

SKYCSR: OPTIMAL COMMUNICATION METHODS FOR COORDINATING GROUND SUPPORT IN A PRIVATE AND GENERAL AVIATION SETTING

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ABSTRACT

SKYCSR

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Delays due to miscommunication of between the pilot and ground service providers are increasing. The objective of this project is to develop a new method of communication between pilots, line service technicians and customer service agents. This will be achieved first through an investigation into current methods and state of the industry, followed by a survey conducted with a group of pilots and flight schools. This culminates in a web application that will take the deficiencies identified in the survey, to make sure ground service or fuel orders are explicitly clear and minimize the probability of a mis-fueling, overlooked fueling, or anything else that could cause a delayed ground service and unhappy customer. The web application, named “SkyCSR” was developed in Visual Studio in an ASP.NET environment. It has an area for FBO’s to login and view inbound arrivals as well as upcoming fuelings. The application also has a place for pilots to input their ground service needs and also a separate page for fuel orders. During the two iterations, the web application received positive feedback, with most of those who reviewed it saying it would be useful to have. The down fall, is that pilots use so many apps already that it is difficult to get a stand-alone app, like this one, “off the ground” so to speak. The recommendation for this web application would be to try an integrate it with already existing applications and websites (i.e. ForeFlight, FltPlan.com) that are already widely used and have saturated the pilot market, but not yet developed a side for the Fixed Base Operators.

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ACRONYM COLLECTION

FBO – Fixed Base Operator

CSR – Customer Service Representative

ICAO – International Civil Aviation Organization

UNICOM – Universal Communications

GSE – Ground Support Equipment

APU – Auxiliary Power Unit

GPU – Ground Power Unit

TSA – Transportation Security Agency

AFP – Airspace Flow Program

GDP – Ground Delay Program

ETMS – Enhanced Traffic Management System

100LL – 100 Low Lead or AvGas

Jet A – Jet Fuel

TABLE OF CONTENTS

SKYCSR: OPTIMAL COMMUNICATION METHODS FOR COORDINATING GROUND SUPPORT IN A PRIVATE AND GENERAL AVIATION SETTING.....	1
ABSTRACT.....	2
ACKNOWLEDGEMENTS.....	3
LIST OF FIGURES	7
LIST OF TABLES	8
INTRODUCTION	9
BACKGROUND	11
GENERAL AVIATION.....	11
CURRENT STATE OF AVIATION.....	12
CHARTER OPERATIONS (PART 135/PART 91).....	13
PSYCHOLOGY OF WAITING.....	15
FINANCIAL JUSTIFICATION.....	17
LITERATURE REVIEW.....	18
PEER-REVIEWED RESOURCES	18
DATA COLLECTION	19
TIME STUDIES	19
FUELING LOGS.....	20
DESIGN	21
CURRENT WEB APPLICATIONS.....	21
SURVEY.....	22
LOGIC DEVELOPMENT	23
WEB APPLICATION.....	24
SCHEDULED ARRIVALS	24
SCHEDULED FUELINGS.....	25
CREATE FBO LOGIN & FBO HOME SCREEN.....	26
METHODOLOGY.....	27
FIRST ITERATION.....	28
SECOND ITERATION.....	29
WEB APPLICATION EXPANSION	30
CONCLUSION.....	31
WORKS CITED.....	34

APPENDICES	36
APPENDIX A – GENERAL AIRCRAFT/AIRPORT INFORMATION	36
APPENDIX B – SURVEY	39
APPENDIX C – WEB APPLICATION SCREEN SHOTS	41
APPENDIX D - DATA COLLECTION SAMPLES	45
ROUTE MAPPING	46

LIST OF FIGURES

Figure1 Traditional vs. Theoretical model of communication.	28
Figure2 Cessna Citation XLS	36
Figure 3 Airport Diagram - Commonly used by pilots to denote where FBO's, Flight Schools, Terminals, Taxi ways, etc. are located on the field.....	36
Figure 4 Cropped image of an "Instrument Flight Rules" Arrival Plate. The important part of this picture is to note the tall mountain ranges that occur north of the San Luis Obispo Airport. These mountain interfere with broadcasts regularly.	37
Figure 5 Screenshot of FlightAware	37
Figure 6 - Screenshot of TraqPak	38
Figure 7 Beginning questions of the survey	39
Figure 8 - second set of questions in survey. Most of the answers allow the respondent to answer more than one.	40
Figure 9 Final page, just contact information and primary airport ID.....	40
Figure 10 - Schedule an arrival.....	41
Figure 11 - Schedule a Fueling Page for Pilots/Flight Schools	41
Figure 12 FBO Profile Creation Page.....	42
Figure 13 FBO side of web application that shows scheduled arrivals for inbound aircraft on a particular day. 42	
Figure 14 FBO side of the web application that shows the upcoming fuel orders.	43
Figure 15 Logic developed in the first quarter to design the algorithm calculating the weights. There is a slight difference between this algorithm and the algorithm utilized, is that this algorithm looks at the actual amount of fuel being taken. This was omitted after pilot interviews responded that they didn't always know how much, and they weren't sure what form to put it in (bring up to so many pounds on board, put on pounds, put on gallons, etc.).....	44
Figure 16- Example of the Fuel Dispatch Log Used to record fuelings, times, dates, customers, gallons sold, and the responsible fueler.	45
Figure 17 Example of the truck sheets used by line service technicians to record gallons sold, meter numbers and gallons left in the truck.....	45
Figure 18 Example of the Jet Truck sheet. It's is used for the same purpose at the 100LL sheet, but with Jet A 45	

LIST OF TABLES

Table 1- Words that appeared frequently in order from greatest to least, from the 2011 study of FBO's. 14

Table 2 - list of primary objectives for web application 24

Table 4 - Average yearly sales/hour 47

Table 3 - Average Number of AvGas Purchases Per Hour, Separated by quarter..... 47

Table 5 - Average Number of Jet A Purchases/Hour..... 48

Table 6 Average, Max, Min of 100LL and Jet Uplifts and Gallons of fuel per uplift 49

INTRODUCTION

Yelling is an exceptionally good motivator. A pilot at the end of an extensive day of flying can be cranky and easily set off by some of the most minor of details. On one particular day, the detail was a late taxi, resulting in the pilot yelling at the front desk for being incompetent. This outburst was the end-result of communication errors that snowballed out of control - culminating in a furious customer and a distraught customer service representative. Miscommunication of this magnitude is not a one-time offense; in fact it's rampant throughout the aviation world and due in part to the fact that information flow relies on the archaic form of communication: radio frequencies. In the private and general aviation sector, inbound airplanes utilize UNICOM frequencies or Global Communication Services (in-flight telephones) to relay messages to ground support at their arrival airport. Frequently, these messages get lost in translation due to a number of limitations ranging from inattentive ground support who simply don't hear the radio broadcast, to technological restraint where the frequency is literally bounced off a physical object (like a mountain range) and never reaches the Fixed Base Operator (FBO).

