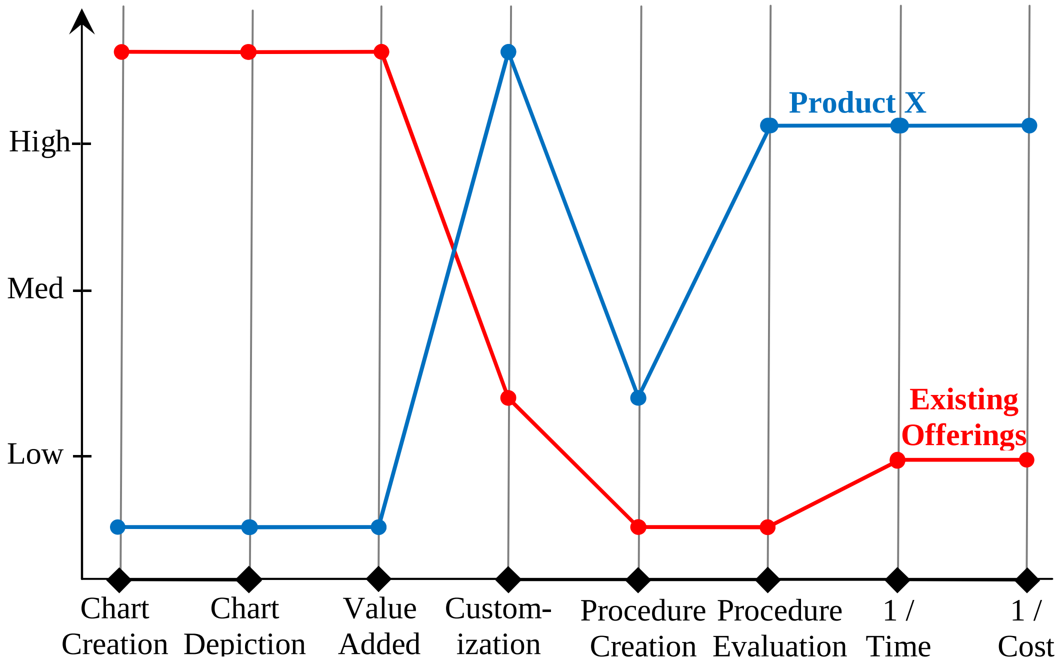


Figure 34 - Product X Value Profile

As demonstrated, Product X offers quite a different value profile than existing competitors. Product X is attempting to create a new market for airlines that want agility, control, and responsiveness. One of the main differences of this value profile is the placement of expertise. With existing competitors, the charting expertise resides with the service provider and the chart provided is a result of that expertise. With Product X however, all the expertise resides with the airline operators. Product X provides the tools to create, update, and analyze procedures and charts, but assumes that the user will have the expertise of how to create and optimize such procedures. It is a "do it yourself" model that provides the airline independence from third party providers.

The main problem with Product X's strategy is how to protect market share and secure a dominant position once this business model is proven. The best option is to create entry barriers for new entrants. Company X can attempt to create entry barriers through economies of learning and network effects. Economies of learning can be created by implementing a feedback loop that constantly collects information about usage patterns and improves Product X's value. This is discussed in more details in section 6.5 Product Development. Network effects will be harder to create. One way of creating network effects is for Company X to use its growing customer base to increase its negotiating power with regulators. For example, a feature that would allow airlines to submit procedures for regulatory approval directly through Product X and reduce the turn-around time for such approvals will greatly increase the value of Product X and create entry barriers for new entrants.

6.4 Competitive Analysis

While the previous section mentioned why existing competitors are not likely to be threatened by Product X's entry in the market, this section analyzes their ability to respond and compete with Product X. The main problem for existing competitors is that Product X's differing business model requires quite different capabilities. Company X's competency lies in developing software tools while existing competitor's competencies revolve around their expertise in building charts.

Figure 35 below illustrates the dimensions of a company's core capabilities (Leonard-Barton, 1995).

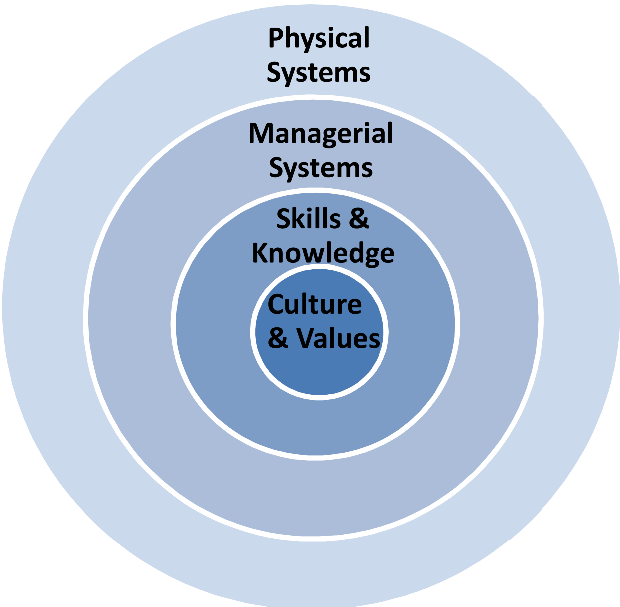


Figure 35 - Dimensions of Core Capability adapted from (Leonard-Barton, 1995)

In order to compete based on a different expertise, existing competitors will have to, at the very least, change the domain of their skills and knowledge. Furthermore, in order to be successful in this new business model, they will likely have to change the basis of their value system to value software development skills at least as much as domain knowledge, their managerial systems to grow and promote the new skill sets required, and their physical systems to accommodate such change.

Adapting to compete within Product X's new business model would require existing competitors to change at every level of current operations, forcing them to redefine what they are good at and what they value. This depth of change is extremely difficult to achieve and the unlikely cases of success usually take a long time.

6.5 Product Development

Based on the analysis of the previous sections, this business venture has four main characteristics that must be satisfied when planning for the development of Product X. These are:

1. **New Market:** as described previously, Product X is attempting to create and grow a new market with a different business model. Product development must recognize that the definition of its target market and the identification of the characteristics of this market are merely assumption and should be continuously monitored. It is important to be prepared to react and adjust quickly.

2. **New Product Type:** means that the usage model of Product X is unknown. One of the largest assumptions that product development will make is to decide which features of Product X will be most useful and in what order the user will want to operate the system.

3. **Scale and Variable Cost:** given the disruptive strategy, Product X's customer size is likely to grow rapidly. It is therefore important to build the product in such a

way as to scale seamlessly and decrease the variable cost of additional customers. This will allow Product X to meet market demand while ensuring good profit margins.

4. **Create Economies of Learning:** in order to create entry barriers against potential new competitors, the development of Product X should create a large learning curve for new entrants by continuously improving Product X based on knowledge gained from experience.