There is no other industry on earth that exemplifies the statement "time is money" better than Aviation. According to Avinode (Ewalt, 2013), a respected aviation leader and jet brokering company, the most popular model of private jet in 2013, was the Citation XL/XLS/XLS+ (See Appendix A, Figure 4), which took off 144,302 times at the rate of \$3,388 USD per hour. In a business where it costs nearly \$57 per minute to keep the engines running, zero delays is the prime objective, which is why maximum efficiency and pre-planning is the top goal for ground services. The aim of this project is to:

- Investigate most efficient means of communication between ground support and inbound aircraft, that ultimately minimizes the total idle and wait time of the aircraft.
- Conduct a survey and interview of pilots, flight schools, and flight instructors to gain an understanding of the perceived deficiencies.
- Propose a possible alternative using cell phone and web application technology.

In order to accomplish this project, there will be a survey given to a group of pilots, flight schools, and flight instructors regarding their experiences with ground services and the delays that are associated. The survey will also be given to local flight schools and private pilots. After the survey has been administered and completed, the answers submitted will be evaluated and a potential solution will be foraged from feedback.

There must be a thorough investigation into the way communication happens now and the general feeling of whether or not it could be better, from pilots, customers, and service providers. The perspective of the pilot must be known in addition to the perspective of the ground crews, since both parties have a different point of view. This project will query known pilots and ground support crews for their input regarding communication or the short-comings of it. As this probe moves forward, the project will also explore whether or not an application on a cell phone would be a viable alternative. Given the feedback, the project will design an application or system that will allow communication between FBO's and inbound aircraft to be more comprehensive and stable, in order to achieve the final goal of minimizing the number of delays due to ground support. The final deliverable will be a website with corresponding application that will be open to a small, local, FBO for beta testing.

For the first point of this investigation- to determine the most efficient means of communication between ground support and inbound aircraft- this project will survey a group of ground services users (hence forth known as customers). By querying this group, a base of data will be gathered to expose what the customer's opinion of ground service delays are. The investigation will look on the side of the ground service providers (hence forth known as line service) and how they perceive ground service delays. After the survey has been completed, a solution will be pieced together from the feedback gathered.

The final investigation of the project is to look into the possible alternative of UNICOM frequencies. This plays heavily into the previous point, but is the actual process of creating the prototype after possible solutions have been identified from the survey. So far, there has been general consensus regarding the use of a web application for scheduling inbound aircraft and identify GSE needs as they arise, especially since most private jets are outfitted with wireless internet access.

The rest of the report is designed as follows: sequentially following this section will be a background on the aviation industry and a review of current equipment scheduling models. Immediately after will be the design, the paper will go in to the finer details of the actual program including the algorithm used by the web application. After this will be an explanation of methods used in the experiment and testing, ending with a show of results and discussion about what works and what doesn't. It will all be wrapped up with a conclusion.

BACKGROUND

GENERAL AVIATION

The term general aviation is a blanket term that references all aviation that isn't commercial. It can include medical flights, sightseeing, business, corporate, flight lessons, personal flights, among others. According to a current and historical trends report, general aviation and air taxi services were responsible for 63% of all tower operations (Shetty & Hansman, 2012), leaving all commercial business to the remaining 34%. Bottom line, general aviation is a large component of the aviation sector. The Federal Aviation Administration's published an annual document called the Federal Aviation Regulation/Aeronautical Information Manual (FARAIM) (Federal Aviation Administration, 2016), a collection of all up-to-date regulations and codes that administer laws on everything that relates, even remotely, to aviation.

The FARAIM is divided into several sections or more commonly referred to as "Parts." Commercial airlines are governed under Code of Federal Regulations (CFR), Title 14, Part 121 named "Operating Requirements: Domestic, Flag, and Supplemental Operations" as well as Part 125 – "Certification and Operations: Airplanes having a seating capacity of 20 or more passengers or maximum payload capacity of 6,000 pounds or more; and Rules Governing persons on board such Aircraft" (Federal Aviation Administration, 2016). This project deals exclusively with private and general aviation, which is regulated by Parts 135 ("Operating Requirements: Commuter and on-demand operations and rules governing persons on board such aircraft" (Federal Aviation Administration, 2016)) and Part 91 ("General Operating and Flight Rules" (Federal Aviation Administration, 2016)). While part numbers may seem extraneous on the outside, it is imperative pilots and dispatchers know what part of the FARAIM they are operating under to ensure they are meeting the regulations set within the FAR. For example, all Part 135 must have flight plans filed with the FAA, even when flying under Visual Flight Rules¹ (VFR) conditions.

General aviation aircraft can fly into any airport, assuming the aircraft is equipped with all of the correct radios, GPS, and that there aren't any weight, balance, or runway condition issues at the airport. Busy airports, such as Los Angeles International Airport (LAX), are considered a Class Bravo Airspace, which means the airplane in that airspace must adhere to strict communication and radio equipment guidelines outlined in the FARAIM. Barring the minimum equipment list, general aviation (GA) aircraft can go to which ever airport they want. Nearly every airport operating around the world has, at least one, Fixed Base Operator (FBO), which is responsible for supplying fuel and services to transient and commercial aircraft. FBO's typically provide 2 types

¹ VFR – Visual Flight Rules: weather conditions generally clear enough to allow the pilot to see where they aircraft is going – no thick clouds, fog, rain, or snow to obstruct vision.

of fuel: Aviation Gas (AvGas or 100 “Low Lead”) and/or Jet A. 100LL is for smaller, piston engine aircraft and is similar to automotive gasoline. Jet A is used only with Jet Engine aircraft, and is similar to diesel. GA pilots will fly in, leave their aircraft with the FBO until they return, whether it’s a few hours or a few days later, leaving the FBO responsible for the aircraft while they are gone. The FBO offers services such as hotels and rental cars, but also services like Ground Power Units (GPU), Air Starts, Auxiliary Power Unit (APU), lavatory services, crew lounge, catering, and other amenities.

There are several ways to fly general aviation. The first and most prevalent is to rent airplanes - flight schools around the country will typically offer a deal on aircraft if a pilot wishes to rent the plane for a few hours or days. Another popular method is to buy aircraft. Groups of people will become fractional owners of an aircraft and use the aircraft when they want. In private aviation, there are hundreds of charter companies that will either buy aircraft to charter trips or act as a professional broker for a buyer who wants the aircraft to fly. One of the largest jet chartering companies is called NetJets, which relies a fractional ownership model. Customers buy memberships to NetJets and become “fractional owners” in the aircraft. Their yearly fees go to maintenance of the aircraft and operational expenses such as the salary of the pilots, dispatchers and ground support services. NetJets operates worldwide and has an expansive fleet of over 650 aircraft, ranging from Embraer Phenom 300 (Light Cabin) to Global G6000 (Large Cabin) (Fleet, 2016).

CURRENT STATE OF AVIATION

The 2008 recession took a massive hit on the general and private aviation industry. In 2015, the number of aircraft produced in the United States (2,400 aircraft) still hadn’t recovered to pre-2008 levels which hovered above 4,000 aircraft per year (General Aviation Market Data, 2015). In a report put out by the Massachusetts Institute of Technology, the number of towered operations in 1990 for commercials and general aviation operations, started at 35 million and 37 million, respectively, with a spike in 2000 as the number in operations for commercial aviation spiking to 42 million per year, and general aviation increasing to 40 million. After 2000, oil prices began to increase exponentially causing the number of annual general aviation operating per year to begin an aggressive decline, reaching 25 million in 2010 (Shetty & Hansman, 2012) and still declining today.

In a February 2014 hearing to the House of Representatives, Committee on Small Business, the GA industry hosts 223,000 aircraft in the US, carrying 166 million passengers annually to airports that have no commercial services provided (The FAA's Impact on Small Businesses In the General Aviation Industry, 2014). Additionally, the general aviation industry employs 1.2 million people in the US and adds \$150 billion (USD) to the overall GDP. In his testimony, Representative Graves stated that “In recent years rising fuel costs, the

decline in the number of pilots in the United States, coupled with the drop off in airline production, has left the industry vulnerable” (The FAA's Impact on Small Businesses In the General Aviation Industry, 2014). With that said, Honeywell has released the expected trends for the upcoming decade, in which they forecast an increase in the number of wide/heavy body aircraft purchases (Prince, 2013).

The problem has become the airlines running out of pilots to staff the aircraft. According to the Federal Aviation Administration (FAA), the number of US Civil Airmen has been steadily declining over the past several decades. According to the General Aviation Market Data, 2014 General Aviation Statistical Databook and Industry Outlook, the number of FAA pilot certificates issued in 2014 was 49,566, a steep decline from the 102,301 licenses issued in 1980 (General Aviation Statistical Databook and 2015 Industry Outlook, 2015). This loss² of human capital has made the need for efficiency within the aviation sector a necessity, especially as more and more pilots make the jump from charter (Part 135) to commercial (Part 121) flying.

The current state of aviation is important to developing the next the generation of aviation web applications. The industry is accelerating its bounce back from the recession, with high market demand for larger and wide-range aircraft, plus the increased globalization of business, private aviation has become an essential tool for companies to effectively manage. The next generation of tools used in the aviation industry will need to be oriented toward efficiency resources and effective time management.

CHARTER OPERATIONS (PART 135/PART 91)

² This loss is due, in part, to the rising cost of obtaining a pilot’s license. According to the Aircraft Owners and Pilots Association (AOPA) website, the average cost hovers around \$9,900, only for the private pilot license. To become a Part 121 (airline) or Part 135 pilot, a student would have to tack on an additional instrument (\$8,000) , commercial (\$7,000), and airline licenses (\$15,000), totaling \$40,000. The other option is to attend a flight school such as Airline Transportation Program (ATP), which, according to their website, boasts a program that can get a student from nothing all the way to a multi-engine license, at the cost of \$63,995. The aviation community is getting ready for an unparalleled loss of trained pilots. The generation of pilots that make up the ranks in commercial companies, are getting ready to retire and leaving behind a large hole that is being inadequately filled. To get more people interested in flying, companies such as JetBlue offer programs to take people from nothing to a full Airbus A320 Type rating for \$125,000.

In the Part 135 world (Grundig, 2013)³, passengers aboard private jets pay top dollar for high quality treatment and beyond exceptional customer service. Private aircraft customers expect no TSA, no wait for the plane, speedy arrivals, quick refuels, cars pulled around, exquisite catering, and no shortage of luxury.

In a 2011 survey conducted by Aviation International News (Aviation International News, 2011),

1500 pilots were asked the question, what makes an FBO excellent? Of the responses gathered, 20% included words like “quick,” “prompt,” “efficient,” while an additional 15% included “attitude,” “friendly,” and “courteous” – highlighting the factors of an excellent FBO and the duality of a business that must not only bring top quality customer satisfaction but also responsive and efficient attentiveness, with very restricted resources. It’s important for FBO’s to pay close attention to these kinds of surveys because it indicates exactly what will make or break a trip for a pilot and their passengers. Top notch service makes FBO’s competitive, keeps the customers returning to them, and will ultimately keep them in long term business

The question remains how to keep the pilots happy with “prompt and efficient” service when the demand of jets varies widely and frequently. Charter companies will call ahead to set up an arrival, informing the FBO of their needs on the ground: transportation (rental car, limousine, personal car), hotel rooms, catering, wine tasting tours, whatever they need. This ensures that the FBO will arrange for the services ahead of time to make sure their aircraft is serviced quickly. These requests are typically for both the crew of the aircraft and the customers on board. Sometimes the charters don’t call ahead to the FBO, in which cases the pilots will typically set everything up or just arrive and get everything figured out on the ground. Normally, as the aircraft nears the airport; the crew of the airplane will call over the UNICOM frequency 5-15 minutes before landing, and alert the FBO of their needs on the ground, which may or may not have been set up previously. At this point, the FBO will get as much as they can, staged for the customers on the aircraft (rental car, catering, hotel reservations) so that they can have the services ready to go in order to minimize time idling and get their crew on their way.

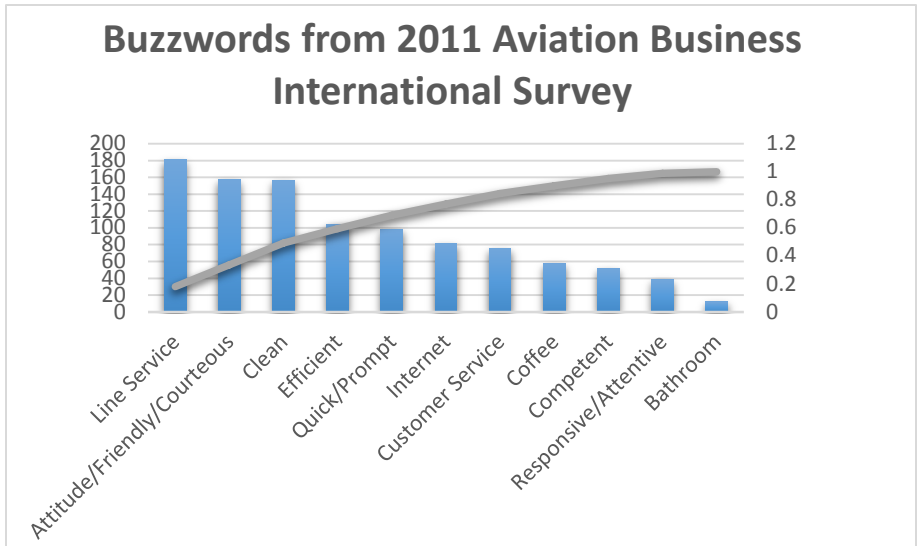


Table 1- Words that appeared frequently in order from greatest to least, from the 2011 study of FBO's.