To satisfy the above four characteristics, Product X's architecture should be highly scalable, modular, and contain a feedback loop that monitors and reports usage patterns. A scalable nature would accommodate fast growth in the number of customer and allow Company X to meet the demands of a growing market. A modular architecture would allow features to be added and modified independently; allowing Product X to implement knowledge gained from the market quickly and be more responsive. A feedback loop would allow Company X to learn from its existing customer base in a non-intrusive manner.

Furthermore, an overall product map can be used to prioritize future features as market knowledge is gained. Small and iterative release cycles would allow Product X to test assumptions, learn from its customers quickly and respond to the market needs using a probe and learn strategy of product development.

7: CONCLUSION

This section provides a summary of the findings of this paper and suggestions on future work.

7.1 Summary

Today's global airline industry suffers from excess capacity. Furthermore, their main stream consumers see the products offerings as relatively undifferentiated. As a result, the dominant competing criteria for its consumers is price. Additionally, ticket pricing can, in some cases, be well below operational cost, not only because of excess capacity, but also because airline tickets are non-durable goods and the marginal cost of filling an additional seat is close to zero. The eventual result is an extremely competitive environment. Aggravated by the rising cost of jet fuel, the global airline industry is suffering from extremely low returns. In fact, in the past decade, almost all airlines have experienced negative returns, not even being able to cover their cost of operation. This has resulted in bankruptcies and consolidations as exemplified by the KLM and Air France merger or the United Airlines and Delta merger.

Since this competitive environment is fairly consistent across geographic regions and type of operations, it is rarely possible for an airline to improve returns by growing its market through increased product offerings related to routes or destination. Since expansion will probably result in larger negative returns, airlines must focus on improving returns by reducing the cost of operations. Since most initiatives that result in efficiency gains are relatively easy to emulate, competitive advantages gained through reducing cost are short lived. On the other hand, in such a cost competitive environment, airlines that are not constantly improving their operational efficiency will no longer be a going concern. Therefore, a new product or service that can provide operational efficiencies to airlines is likely to experience very high adoption rates once the returns have been proven.

Airlines can increase efficiency in many aspects of their operations including scheduling and labour costs. In terms of technology based product innovation, the one area of airline operations that is most likely to experience the most benefit from improved technological capabilities is the flight operations engineering department within airlines. With the business objectives of “first safety, then efficiency”, this department focuses on three main types of activities. First, they measure the performance of flight operations at an extremely granular level, in most cases, recording over 40 parameters for each flight. The reason is that the improved accuracy and granularity of what is monitored provides the ability to reduce safety buffers allowing improved operational efficiencies without sacrificing safety. Second, the flight operations engineering groups is constantly optimizing and adjusting daily operations based on the implications of the changes in the parameters they monitor. The third set of activities revolves around planning and implementing initiatives to increase operational safety and efficiency.

In order to perform these ongoing activities, the flight operations engineering department relies on external vendors. Figure 36 below illustrates this market’s value chain together with its implications as described in the industry analysis section.

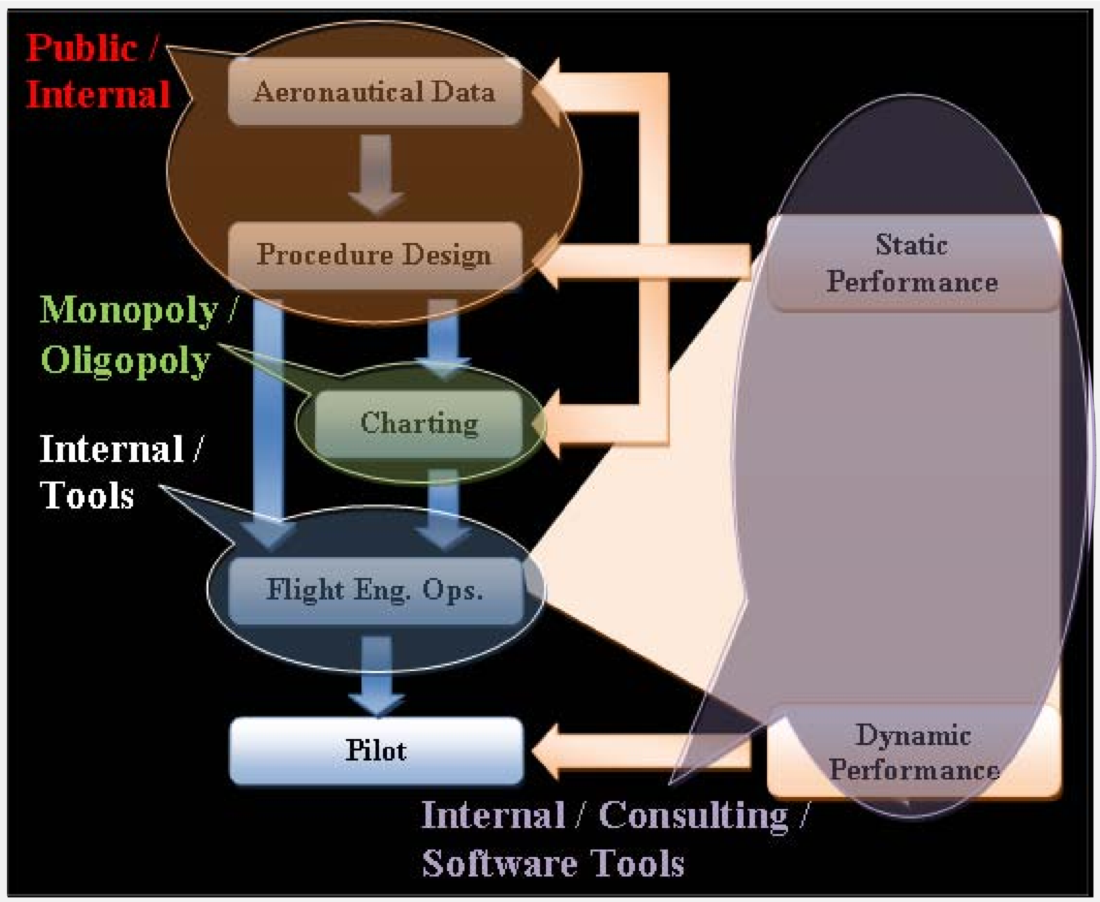


Figure 36 - Value Chain Implications

As illustrated in the above figure, aeronautical data and procedure design is usually provided by public agencies and regulatory bodies. Airlines use this public data the majority of the time. However, when the flight operations engineering department deems that efficiencies can be gained by tailoring the specific flight procedure, the activities involved in doing so are mostly done internally within the department.

Pilots use charts to fly intended procedures. Globally, charting is currently a duopoly with Jeppesen and Lido owning over 90% of the market in commercial aviation. At a regional level, Jeppesen holds a geographical monopoly in North America, and Lido a geographical monopoly in Europe.

Under these market conditions, Product X has the potential to disrupt the market for charting procedures by competing based on a different business model. Rather than owning the charting expertise and selling finished charts, Product X allows airline operators to use in-house expertise to build and publish the charts themselves. This new business model not only lowers the airline's charting costs but also offers much shorter turn-around time. The decrease in the time required to update and publish new charts provides operators with the ability to tailor procedures to actual flight conditions and thereby reduce the need for safety buffers and increase operational efficiency.

7.2 Future Work

This paper is strategic in nature and attempts to offer neither tactical nor operational recommendations. Some of the next steps to building Product X are:

- An analysis of the actual competencies of Company X compared to the competencies required to build and deliver Product X. The gaps should be identified and recommendations should be provided.
- A business case analysis of the order of magnitude of the cost and resource requirements for this business venture compared to the potential returns
- A technical solution and prototype of Product X
- Implementation and delivery plans complete with schedule and resource allocation

APPENDICES

APPENDIX 1: HUB AND SPOKE NETWORK

Prior to deregulation carriers were assigned linear routes, usually with intermediate stops. Post deregulation, specific airports were designated as “Hubs”. As a result, airlines are able to increase capacity utilization since any specific flight is now serving not only passengers with that destination, but also passengers with connecting destinations. Lastly, this model allows airlines to further increase their product range by forming partnerships with other airlines that service different “spokes” from the same “Hub”. This new system of hub and spokes has increased capacity usage and decreased airlines’ costs. As expected, the competitive nature of deregulation lowered ticket prices, which combined with economic growth and increased consumer affluence to produce in large increases in air traffic.

However, since airspace capacity at “Hub” airports is limited, a major side effect of increased air traffic has been congestion at these airports. Furthermore, since this Hub and Spoke system is highly connected, problems at one “Hub” airport can have large repercussions through the whole system. As air traffic is diverted from one busy Hub airport to another, the problem ripples throughout the whole system. A good example of this problem is the April 2010 Iceland volcanic activity that severely affected air traffic through Heathrow Airport (London, England) and practically crippled global air travel (Queensland Newspapers, 2010).

APPENDIX 2: ICELAND VOLCANO ASH CLOUD CHOKES GLOBAL AIR TRAVEL (QUEENSLAND NEWSPAPERS, 2010)

The Courier-Mail – April 16 2010 8:25 pm –

THOUSANDS of Queenslanders have been stranded at airports around the world or had their holiday plans thrown into chaos as the impact of a volcanic eruption in Iceland spreads across the globe.

Major Asian hubs including Singapore and Bangkok have been swamped with stranded travellers after the cancellation of connecting flights in the biggest shutdown of airspace since the terrorist attacks of September 11, 2001.

Qantas cancelled all five flights to Heathrow on Friday and one to Frankfurt, leaving more than 1000 people uncertain as to when they could start their European voyage.

A further 1000 passengers were stuck in Singapore, and about 350 each in Hong Kong and Bangkok as people heading to Europe found their connecting flights had been cancelled. They are likely to be stuck there in transit for several nights.

Qantas group executive David Epstein said most European airports were likely to be closed at least until Sunday.

Qantas has five flights a day to Europe, which means a further 2000 people could be affected by flight closures out of Australia this weekend.

Singapore Airlines' public relations manager Susan Bredow said passengers with onward connections to Europe should stay at home rather than head to the airport.

"The concern about people going up to Singapore is that, from what we understand, Singapore hotels are pretty much at capacity," she said.

"Until we get some sort of clarity as to when those airports are going to open again, we don't want people just to go off and not to complete their journey."

Scientists have warned that Wednesday's eruption at the Eyjafjallajokull glacier could be a preview for a series of eruptions, with more magma being jetted into the air refuelling the cloud. The last time this volcano erupted, in 1821, it lasted two years.

New Scientist editor Roger Highfield said of the spewing cloud: "It could be hours or days, perhaps months or even longer."

Singapore Airlines also cancelled seven flights, including two from Singapore to London, with 2200 passengers affected, although none of its flights leaving Australia were cancelled.

Other airlines to have cancelled flights include Malaysian Airlines, Emirates and Cathay Pacific. Passengers have been told to check with their airline's website before heading to the airport.

The 10km-high plume of ash has affected millions of air travellers, with much of Europe shutting its airports. The number of flights cancelled worldwide is about 6000.

Countries that shut all their airports include Britain, Ireland, Denmark, Norway, Sweden, Finland and Belgium. Germany and France closed some of their major airports.

But there was some cheer for travellers as Sweden tonight began to gradually reopen its airspace and UK authorities allowed some domestic and North Atlantic flights to and from Northern Ireland and some parts of Scotland.

Professor Richard Arculus, a volcanologist from the Australian National University, said ash was a particular hazard to aircraft as was discovered in 1982 when a British Airways 747 flew into a plume from Galunggung volcano in Java.

All four engines failed, and pilot Captain Eric Moody had to glide the plane for 14 minutes before he could restart them.

APPENDIX 3: AIRLINE STRUCTURE

Air Canada (Cogmap, 2009)

From Air Canada’s organizational chart the following deduction can be made about their organizational and functional structure.

CEO

Executive VP & COO **(Operations)**

Executive VP & Chief Commercial Officer **(Sales & Marketing)**

Senior VP, E-Commerce, & CIO **(Reservations & Ticketing)**

Senior VP Employee Relations **(HR – Administrative)**

Executive VP & CFO **(Finance – Administrative)**

VP & General Counsel **(Legal – Administrative)**

VP Corporate Communications **(PR – Administrative)**

APPENDIX 4: US AIRLINE DATA 2000-2008

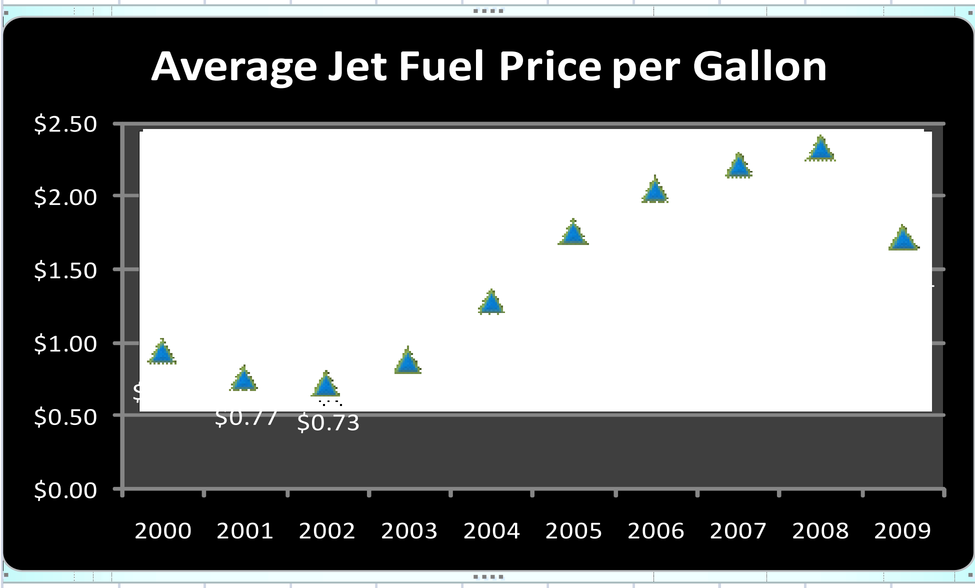
Operating Income (Massachusetts Institute of Technology, 2009)