³ FAR Part 135 applies to turbojet engine powered aircraft with 1-30 seats, non-transport category turbo-propeller powered aircraft with 10-19 seats, and transport category turbo props with 20-30 seats.

In addition to the needs of the customer, the crew will have a disparate set of needs – Ground Power Unit (electricity for avionics, cooling system, radios, while the engines are off), Auxiliary power, Air Start, Fuel, oil, De-ice, Icing-Inhibitors, lavatory services, oxygen services, dish washing, linen washing, catering for cabin attendants, among others. These needs are also communicated over frequency but take a second seat to the needs of the customer depending on whether the passenger(s) are being dropped off or picked up. The crew needs are accomplished after the customer has exited the ramp or gone into the FBO.

Much too often, the needs of inbound aircraft are lost in translation, due to a couple reasons (1) radio frequency is picked up by a different FBO that operates on the same frequency, (2) Customer Service at the FBO doesn't hear the radio call, and (3) Connection is bad enough to not be able to hear the incoming transmission. Some of these are avoidable, having a customer service agent near or around the radio in addition to having the volume sufficiently turned up, is a good resolution. The others are not so easily remedied – mostly due to technical limitations. Frequencies, for example, are limited. Frequency allocation is a long process, plus frequencies are used multiple times since the bandwidth being allocated by the National Telecommunication and Information Administration, is finite. Occasionally, a common frequency overlaps in airspace and causes some confusion on the ground as to which FBO in which city the plane is actually going to. Other times the broadcast will never actually make it to the FBO. Frequencies, depending on the energy and wavelength, have a limited distance – a distance that is sometimes overestimated by pilots. For the San Luis Obispo area, it's commonly observed if airplanes call in too soon, the frequency will bounce off surrounding mountains and never makes it to the FBO (See Appendix A, Figure 6).

PSYCHOLOGY OF WAITING

An important proverb in the private aviation industry is “hurry up and wait.” Pilots scurry to get to their destinations on time, only to be delayed by late passengers, air traffic control, or flow times in to and out of busy airports. During the first iteration, a pilot made the comment that nothing was more frustrating than waiting on services and seeing the line technicians slowly meandering toward the fuel trucks or support equipment, especially when there are plane waiting for service. It's clear that pilots assume there is going to be a wait: there are a limited number of line personnel, a limited number of equipment, and a somewhat endless supply of pilots and passengers needing *something*. It plays right into the psychology of waiting for services, or referred to as queuing by industrial engineers; should the pilot see the line working tirelessly to get all the requests met, that they are more readily appeased if their fuel or ground service is delayed, because they know it's not late for a lack of trying, it's late because there simply weren't enough resources. According to the New York Times article, this is “perceived as fair” and they are willing to wait longer (Matter, 2012). Matter goes on to say there is a universally accepted principle when it comes to lines: first come, first served. Should this

queue deviate from the pattern in the slightest, the largest injustice has occurred and it makes those waiting in line very upset.

While waiting on the ramp, the pilots have two priorities: make sure the plane is ready for take-off and make sure the plane is ready for take-off before the passengers arrive. The passengers that fly privately, are not interested in waiting for the fuel truck to finish fueling or the plane to be un-chocked or loaded up, they are interested in getting to their destination as quickly and smoothly as possible. The problem of delays seems to lie not only with the high impact airports, but also the small airports with no commercial services that have very few resources. Private FBOs at Los Angeles International or San Francisco International will see hundreds of aircraft in a single weekend, all needing services of some type. Luckily, chartered aircraft will typically allow for an hour of downtime between arrival time at the FBO and expected customer arrival time, in the hope that this will ameliorate any potential delays on the ground.

Another important factor in waiting is the idea that if a business keeps people occupied while they wait, it will make them feel as though time is passing more quickly. This was discussed in Matter's article, *Why Waiting is Torture*, where he included the point that a large number of passenger complaints at the Houston International Airport had to do with waiting too long for bags (Matter, 2012). The airports response? Make the route the passengers have to take from the airplane to the baggage carousel longer, giving the baggage handlers more time to get the bags off the aircraft and on to the conveyors. The passengers ended up with a route that was six times longer than the normal route, and the airports ended up with nearly zero complaints (Matter, 2012). This was also discussed in a lecture by Don Norman, who stated that "keeping them [customers] moving fast, keep them filled with interesting things to look at, interesting activities to do" will make the wait seem so much shorter (Norman, 2008). For FBO's this could mean a multitude of things, for one requests can be filled in "Stages." Typically the aircraft will request fuel, ground services (GPU or APU), and coffee/ice/newspapers. If the first two can't be met right away, let the pilot know, then begin the coffee/ice/newspapers process while they are waiting for fuel or other services.

Going forth, for any kind of aircraft support operation, it should be stressed that while safety is a definite first, customer service is a close second, and good customer service, as understood in the 2011 FBO Survey, means prompt and swift services. With that said, pilots understand that lack of resources, but they don't comprehend line technicians slowly walking or meandering around on the ramp when there are clearly orders to be filled or services to be rendered. The most important psychological factor is to - apology for lack of a better word- "look" busy.

FINANCIAL JUSTIFICATION

A large part of the decision to do a web application, hinged on the financial justification. From the FBO perspective, a lost sale can result in the loss of thousands of dollars plus the possibility of the customer not wanting to return. To understand the financial value of a client, data was collected to understand the number of transient aircraft that receive services and the number of gallons sold per uplift. On average, a single day can bring in 18 Aviation Gas customers and 12 Jet A customers. Transient 100LL customers take an average of 40 gallons per uplift, at an average price of \$4.63 per gallons, means that the average customer will spend \$185 per uplift. For Jet A, the average price being \$3.61, and taking an average of 370 gallons per uplift, will spend \$1335.70. Every aircraft that comes in for business, there is a huge value associated with it. The loss of one those customers, would mean losing not just that sale, but future sales as well.

In addition to the lost sales, there is also the added savings of line personnel's time. While it may not necessarily benefit the bottom line of the business or save money on the customer side, giving the FBO and, subsequently, the line service technicians a heads up regarding ground services will help them prepare the equipment, and not send them scrambling when the plane arrives. A typical aviation ramp can cover a few acres, making the movement of line service technician crucial. Should a line service technician not realize a plane is requesting a GPU, Air Start or fuel, they may have to back track for several minutes before arriving at the equipment needed, adding on more time to the fueling or services. According to the route maps that were observed over the course of a week, it was observed that the line would walk back and forth from the fuel truck 3 to 4 times per hour, at a distance of 170 feet. Assuming they walk at a normal pace of 2 mph, which means it takes on average 5.34 minutes to get to the fuel trucks, which makes it 5641 minutes spent per year. At California's current minimum wage of \$10.00 per hour, a company can spend \$950 on employees walking between the fuel trucks and the FBO.

Any delays or malfunctions on the pilot side, as mentioned before, can be costly as well. The cost to operate and maintain a small aircraft like a Cessna 172, which flies an average of 200 hours per year, is around \$23,000, without including fuel or landing costs (Finance). On the jet side, the cost of operating increases exponentially. To own and operate a used Cessna Citation XL/XLS, the average cost is \$8.8 million dollars, with fixed costs per year running around \$425,000 for maintenance and certifications (Van Allen Group, 2012). When the engines are running, the Citation operating cost per hour, including the fuel and operating costs run about \$3,388 USD per hour (Ewalt, 2013). A late fueling or a late ground service could delay the beginning of the trip and add on additional time to the bill, resulting in unsatisfied customers and pilots.

LITERATURE REVIEW

PEER-REVIEWED RESOURCES

The subject of private aviation ground equipment movement and scheduling efficiency has had little research published. Private aviation necessitates a reactive response, scheduling can only help so much when most arrivals are unplanned or given a short hour or two notice. For the situations in which an FBO is overworked with the number of aircraft are near or over the available capacity of the FBO, the research found is based on the way triage algorithms are performed. In the aviation world, a First Come, First Serve (FCFS) method is not always the most optimal. An example being a small jet may request the use of ground service equipment (i.e. having the Ground Power Unit to keep the aircraft electronics running while the engines are off) for two or three hours until the passenger arrives, followed ten minutes later by other pilots who decides GPU assistance to start the plane, ten minutes.

There is very minimal literature regarding the optimal ground services arrangement for aircraft that are private or general aviation, but plenty of literature regarding the airlines. In one piece titled Reducing Flight Delays Through Better Traffic Management (Sud, Tanino, & Wetherly, 2009), the system being tested is called AFP or Airspace Flow Program which was introduced as a solution to the Enhanced Traffic Management System (ETMS), a decision support tool that utilized the use of ground delays, causing significant wait and idle times to build up. The purpose of this paper was to investigate the use of Ground Delay Programs (GDP's) and whether or not they were useful in managing large scale arrivals and departures. It was concluded the GDP's do not work, and instead AFP is a much more time and cost effective style of managing arrivals and departure. While this Sud, Tanino, and Wetherly's paper does not directly relate the investigation of this research, their allocation simulation technique is useful and may potentially contribute to analysis later on. The difference is that this paper can make assumptions about departure and arrivals times, whereas in the general and private aviation world, this assumption cannot be made.

In another case study, a team investigated the movement paths of aircraft from one area of the airport to another in the most efficient way possible, in regards to both time and emissions. This problem applies to all pilots but doesn't necessarily apply to ground support equipment. The motivation behind this piece was investigate the efficiency of aircraft movement on taxi ways before and after takeoff. While this large scenario doesn't apply to the research of this paper, the routing mapping does. The team mapped the general steps of the aircraft, then applied the Quickest Path Problem with Time Windows (QPPTW) which uses "vertex based label-setting algorithm based on Dijkstra's algorithm and can sequentially route aircraft on the airport surface, using a directed graph model of the airport" (Ravizza, Atkin, & Burke, 2014)

Similar to the way a doctor must determine the order of care for patients in the emergency room, so must ground service providers determine the customers who need the most attention, and allocate the resources as new needs become known. Similarly, a few papers on the topic of triage, advocate for short term, dynamic, scheduling that evolves throughout the day and make the case for blocking out times for the most important of surgeries or treatments, while less important calls are balanced in between (Rauner, Schaffhauser-Linzatti, & Niessner, 2012) (Herring & Herrmann, 2012). These papers commonly rely on capacity planning with finite amount of resources.

Another line of thinking behind job shop scheduling is the use of genetic algorithms, which constantly evolve given new constraints and data, and eventually yield several optimal solutions. In this paper, assumptions such as processing times are determinable, each vehicle can be processed only one operation as a time, and that there are no restrictions, are applicable to the problem of ground support equipment scheduling, but they have a major difference: this paper assumes arrival times and departures are known, plus time spent at the terminal is fixed or previously know (Cheung, Ip, Lu, & Lai, 2005). These assumptions won't hold up for the general/private aviation sectors since most of these times are influx and constantly changing, but parsing out the information yielded from the algorithm into readable Gantt chart was an inventive way to show results and the schedule for ground crews.

DATA COLLECTION

TIME STUDIES

An important aspect in data collection is the time study. The study conducted for this project looked at the time it takes for line service technicians and customer service personnel to fill a customer order for fuel. There are two separate studies going on – one from the perspective of the customer service representative, the other from the perspective of the line service technician. The reason these time studies are delineated as such, is because there are discrepancies present between them due to differences in the time the order is read back versus the time the fuel is actually pumped. For example, a customer will call in an order to the customer service representative (CSR), and the CSR may become busy with other tasks and forget to call the order out to the line service techs. Having the two studies partitioned will reduce the discrepancies that may occur from the CSR not calling the fuel order out, or an LST not calling the fuel order back to the CSR.

For CSR's, the steps between receiving a fuel call and pushing the button to let the customer out the door, is fairly straight-forward. First the call/order is received, which is then called out to the line service technicians (LST). The LST's then call back the fuel order to confirm the order and tail number is correct. The CSR then waits for the read back from the line service technician, which after receiving, calls back the account name, tail number, ending meter, gallon total, and a cap secured check. The CSR then proceeds to charging the customer

and the customer is then on their way. If this project had been concerned with 5s'ing the station, the steps in this process would be broken into micro-movements, times and distances. Since this project is concerned with only the major steps and times, the time study remains at a 'macro' level, especially since the CSR remains at the same location for most of the call.

With the LST's, it a similar story, but their tasks are much more easily broken up and regimented such as "Chock Truck", "Ground Aircraft", etc. While there are more steps and procedures for line service to follow, their tasks are easier to delineate and time (i.e. Fueling an aircraft is a prescribed method: chock truck, write meters down, ground aircraft, unreel hose, etc.). The LST time study begins with the initial call out of the fuel order, and ends as soon as they call the fuel order and gallon total back the CSR.

FUELING LOGS

As mandated by the FAA, companies that buy and sell fuel must maintain records of fuel sales for no shorter than three years after the exchange was conducted. This means there is copious amounts of digital fueling data since 2010, and even further back in paper format. Examples of fueling logs can be found in the Appendix, Figures 6, 7, 8. The benefit from this data is that dates and times are recorded for all fueling, which means accurate rates of fuel sales can be extracted. Additionally, accounting keeps a record of all fuelings, which were accessed to gather the averages of fueling amounts.

There are a few key performance metrics gleaned from this data. After poring over umpteenth spreadsheets there are 6 main categories of fueling data that was collected.