Airline	2000	2001	2002	2003	2004	2005	2006	2007	2008
AMR Corp	1,381	-2,470	-3,330	-844	-134	-89	1,060	965	-1,889
Continental Airlines Inc	729	144	-330	188	-238	-39	468	687	-314
Delta Air Lines Inc	1,637	-1,602	-1,309	-785	-3,308	-2,001	58	1,096	-8,314
Northwest Airlines Corp	569	-868	-846	-265	-505	-919	740	1,104	-5,564
UAL Corp	654	-3,771	-2,837	-1,360	-854	-219	447	1,037	-4,438
US Airways Group Inc I	-53	-1,683	-1,317	-251	-378	-	-	-	-
US Airways Group Inc II	-	-	-	-	-	-	558	533	-1,800
America West Holdings Corp	-13	-411	-159	22	-44	-	-	-	-
Total Network	**4,904**	**-10,661**	**-10,128**	**-3,295**	**-5,461**	**-3,267**	**3,331**	**5,422**	**-22,319**
Average	**700.6**	**-1523**	**-1446.9**	**-470.7**	**-780.1**	**-653.4**	**555.2**	**903.7**	**-3719.8**
Southwest Airlines Co	1,022	631	341	379	404	725	934	791	449
JetBlue Airways Corp	-21	27	105	167	111	48	127	169	109
AirTran Holdings Inc	81	7	31	86	30	23	41	138	72
Frontier Airlines Holdings Inc	81	16	-31	27	-26	-8	-10	-35	-47
Total Low Cost	**1,163**	**681**	**446**	**660**	**518**	**788**	**1,092**	**1,063**	**583**

Carriers									
Alaska Air Group Inc	-33	-126	-93	-18	6	167	-87	212	-129
Hawaiian Holdings Inc	-14	17	-56	-15	-7	2	1	7	92
Midwest Air Group Inc	7	-38	-54	-30	-45	-65	1	-	-
Total Other	**-40**	**-148**	**-204**	**-63**	**-47**	**103**	**-86**	**219**	**-37**
Total	**6,027**	**-10,128**	**-9,886**	**-2,698**	**-4,990**	**-2,376**	**4,337**	**6,704**	**-21,773**
Average	**430.5**	**-723.4**	**-706.1**	**-192.7**	**-356.4**	**-198**	**333.6**	**558.7**	**-1814.4**

APPENDIX 4: HISTORIC PRICE OF JET FUEL (UNITED STATES GOVERNMENT, DEPARTMENT OF ENERGY, FEDERAL STATISTICS, 2010)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Average	$0.94	$0.77	$0.73	$0.88	$1.28	$1.75	$2.03	$2.21	$2.32	$1.71



APPENDIX 6: INTERVIEWS

Interview Methodology

The purpose of the interviews performed for this project is to gather current market and industry information. The goal was not necessarily to achieve accuracy in the data collected but to gain a better general understanding of the industry and to confirm assumptions. For this reason, two decisions were made. First, interviewees were picked from different sections of the value chain as well as a wide range of geographical locations. Second, the interview questions were purposefully designed to be very open ended and generic. The idea was to remove any assumptions from the questions and not to lead the interviewee in any way. A few more specific interview questions were created, but those were only asked if the interviewee approached that specific subject themselves. The interview questions are listed in the next section.

The interviewees for this project were kind enough to offer their time and agree to be interviewed. However, these interviews were not officially authorized by the company that the interviewee works at, and therefore, the opinions expressed during the interviews were solely those of the interviewee and not necessarily representative of the company. Furthermore, due to the informal nature of these interviews, interviewees specifically requested not to be directly quoted. In order to accommodate this request and to ensure that comments are not misused, misrepresented, or taken out of context, the result of these interviews are presented only in aggregate form.

The remainder of this appendix lists the interview questions, the interviewees, and the aggregated result of the interviews.

Interview Questions

Three main goals were identified for the interview activity:

1. Understand how operational efficiency is measured
2. Identify current pain points
3. Understand the decision process

Interview questions were designed to guide the conversation towards the above topics without leading the interviewee to any specific answer or conclusion. In very general terms, interviews were structured in the following way:

Introduction

Since the interviewees had little previous knowledge of the interviewer, the interview always started with a short summary of this project, and the purpose of the interviews. The interviews were thanked for them time, and assured that they would not be individually quoted.

Measure

The interviewees were asked, in their opinions, what are the business objectives of the flight operations engineering department of airlines. Based on their answers, the next questions would ask how these objectives are measured, tracked, and reported.

Pain Points

Next, the interviewees were asked, in their opinions what were the biggest impediments in achieving the above business objectives. When problems were identified, interviewees were then asked why they thought the problem existed, and what would have to change for the problem to be removed or improved. Finally, the interviewee would be asked what changes they see happening and what they would change, if they could.

It should be noted that while most interviewees were happy to answer these questions about the industry in general, many refused to approach the topic of their current position or current company.

Decision Process

It was decided that the best way to identify decision processes was by asking interviewees to tell the story of existing experiences. First, the interviewee was asked to identify major changes in the past that attempted to provide operational efficiencies and that have either succeeded or failed to do so. When the scenarios were identified, the interviewee was asked to start at the beginning and describe how, when, and by whom the potential change was identified, how the decision was made to implement the change, how long the overall process took, and how was success or failure defined and measured.

Areas of Interest

While the above sections were covered in every interview, a few areas and questions that are more specific were identified and only asked if the interviewee approached the subject themselves or if there was enough time left. These were as follows.

- Extent and cost of use of non-public procedures
    - Where do you use them
    - What % of overall procedures
    - Why did you start creating them

- What benefits are you getting from them
    - How did you build them and who owns them
    - Where did you get your obstacle and terrain data
    - What is the cost associated with building them
    - Why do you not use them more often
    - How do you cyclically review and maintain them

- Charting

    - What is the budget / cost of charting
    - What do you need to chart
    - Who do you use for charting and why
    - What is the cost involved in switching

Interviewees

Person	Position	Company	Country	Date	Duration
Mr. Paul-Franck Bijou	CEO	Quovadis (Airbus Subsidiary)	France	June 08 2010	40 min
Mr. Arvid Von Nordenflyght	Pilot (Retired)	United Airlines	USA	June 09 2010	1 h 10 min
Mr. Alan Marshall	Pilot	WestJet Airlines	Canada	June 15 2010	45 min
Mr. Jim Hartman	Flight Ops Engineer	Delta Airlines	USA	June 16 2010	35 min
Mr. Scott Wilson	Director Flight Standards	WestJet Airlines	Canada	June 24 2010	55 min

Mr. Brian Gleason	Director, Flight Operations Engineering	SouthWest Airlines	USA	June 29 2010	1 hr

Interview Results

The overall results of the interviews were divided into the following sections:

- Areas of Concern
  - Ticket Pricing and Sales
  - Competition
  - Interconnectedness and Natural Catastrophes
- Operating Efficiencies
- Flight Operations Engineering Objectives
- Measuring Efficiencies
- Airline Structure
  - Unions and Culture
  - Pilot and Dispatcher Relationship
  - Aircraft Types and Policies
- Decision Process
- Change Process
- Hedging
- Fuel
  - Factors affecting Fuel Burn
- Politics and Government Programs
  - Tax Programs
  - RNP / PBN - NextGen (FAA – US) / SESAR (EuroControl – Europe)
  - Local Standards
- Route Optimization and Tailored Procedures
- Charting
- Cargo
- Takeoff Weight

These sections are covered below.