- 1) # of AvGas (100LL) uplifts per day and the average
- 2) # of Jet A uplifts per day and the average
- 3) Amount of AvGas sold per day and average
- 4) Amount of Jet A sold per day and the average
- 5) Average gallons sold per uplift (100LL/Jet)
- 6) Rate of fuelings per hour.

The first four (number of AvGas and Jet A uplifts per day and the gallons sold per day) can be learned from fueling data provided by the accounting department. In their spreadsheet, it has each uplift organized by day and gallons sold. Through this data, the actual and average number of uplifts per day can be gleaned. The fifth metric, average gallons of AvGas and Jet A sold per uplift, can be found in the same spreadsheet, after a bit of data re-organization and manipulation, namely adding up the gallons sold and dividing by the number uplifted that day.

Finally, the sixth metric, rate of fuelings per hour for AvGas and Jet A, were extracted through a manual method. Each day, the customer service representative begins a fuel dispatch sheet, in which the times are marked from when the fuel order is called out to line service until when the fuel call is finished. For this paper, the time the fuel call is called back is the time in which the fuel call is recorded. By going through every day of the 2012 year, one can tally up the number of fuel calls per hour, then using this data from January until December, averages and rates can be calculated, and trends can be extrapolated.

For this research, the fueling logs for both Jet A and Avgas have been parsed out to create an accurate representation of the fuelings per hour, broken up by quarter. First is avgas. There is no significant change between the number of fuelings per hour, and per quarter, so an average an accurate representation of the yearly rate of fuelings. These do not account for the number of aircraft on the ramp at any given time, and, additionally, not all aircraft require fuel when they land, they may only be here for a quick pick up or drop off. The use of this data though, shows how tied up the resources are on the ramp. As displayed in the Appendix - table 2, the average fuel call rates between, 0900 and 1300 hovers between 1 and 2, which means that 2 Avgas trucks and 2 line personnel are tied up taking care of those orders. Quarter 2 and Quarter 3 are the busiest for the FBO, at the times between 1000 and 1500, where the rates of fuel orders average 1.6 per hour.

Next is the Jet A data (table 4). The average purchases of Jet fuel per hour reveal an interesting pattern. There are 3 distinct spikes in the rates of orders, one around 0800, another at 1200, and a final spike around 1600. This pattern is similar to that of a normal working day. The spike around 0800 is due to of the beginning of the work day; the jet is picking people up to take them to work, or possibly dropping them off, while the mid-day spike is the half day mark, where people either have meetings in the morning and travel in the afternoon, or vice versa. The final spike in the day is the reverse of the morning spike, where people are returning from work or coming from home. These spikes range from 1.5 to 2.5 jet calls per hour.

DESIGN

CURRENT WEB APPLICATIONS

Websites such as ForeFlight, TraqPak, and Flightaware, which are ubiquitously in industry, are well known, and have already engaged the target audience for the SkyCSR web application (commercial and general pilots).

TraqPak is a subscription based website that allows FBO's to see the tail number of inbound aircraft, the type of aircraft, estimated arrival times, estimated time enroute, and the departure airport. There are no services that are included on either of these websites. According to their website, their web application offers live like tracking with "Fully integrated functionality driven by FlightView® active air traffic information" and offers a detailed historic activity data.

Other websites such as FlightAware, offer live tracking, maps, flight statuses, delays, all aircraft across all sectors (airline, private, general, etc.) The company also offers flight planning services such as “airport activity, flight and airport maps with weather, aviation statistics, flight planning and instrument flight rules procedures for airports in the US” (FlightAware, 2015).

On the FBO side of the services planning, there aren't any “industry standard” applications. Some companies use web applications called TraqPak, FlightExplorer, or Flightaware. Flightaware is limited only to the planes that have filed flight plans, leaving out a large portion of general aviation and VFR flights that don't require a plan to fly. Flightaware is also for general information, meaning anyone, anywhere can access the information, which makes some aircraft owners weary, and pay to have their tail numbers blocked from tracking programs. FBO's typically keep track of customer service requests with a Customer Resource Management (CRM) tool such as Microsoft CRM or the Oracle application Corridor. Corridor is tailor specifically to the aviation industry and has many extremely useful applications. Unfortunately, Corridor is unable to be linked to a web application where pilot can arrange an arrival and services needed, and relies on the customer service agent inputting all applicable information into the database.

SURVEY

The survey was administered to a group located at the San Luis Obispo Airport. Pilots included are general aviation pilots (Part 91), contract Pilots (Part 135), and flight schools who call for fuel from the local fuel provider. Those who took the survey have dealt with ground services directly – pilots, flight schools who call for fuel, etc.

The goal of the survey (See Appendix B, Figures 7-9) is to take a general baseline for how the ground service technicians are doing so far and what the observed causes for delay are, from the customer's (pilots) perspective. The survey included 8 questions, beginning with the participant's involvement in aviation. It specifies classification of the participant, determining whether they are recreational flyers (flying for fun), instructors, or FAA Part 121, Part 135, or any other category they fall into. The following questions then ask about experiences with delays, how often they happen, and to give specific examples of delay causing behavior or scenarios they have personally under gone. The questions include areas for responders for free write responses, and the questions leave the answer open so that they participant can respond how they see if, without making them feel like their answers should be directed toward any one problem. The final question is a free response question and calls on the participants to recount any particular recurring issue or problem they see with ground support.

From the responses (n=34), fueling operations generally run smoothly. 92% of surveyors are based at the local airport (KSBP), and they are divided between career pilots (Part 121/ Part 135) and instructor/student (Part

61/Part 91/Recreational), with the majority (85% of respondents) being Part 135. The majority of the respondents (25) stated that they were only delayed a few (1-3) times, while 7 respondents stated they had been delayed 2-5 times per month, with the last respondent saying they had never been delayed due to waiting for ground services. Delays were defined as waiting for services longer than 10 minutes.

The next question asked what the causes for the delays seemed to be. By asked what the perceived causes are, the fuelers can understand how the customers perceive what their delay is being caused by. More than half of the respondents (21) reported that they believed their delays was due to the lack of line service personnel (the technicians that fuel the jets). A significant portion (14) also reported that their delays were due to their fuel order being forgotten or that there wasn't enough ground service equipment to meet the demand. Other responses included "wrong fuel order being executed" and "undertrained staff." A few respondents choose to respond in the write in section, one in particular responded with "lack of communication between ground service personnel" and "errors in catering/missing catering."

The final question of the survey asked respondents to list a particular instance in which they were delayed on the ground due to customer service/line service operations. The goal of this question was to tap into the particular memories that caused annoyance. For most pilots, there is always that "one" experience at a jet center or FBO that sticks in their mind as being the paragon of incompetence, which was what this question aimed to capture. Out of the 16 respondents, 8 responded with being delayed due to the fuel trucks not moving quickly enough, that the aircraft must wait for others to be fueled before them, or that there was not enough personnel manning the ground support equipment to meet the demand of the incoming aircraft.

LOGIC DEVELOPMENT

Once the survey was completed, and the idea for a web application was finalized, a good portion of time was spent on developing the logic behind the algorithm (Appendix C – Figure 15). The paper goes into more detail later on but generally, the algorithm works by evaluating the needs of the customer and ranking them based on how many services they will need on the ground. Services that are labor intensive, long, or directly relate to the customer have a heavier weight, while services that are easy to accomplish, may take only one technician or relate to the crew have a smaller weighting. The score they are given is the summation of the weights of the requested services. The algorithm then looks at whether the aircraft is quick turning or not, if they are quick turning the summed weight is multiplied by 10, if they are not quick turning, the summed weight is multiplied by 1. Weights are then categorized in to LOW, MED, or HIGH and recorded in the database.

WEB APPLICATION

At the beginning of the project, it was important to identify the basic goals of what the application would be able to do. Based on the responses from the survey, there were a handful of tasks that the application must be able to do to provide any sort of relief to the ground support team:

Table 2 - list of primary objectives for web application

Schedule Arrivals
Schedule Fuelings
Create FBO Profile/FBO Login Ability
Ability for FBO to see needs of inbound aircraft
List of inbound aircraft organized by urgency

The following sections run through the design of each page involved with the web application.

SCHEDULED ARRIVALS

After observing the general and private aviation, there were a few assumptions made regarding basic information needed to schedule and arrival. There is a specific reason that scheduling arrivals and fuelings are delineated separately. This has to do with understanding the general circumstance of the aircraft – if we know there is just a fueling scheduled, the aircraft is most likely already on the field, and the fueling can be done at any time or is a known customer. Arrivals are separated because it notes that the aircraft has yet to land on the field and may require additional services and assistance beyond fuel.

The form (see Appendix Figure 6) asks for the most common of requests: Arrival airport identifier (a 4-letter code that signifies an airport), the FBO at the airport they are going to (since not all airports have the same FBO's or only one), name, email, tail number, airplane type, arrival date, and arrival time.

Once the “order” is submitted, an email will be sent to the pilot confirming their order, and an additional email will be sent to the email the FBO provides when they signed up. The web application, built primarily with ASP.NET and SQL, will organize the aircraft using an algorithm that “weighs” particular ground needs (See Figure 5). The more needs an aircraft has, the higher its “weight” becomes.

The algorithm takes into account how close the aircraft is to landing, whether the aircraft is quick-turning, if they are taking fuel, if they have any rental car or personal vehicles that need to be pulled around planeside, etc. Aircraft that are landing the same day have a weight of 8, aircraft landing within a day or two have a weight of 3 and landing outside of the two day window, weight of 1. The rest of the weights are as follows:

Event	Weight
Quickturning -	YES – 10/ NO-1
Jet A	10
100LL	7
Rental Car	8
Lavatory Service	3
GPU	4
Catering	4
Airstart	6

All weights are added together, then multiplied by the quickturn weight, which is either Yes or No based on the pilots input. A score of higher than 110 is recorded as a “HIGH” urgency, a score lower than 40 means “LOW” urgency, while score that lie inbetween are recorded are “MED.” The weights were chosen based on time and resources expended, plus a consideration toward customer service. Weights ranging from 1 to 3 typically only require one line service technician or is a simple and relatively easy task. Weights ranked between 4 and 7, may require more technicians and may be more time consuming, while weights above 3 are considered more time consuming, hold more in terms of customer satisfaction or take the participation of more than one technician.

For example, while a rental car may only take one line service technician to deliver the car to the aircraft, is ranked as an 8 because it holds such a high customer satisfaction level. When customers have to wait for rental cars that should have been planeside on arrival, are typically dissatisfied with the level of service, and less likely to return to that particular FBO. Another example is the airstart. In terms of operability, the airstart is quite similar to the GPU, but more difficult to move, hook up to the aircraft and start, and generally takes a longer amount of time. It typically takes two technicians, which end up taking more resources away from the rest of the ramp, thus the airstart was ranked a 6, while the GPU is ranked a 4.

After submitting, the web application updates the “Arrival History” table in the database through a series of SQL injections, then redirects the user to a “Thank you” page and asks if they want to schedule another arrival or if they would like to return to the home screen.

SCHEDULED FUELINGS

As mentioned before, the scheduling fuelings page is separate from the arrival scheduling page. Fuelings assume the aircraft is already on the field, and streamlines the process by not having to ask for additional services. The page (see Appendix Figure 5) opens with the airport identifier of where the aircraft is located, then asks for the FBO name where the aircraft is being stored. It then asks the basic questions: what type of fuel, fuel request, date and time this needs to be completed by (with an option for ASAP), the account name, tail number, and any special requests.

The requester can then submit the fuel order and have the application update the database and send a notification to the FBO of the fuel order, both through email and on the FBO's website. The algorithm this webpage passes through is similar to that of the scheduled arrivals, but taking into account the psychology of a customer waiting, the most important algorithm is that they are fueled fairly and in the order in which they ask, also known as first come, first served. This website will still perform an algorithmic check and assign a weight, but these weights will be more at the discretion of the technician.

The reasoning behind giving discretionary power to the line technician, is that there are often times multiple trucks running that can take care of fuelings. For example, an FBO with two trucks servicing an entire airport will not fuel aircraft in a First Come, First Served only. They will evaluate the orders in a First Come First Serve manner but also consider circumstance. An example would be if the next aircraft in the theoretical queue was on the other side of the airfield, while the second aircraft in the queue may be right next to the current aircraft, it would be a waste of time to drive to the other side of the airfield, then return to near the same spot fuel the other aircraft, especially if they can send the other truck to do the fueling. The web application will support a heuristic approach to fueling the aircraft and allow the line service technicians to make the call on which fuelings are the most important, with supplemented information provided by the web application and the weights calculated.

CREATE FBO LOGIN & FBO HOME SCREEN

In order to start viewing arrivals and upcoming fuels, the FBO must create a profile. The profile includes all the basic services and amenities the FBO provides plus the airport identifier (ICAO⁴) they are based at, a primary email, telephone number and frequency they monitor (see Appendix – Table 5). Once this has been established, the FBO will receive an email that confirms their log in account, then be redirected to the login page.

The main screen for the FBO, opens to an SQLdatasource produced gridview, which populates based on the relationship of the "Arrival FBO" and the "FBONAME" associated with email logged in with. The gridview has the arrival id, ICAO, email, name, tail number, aircraft type, ground services and the level assigned to the arrival. The arrivals populate based on the associated FBO name with the email that is used to log in.

The table can be sorted by what ever criteria the user wants to use, and once a record is selected, the form underneath the table produces a label with the name and email of the pilot, plus a message box and confirmation button. This will enable the FBO to send messages to the pilot if they need to clarify needs, services, or arrivals. In the event that the instructions by the pilot are unclear or if there is a problem with the services the FBO is offering, this will allow the FBO to contact the pilot quickly.