Areas of Concern

When asked about the main problems or concerns within the aviation industry, the answers covered the following topics.

Ticket Pricing and Sales

One of the main problems mentioned for airlines in general is setting the selling price of tickets. The concern, of course, is that airline seats are not durable goods and the marginal cost of an additional passenger is close to zero. So the concern is: at what point does an airline start to cut prices for a specific flight?

However, since this area is somewhat unrelated to this project, the topic was not investigated in any further depth.

Competition

In general, the airline industry suffers from excess capacity with price being the primary differentiating factor for its main consumer base. This results in little room to growth, fierce competition within existing market, undercutting, and price wars. An example that was given is that for many years United Airlines was flying New Zealand to Los Angeles. However, they gave that up after a few years because they were unable to generate any profits. The reason given was that Qantas and Air New Zealand started a price war upon United's entry into that route, and maintained low prices until United exited.

Another point of interest about the nature of competition within the airline industry is that the legacy carriers tend to fly the long-haul routes where they can generate the highest profits and smaller carriers cover the shorter routes. However, smaller carriers that cover those routes are not necessarily generating profits from ticket sales. Rather, the larger carriers pay them on a per-leg (per-flight) basis, regardless of the number of passengers, just to maintain service to the smaller cities.

Interconnectedness and Natural Catastrophes

As the number of interconnections between different areas of the world increases, a single natural catastrophe in one part of the world can affect airlines throughout the globe. Some of the examples that were specifically discussed were the Iceland volcano that blocked airline operations in Europe for many weeks and the earthquake in Chile earlier this year. Because of these catastrophes, some airline operations such as flights, aircraft deliveries and flight operation projects had to be cancelled or postponed resulting in large financial losses, delays, and inconvenience.

To understand the extent of the damages to the airlines one must compare actual operational losses to airline margins. An airline may only have a small number of flights through a specific region, or a small number of flights that are affected by the event, say 5%. However, that's 5% of operating revenue that will be taken away straight from the bottom line of what little profit margins currently exist or don't exist in the airline industry.

Furthermore, safety concerns that are so prevalent in the airline industry can aggravate the situation. For example, the European "protection principle" was mentioned which implies that regulators must take appropriate measures to protect the public against any foreseeable risk. As a result, in the case of natural catastrophe, regulators stop all commercial airline traffic, not necessarily because it is actually unsafe, but because they don't know whether it is safe or not. Such requirements for safety and protection delay normal operations further and increase the financial losses.

Operating Efficiencies

In almost all interviews, when discussing efficiencies in flight operations engineering, at some point or other, the discussion came back to operational efficiencies in general. The basic understanding is that within an industry of extreme low margins that is subject to a high level of risk from external factors such as currency and fuel fluctuations, global economy, weather patterns, and natural disasters; the only way to survive is through extremely efficient flight operations engineering operations. At the end of the day, one must understand that is only one part of overall airline operations and efficiencies must be gained throughout an airline's operations.

When looking at increasing efficiencies, airlines should focus efforts on the parts of their operations that are most inefficient. The two main factors in identifying areas of focus are maturity of airline operations and overall airline structure. Immature operations can create the largest efficiencies by focusing on areas such as scheduling and crew planning. On the other hand, highly unionized and hierarchical airlines can find efficiencies by improving employee relations and their ability to be flexible and responsive to changing market conditions.

In terms of scheduling, as one interviewee said "if you can get 18 hours a day out of your fleet instead of 11 hours, I think that makes fairly straight forward sense". The problem, of course, is to balance the desire to increase flight time with the demands of the market and the limitations of changing time zones. On long flights, airlines must juggle time zones, daylight windows that have higher market demand, and general weather conditions such as wind direction. In general, optimizing schedule to increase flight time can generate incremental efficiencies.

Another source of operating efficiency is employee relationships and internal programs. Improved employee relations not only provide savings in cost of labour but reduce requirements in redundancy in body count. For example, one airline was able to completely remove extra pilot and flight attendant body counts by implementing a culture of voluntary (paid) overtime to cover sick days and time offs. Internal training programs and facilities can decrease the cost of training as well as provide savings on travel days. However, such programs usually require upfront capital expenditure and investment in internal competencies.

Another example given by an interviewer is as follows. Depending on an airline's operations, let's say that fuel cost is about 12% of overall operating cost and crew cost is about 15% for short haul carriers and 8% for long haul carriers. Now, that airline operator can put in place a fuel initiative that will 1 to 3% of annual fuel cost, which is quite large. However, when you look at that airline's operations you find that they don't have the correct mix of captains and co-pilots, so that they have daily problems creating the right combination of one captain, one co-pilot, and one aircraft type. As a result they have to cancel flights because they can't manage their crew properly and the reality of crew cost is much higher than fuel cost. In this case the airline can experience 5% efficiency within 3 months with much lower expenditure than any fuel initiative can provide.

Flight Operations Engineering Objectives

In terms of objectives, flight operations engineering's primary focus is airline safety, and then, efficiency without compromising safety. In order to create efficiencies within the airline industry, this department must also overcome the challenges associated with working within such a highly regulated environment.

In order to generate efficiencies without compromising safety, one of the primary jobs of this department is to understand the maximum performance of a given aircraft at a given airport. To understand the maximum as well as optimum aircraft performance, the aircraft's flight manual is used.

It would seem that this department focuses mainly on what they consider "performance challenged airports". Four major characteristics of an airport are considered: runway length, altitude, temperature, and terrain. Airports that have a combination of shorter runways, higher altitudes, warmer temperatures, and high terrain (for example mountainous areas) require higher performance capabilities from the aircraft. One of the main objectives of the flight operations engineering department is first to guarantee safety of flight at such airports, but also to generate efficiencies in such environments. Some of the tools used include matching aircraft types to specific airports and routes, monitoring aircraft performance, calculating takeoff weights close to real time, monitoring fuel burn data, and tailoring flight procedures and flight paths. Other aspects of efficiency include studies to investigate how efficiencies can be better measured, managed, and reproduced consistently. In terms of safety, this department is also responsible for the contents of navigational charts and databases used by the flight management system on board of the aircraft.

When asked about changes in the industry in general that would help create efficiencies, the largest leaps in efficiency are expected to come from aircraft manufacturers. The next generation Boeing 787 aircrafts, for example, are expected to provide a very large leap in performance in terms of fuel burn.

Measuring Efficiencies

The ability to measure performance seems to be one of the major challenges of the flight operations engineering department. There are two main goals in increasing the granularity of measurements. First being able to consistently understand the largest factors affecting daily operations allows airlines to focus efforts and prioritize activities. Second, the ability to measure the effect of changes better allows airlines to build stronger business cases, understand expected returns on specific investments with better accuracy, reduce risk and increase predictability.

On any single flight, there are a lot of factors affecting fuel burn such as wind, temperature, barometric pressure, weather patterns, aircraft weight, drag, flight path, air traffic controller instructions, pilot decisions, and so on. (see section Factors affecting Fuel Burn). Today, most modern airlines have an ACMS (Aircraft Monitoring System) function that automatically records 40 parameters or more on every flight and allows that information to be downloaded to a main database upon landing. This information is very detailed and specific.

When the above information is used to monitor a specific aircraft (referred to as "monitoring per tail number"), this information is very useful in providing two types of information. First, it can provide near real time information on issues that could be a safety concern. One interviewer, for example, described a case where an airplane was grounded minutes before its scheduled flight because of concerns that the engine might die during the flight. While such situations are rare, a more common use of this data is to monitor the rate of performance degradation of each aircraft. Using data gathered over the span of about one month, the flight operations engineering department can not only decide when to schedule specific aircrafts for maintenance, but also decide how much extra fuel should be carried on a per tail number basis rather than per aircraft type in general. In this way, this level of granularity is used to increase safety and efficiency simultaneously.

On the other hand, at the aggregate level, airlines would like to be able to determine actual value generated by specific investments or initiative and to derive patterns that can guide future spending and efforts. However, there are major challenges in using this data at an aggregate level. When asked about what is measured and monitored at the aggregate level, common answers included looking at the overall fuel burn from last year, adapting it for major changes such as new destination, and comparing it to this year's fuel bill. Almost all interviewer expressed that looking at the data at any other level of granularity could be misleading.

The main reason quoted for this limitation was that there are simply too many parameters and too many variables creating too much noise to be able to detect the pattern in the data.

Airline Structure

One of the major factors affecting an airlines profits in terms of its ability to generate efficiencies, adapt to changing environment, and general responsiveness is the internal structure of the airline. In terms of airline structure, three main areas of interest were identified; Unions and culture, pilot/dispatcher relationship, policies regarding aircraft types and pilots. Each of these areas is discussed further in the following sections.

Unions and Culture

The structure of an airline in terms of it unions, it's hierarchical structure, and its general culture can have major affects in the airlines' ability to generate efficiencies. First change seemed to be hardest to implement in highly unionized and hierarchical airlines. When asked about the change process and timeline, interviewers from large unionized airlines would describe a change in terms of many years (for example 7 years), whereas similar changes in smaller non-unionized airline was described in terms of months (about 12 or so).

The second major difference was the airline's desire to experiment. Smaller non-unionized airlines prided themselves in giving examples of all the different things they tried and all the little ways they were able to generate small amounts of efficiencies. Larger, unionized airlines, on the other hand, prided themselves in the fact that changes were done after proper due diligence and after everyone affected had a chance to be heard. In one large airline, for example, a specific decision was implemented only after union reps, senior pilots, senior flight attendants, and so on, were all consulted and everyone had been trained appropriately. On the other hand, a smaller non-unionized airline described a specific change as "well pilots got a fair bit of notice. They were sent the training materials. They're all professionals, and so responsible for their own preparation".

The last, but certainly not least major difference was the cost of labour and training. Good employee relationships between management and flight crew generally resulted in lower cost of labour. One airline described that because of their internal culture they were able to remove all extra "body counts" and cover sickness and absence through a volunteer program were full time employees are paid overtime. The ability to implement such programs can allow airlines with good employee relations to generate efficiencies otherwise not possible.

Interestingly though, one aspect that all interviewees agreed on was that monitoring anything on a per pilot or per crew basis, while absolutely possible and even valuable, was deemed too big of an intrusion. To quote the interviewees "the pilots would feel like big brother is watching them. They wouldn't like that at all".

Pilot and Dispatcher Relationship

Interestingly enough, the relationship between pilots and dispatchers seemed to be constant across all interviews. With the increasing granularity of real time data collection and automation, it seems that most of the decisions regarding the flight are performed at the dispatcher or prior to the dispatcher with a little wiggle room for the pilot to adjust.

While in theory pilots have the final say on everything concerning the flight, all interviewers agreed that in reality they rarely change anything. One pilot expressed that he may speak to his dispatcher perhaps once every three months, and even in that case it is usually to clarify something rather than change it.

Aircraft Types and Policies

Two main questions for an airline is how many types of aircraft do they operate in their fleet and how much flexibility they have in changing. If an airline operates all the same aircraft type, then maintenance and scheduling tasks tend to be easier. The airline requires less spare parts and can alter switch maintenance schedules quickly based on the real time performance of each tail number. In terms of flexibility, crewmembers can operate on any tail number, so flight schedules and destinations can be changed easily and quickly.

On the other hand, diversity in the fleet allows the airline to tailor aircraft to specific routes and destination and derive better performance out of each aircraft type. Delta Airlines for example, claims that such diversity (19 aircraft types) allows them to provide better service to a diverse set of destinations and create efficiencies in doing so. Southwest Airlines on the other hand believes that their fleet of only Boeing 737s has allowed them to create efficiencies in maintenance and flexibility. The second benefit of a diverse fleet is that it more easily allows experimentation with a subgroup. As one interviewee described "if you have 10 airplanes of a specific type and you want to try a new technology, then you have train maybe 100 crew members and a handful of destination. Then you can try that and see how it works. But, when all your aircraft are the same now trying to ensure that only those with the training end up on the specific aircraft and the specific route that has the new technology would be a scheduling nightmare. So you end up with a situation where you have to either train everyone or not do it at all".

Decision Process

The single most important factor in any airline's decision process is the business case. For airlines, the ability to make a business case revolves around being able to prove the business case. Proving relies on the ability to measure accurately and reliably the impact of the required investment. For most investments, it involves two activities. First, it involves designing an experiment that can apply a much smaller initial investment to a sub group. Then, the experiment must prove the impact of that investment by measuring something specific, and extrapolating those results to show the expected benefit of investing in the full solution.

With most of the examples given through the interviews, the largest challenge always seemed to be the measuring part. What do we measure, how do we measure it, and how can we minimize the noise in the data to show a relationship between the changes we see in what we measure and the investment made. The original small investment is somewhat more readily made if there is a logical deduction that there are efficiencies to be gained in that area. The harder part is designing an experiment that can be contained and provide results that can be extrapolated.

Once the business case is proven, the extent and speed of adoption depends largely on the airline structure. The smaller, flatter, and more agile airlines tend to adopt a “just do it” culture. In such cultures adoptions is much quicker and they are more likely to invest in even the smallest gains if they believe in the business case. In larger more unionized airlines, the next question is the impact on the unions, crews, and so on. It’s not necessarily that adoption will not happen, but rather it is a longer process. If the efficiencies offered are small, the cost of going through that process may be larger than the perceived efficiencies, and therefore, adoption may not happen. As a result, smaller and more agile airlines are more likely to make investments that have smaller returns, as long as they believe in the validity of the business case.

In terms of decision makers, it seems that most initiatives are started at middle managements. Upper management must agree to the initial investment and will definitely have to approve the final investment. Once the decision is made, the change is usually “pushed down” and implemented. In all interviews, all examples of changes given were initiated and implemented in a top-down fashion.

Change Process

Once a decision is made to implement a change, the process and duration of that change depends on a few main factors. First, it depends on how many external entities need to be involved in the change. If it is a change that involves buying form a third party, then there is usually a bidding a process and the time required for the third party to deliver the desired parts. If the change requires regulatory approval, then it is largely dependent on the country, the mandates of the authorities, and their knowledge of the technology. For example, approving new RNP procedures is highly dependent on the authority’s mandate to facilitate such approvals and their familiarity with RNP technology.

Internally, the change process depends on the extent of the change and the size of the airline. If aircrafts need to be upgraded, then the change will happen through the airplane’s preset maintenance schedule. The size and diversity of the fleet will have a large impact on the duration of this change. If training is required, depending on the type of training, for example, classroom, simulator, or online training, then the crew needs to be trained in small groups to allow continuing daily airline operations, and that can take some time.

In general, however, all changes described through the interviews took a minimum of one year to implement. Many of the bigger changes were planned into a five-year plan.

Hedging

Airline use hedging as a way to protect themselves from the variability of the market. There are two types of hedging that is most prevalent in the airline industry; fuel hedging and currency hedging.

Long haul carriers tend to be much more sensitive to hedging than other carriers. Local or regional carriers tend to operate within markets that use the same currency and where fuel prices do not fluctuate much between different departure cities. In such local environments, fluctuations in currency or fuel are experienced equally among competitors and hedging plays a much smaller role, if any at all. However, long haul carriers are operating internationally. They must hedge to protect themselves against competitive disadvantages such as currency fluctuations that can diminish the value of their revenues compared to local costs of operations and fuel fluctuations that can provide competitor airlines of differing nationality a cost advantage. As a result, hedging decisions can have quite a large impact on their balance sheet.

Fuel

Decreasing fuel consumption is currently a major concern for most airlines. The main reason for this is the increasing price of jet fuel, especially in the past eight years. Other reasons include increasing global environmental concerns and the possibility of green taxes that will further handicap an already suffering industry.

As a result, there was agreement among the interviewees that today, all major airlines are implementing fuel saving initiatives. They differ only in the extent to which they commit resources to such initiatives.

There was also further agreement among the interviewees that decreasing fuel consumption is a game of diminishing returns. The single most important factor in efficiency in terms of fuel consumption is choice of fleet and aircraft type. Efficiency is probably the most important and focused on feature of new aircraft at Boeing, Airbus and Bombardier. One interviewer estimated that upgrading airline fleet to the latest aircraft can easily provide fuel efficiencies of 30% to 40%.

From here, airlines can implement a number of fuel reduction initiatives. The standard initiatives include one-engine taxi way, gate-to-gate optimization, and at the extreme end, performance based navigation (PBN) procedures such as RNP and RNAV. Airlines can implement fuel follow up systems in which pilots are incentivized to optimize their fuel burn and cost index.

Factors affecting Fuel Burn

This section is meant to provide a quick summary of the main factors affecting fuel burn. The first factor is the direction of the wind. Head wind creates drag and slows down the airplane while tail wind helps the airplane and decreases fuel burn. Sometimes, airlines can decrease fuel burn by flying a longer route that offers more favourable winds. While the direction of the wind is generally easier to predict, the strength of it on any given day is harder to predict. Deciding what route to fly was compared by one interviewer with deciding which route to take during rush hour traffic: “Do you take the freeway and risk traffic or do you take the back way and opt out for predictability?”

Another factor affecting fuel burn is enroute weather. Major weather patterns such as hurricanes and ash clouds can make a route unsafe and uncomfortable to fly. Other less extreme weather factor include air temperature as aircrafts tend to perform better in colder temperatures.

Another important factor about fuel burn is that the rate is not evenly distributed throughout the flight. In general, departures, including takeoffs and climbing tend to consume by far the highest rate of fuel burn. One interviewer specified that takeoffs consistently burn between 3000 to 4000 pounds of fuel no matter the length of the flight. On the other hand, continuous descents, slowing down, and maintaining optimum speed will consume the lowest rate of fuel burn. As a result, longer flights will generally result in lower average fuel burn per distance (mile or kilometre) than shorter flights.

The definition of optimum speed is also very important to airlines. First, the flight management system on board the aircraft will calculate the most efficient speed and altitude for that aircraft at any given time based on aircraft weight and weather conditions. This information is then automatically used to calculate a "cost index" which balances the additional time related cost of slowing down the airplane and increasing flight duration with the savings from decreasing fuel consumption. The resultant "optimum speed" is displayed to the pilot in real time.

Politics and Government Programs

When asked about any government or political incentives that helped in promoting fuel efficiency initiatives, the interviewees mentioned the following programs.

Tax Programs

While there was some consensus that some countries provide local government incentives to fly greener, the only incentive that was mentioned by name was "ETS"

(Emissions Trading Scheme) offered in Europe. When specifically asked about the United States, interviewers said that while there was talk of such programs in the future, there were currently no incentives in the US.

RNP / PBN - NextGen (FAA – US) / SESAR (EuroControl – Europe)

Many interviewers seem to agree that one of the largest leaps in creating fuel efficiencies is the adoption of what is referred to in North America as RNP (Required Navigation Performance), and in Europe as PBN (Performance Based Navigation) flight procedures. One interviewer estimated that today, the average flight travels 50% more nautical miles than the most direct route would require, while another interviewer estimated that by adopting RNP through all approaches the airline could save at least 1 minute of flight on each landing. However, the problem is that even if the airlines upgrade all equipment, crew, and procedures to adopt this new technology, it is all dependent on each airport's air traffic controller to authorize such landing.

The NextGen program (by the United States' Federal Aviation Administration) and the SESAR program (by Europes' EuroControl organization) are two of the strongest promoters of this technology who have vowed to implement it throughout North America and Europe in the near future. However, currently, the only airline to consistently make use of this technology is Canada's WestJet airline where the technology is used at all Canadian destination with the exception of Montreal, Toronto, and Vancouver airports. However, even in WestJet's case, gaining approval from the air traffic controllers has been an uphill battle.

As far as NextGen and SESAR are concerned, the interviewers expressed a different philosophy between the two programs. The US's NextGen program seems to be taking a bottom-up approach where they have start by implementing what works today and then think of the next layer for the future. On the other hand, Europe's SESAR program is taking a top-down approach, where everything must first be implemented in theory, and then it is all turned on at the same time. The plan is still for both programs to reach the same end at the same time, however, the result is that today, the FAA's NextGen seems to be much further ahead that Europe's SESAR program.

Local Standards

Globally, the two largest bodies that create flight standards are ICAO (International Civil Aviation Organization) and the United State's FAA (Federal Aviation Administration). While FAA standards are applied mainly in the United States, ICAO standards tend to be used internationally. However, most local governments will adapt the ICAO standards slightly for the purposes of operating within that country. Some interviewers mentioned that while these differing standards are all very similar, they are not necessarily compatible. Accommodating for these differences can create additional cost inefficiencies. Furthermore, in adopting new technologies such as RNP, getting approval from the different regulatory bodies of each country can also create large time delays.

Route Optimization and Tailored Procedures

When attempting to optimize flight paths, airlines must first and foremost comply with AT mandate. Therefore, in the vast majority of cases, especially at international and busier airports, airlines may have no other choice than to fly the common generic published procedures and flight paths. For the remainder of cases, airlines may try several things.

When an airline is considering a new destination or trying to optimize an existing destination, the first thing they will do is to negotiate with the airport authorities. In geographical areas where visibility is not a common problem, most efficiency can be gained by simply asking the air traffic controller for a “visual approach”. In this case, the pilot will see the runway and take the shortest and most optimal path. The next option is to ask to be redirected to a route that uses a secondary navigational aid or runway that better suites the airline’s flight path.

The above options are most commonly used. In less common cases airlines can apply for private or tailored procedures. The most common form of tailored procedures are one-engine out departure procedures that are usually created in “problematic airports” with short runways, high temperatures, or mountainous geographical areas. These procedures are created as much for safety reasons as for efficiency gains.

More recently, airlines have begun creating tailored procedure to take advantage of newer technologies such as PBN (Performance Based Navigation). These procedures use the technological capabilities on board the aircraft rather than the ground based navigational aids. As a result, they can increase safety, efficiency, and access; especially at airports with poor or limited existing infrastructure.

Gaining approval for tailored procedures, especially those based on newer technologies can take between 6 to 12 months, and in some extreme cases even years, depending on the comfort level of the regulatory bodies and the local airport air traffic controllers with such tailored procedures. Interviewees who had experience with such procedures consistently reported that the hardest and most time consuming part of adopting such technologies and tailored procedures involved educating local authorities.

One of the largest drawbacks of creating tailored procedures is that the airline is now responsible in maintaining them and assuring constant accuracies. One interviewer reported that, even though that airline was not using any PBN based tailored procedures, they still needed two full time employees to maintain their limited set of tailored procedures at their 400 airports. If any of the procedures are affected by changes at an airport, that procedure then needs to be charted again and reprinted, which requires additional cost and turnaround time.

Charting

Charting is a global duopoly with Jeppesen holding a monopoly in North America and Lido being more prevalent in Europe. When the interviewers were asked their opinion about why that is, answers revolved around habits, preferences, and little differentiation.

Jeppesen was the first active charting company in North America. As a result, it quickly became the only choice and then, the de facto standard. North American airlines chose Jeppesen because the known brand meant reliability and predictability, and because most pilots would already be familiar with the Jeppesen graphics. Airlines now tend to stay with their chosen charting company because it works, and why change something that works. The change itself entails quite a large cost, especially if the airline has a large set of tailored procedures. Another problem with switching charting company is that the pilots and associated unions need to be convinced.

One interviewer said “Like most things in life there’s no one chart that is perfect. They each have their advantages”. While all charts will display the same information, each charting company will use slightly different graphics and layout. In an industry where change is slow and safety is a main concern, breaking old habits, especially within the pilot community, can encounter a lot of resistance.

Another main reason mentioned for staying with the same charting company is that Jeppesen and Lido are currently not trying to differentiate on a cost basis. Their cost are very comparable and as such do not offer enough of an incentive for airline to consider going through the hassle of making such a change.

One of the most recent changes from the charting perspective is the move from paper charts to electronic flight bags. However, all airlines interviewed expressed that the current initial investment required to adopt electronic flight bags does not warrant the change. They did, however, mention that such change was surely to happen in the future. In fact, they predicted that most new airplanes will come out of the factory already equipped with the instruments.

Cargo

Most airlines create additional revenues by carrying cargo. However, interviewers estimated that the revenue from cargo is between 1-2% of passenger revenue for the same weight. As a result, while cargo can be used to generate additional revenue, it is never used as a replacement to passenger revenue.

One of the advantages of carrying cargo is the flexibility it provides. Most cargo contracts specify a specific amount of cargo to be carried within a specific timeline. As a result, airlines can vary the amount of cargo they carry in each flight based on the conditions at the time of the flight.

Takeoff Weight

The maximum takeoff weight of an aircraft is calculated based on the one-engine out procedure. The idea is to design a procedure that the aircraft can safely fly on a single engine failure at critical point of takeoff. The maximum takeoff weight of the aircraft is then the maximum weight at which the aircraft can still safely fly the one-engine out procedure.

As explained in the previous sections, aircraft performance is based on many environmental factors that can change quite quickly. Therefore, one of the topics discussed with the interviewees is how, when, and by whom is this weight calculated.

The general answer was that there are multiple stages in calculating this weight. First, the flight operations engineering group performs the analysis. They look at a range of conditions in the various seasons for that particular airport include ranges in temperature, barometric pressure, runway conditions, and anything else that could affect aircraft performance. From this analysis they develop a set of one-engine out procedures that are very specific to a particular runway and aircraft. This analysis is then fed into their overall flight planning system.

Around 2 to 4 hours prior to the actual flight, the dispatcher looks at the actual conditions at the airport. Most airlines have a predictive system that looks at the trend in weather conditions at the current airport and estimate the conditions at the time of take off. About one hour prior to the flight the final flight plan is released to the pilot, which then include not only the takeoff weight and fuel of the aircraft, but the estimated conditions that the calculations were based on.

Once everyone is on board and everything is loaded, the dispatcher makes final calculations based on the actual weight of the aircraft and the current conditions. The actual weight of the aircraft is calculated by adding the empty weight of the aircraft (which is known before hand) and the weight of the passengers, luggage, cargo, and fuel. Passenger weights are calculated by multiplying the number of passengers checked in by a weight that is dictated by the regulatory body.

Interviewees mentioned that in some extreme cases weather conditions can change quite quickly. The two factors that can change the quickest are barometric pressure during storm season and runways that become contaminated due to rain or snow. In such cases the dispatcher will hold the airplane and take some weight off. The primary means of reducing weight is by removing cargo. Once all the cargo has been removed, the next option is to decrease the number of passengers. For most airlines, this is usually the last resource.

In order to minimize the chances of having to ask passengers to get off the airplane, airlines usually cap the capacity of the airplane during risky seasons. For example, they may only sell 150 seats in an airplane with a capacity of 166. Passengers will then be allowed to fly on “stand-by” if the conditions at the time of the flight allow for the additional weight.

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