⁴ International Civil Aviation Organization (ICAO) – airport identifiers that are unique. The ICAO for Los Angeles International Airport is KLAX (LAX)

Toward the bottom of the page, there is a section for scheduled fuelings. This gridview populates the upcoming fuelings and displays the fuel type, request, fueling date, time, account, tail number, plus any special requests. The form also allows for ASAP fuelings. When this gridview is selected, a menu appears at the bottom that shows the user the exact order with the fuel type and account name. It also displays two buttons, one that says “confirm”, the other saying “finished.”

Ideally the line service technicians will have access to the display which fueling (via Ipad or computer station in the fuel trucks or line shack), and they will be able to confirm the order as it arrives, then, once the order is complete, press finish. Once they have finished the fueling and pressed finished on the form, the customer who submitted the order will get an email notification saying their fueling has been completed, while the FBO will be able to see when the fueling has been processed and completed.

METHODOLOGY

The first step in developing the web application was to pinpoint the necessary items needed on the forms. This was determined, as mentioned before by the pilot survey. The pilot survey was intended to understand the deficits that even the more experienced line personnel can experience. In the aforementioned results, it became apparent that the majority of delays were caused by the perceived lack of ground support personnel and equipment. Since it is not financially responsible to have 9 or 10 line personnel at an airport that experiences arrivals at a rate of 6 per hour, during peak season, it would be helpful to be able to see all inbound needs of scheduled arrivals, so that ground support equipment can be readied and prepared, whether this means having the GPU set up or having the Jet trucks topped off with fuel.

In addition to the pilot survey, numerous observations and time studies were taken with the line crew at the local airport. These observations yielded a few best practice methods for the line crew, that wouldn't have been apparent from surveys. Heuristic methodologies, also known as best practices, are typically learned on the job and don't necessarily follow a standard operating procedure, but make the job of the line service technician efficient or easier in some way. For example, a line service technician must ground the aircraft and fuel truck to protect themselves and the equipment from electro-static discharge. After observing senior line technicians, it became apparent that their best method for making this particular step more efficient was to ground the side of the aircraft that would be fuel last⁵, to save them from walking back and forth an extra trip. Heuristic methods like the one described previously, cannot always be accounted for in models, which makes it important to provide as much helpful information to the fuelers as possible, but then leave them with the final decision as to their next move.

⁵ In some types of aircraft, the tanks are filled one by one via fuel caps on the top of the wing. Other aircraft are filled from a single opening, similar to a car, on the side of the aircraft. This is referred to as “single point fuelings.”

After the pilot survey, the web application was developed. The web application was established using visual basic and ASP.NET. As the web application came together, more pilots and flight schools were asked for input regarding layout and basic information for arrivals and fuelings. The majority of the programming took place at the Cal Poly Industrial Engineering computer labs, since they are equipped with the software needed. For the first iteration, the website was reviewed by a local flight instructor and several pilots. They gave specific recommendations based on usability, interface, design, application, even further possibilities for expansion. The application was iterated three times based on feedback from a select group of pilots, flight schools and instructors.

The web application was re-evaluated to the extent that was applicable to the scope of the project. Additions to the application were included after being vetted by multiple users for their input regarding the effectiveness of the addition. Most of the additions and expansions to the application came after the first iteration and were then vetted and improved upon during the second iteration.

RESULTS AND DISCUSSION

FIRST ITERATION

During the first iteration it was understood that the original design needed some reconfiguring. The layout of the physical website was lacking structure and uniformity, and it was noted that several of the columns in the grid view showed up when they were supposed to be hidden. Most of the website was manual, meaning the use of “enter”

to move the cursor, actually submitted the form. Generally the layout was satisfactory for the schedule arrival and schedule fueling pages.

Throughout the discussion, fueling became a much more apparent issue than previously realized. After talking with pilots, the general consensus was to “get the job done” as quickly as possible with as little error as possible. The application, while not being quicker (yet) than calling the FBO, ensures that the needs to conveyed to the arrival FBO and takes out any possibility of miscommunication.

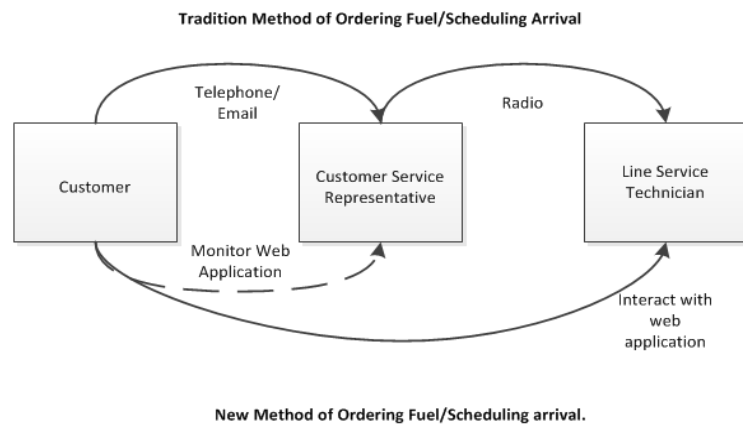


Figure 1 Traditional vs. Theoretical model of communication.

The first iteration group observed that fuel orders are typically forgotten or erroneously communicated in the process of dispatching the orders to the line service technicians. Customer service agents typically work as “middle-men,” where the customer gives the order to the customer service agent, which is then dispersed by the agent to the line service personnel. A suggestion from the first iterant group was to make the application available to customers who just need fuel and determine a way in which line service technicians would be able to interact with the fuel order directly, instead of relying on the customer service agent.

After this interaction with the first trial, the “schedule a fueling” page was developed. This page, as explained before, has the user input types of fuel, special request, account information, etc. The information submitted is then stored in the data base and saved until accessed by the FBO, on their home page. The home page then shows upcoming fueling and all necessary information. The grid view that this information is stored in expands downward to show details regarding the fueling and two buttons: confirm and finish. This portion of the page will allow line service technicians to confirm they have received the fuel order. As soon as they push the “Confirm” button, the data base will update on both the FBO home screen and the line service screen. After confirming, the LST can go fuel the aircraft and upon completion, they can push the finish button, which will alert the FBO that the fueling is complete. It will also alert the customer that their fuel order has been complete. By having the line service technician directly involved with the customer order and not relying on the customer service agent to dispatch out the correct fuel order, the probability of errors in a fuel order will sink. Line service technicians are given the fuel order directly; while customer service agents are aware the fuel order has been submitted and can monitor the progress as an inactive bystander.

Throughout the first interaction there was also discussion regarding a “modify” or “cancel” fuel order. This was considered, but will ultimately be for a later version of the web application. It was stressed that the most important factor is to keep the form simple and straight to the point. Only the most pressing of issues should be allowed on the form, everything else should be kept to a minimum. Of the participants, the average time it took to put in the fuel order from the web application was 2:05.96 minutes. The average time it took to call in the fuel order was 1:02.64 minutes. While it was faster for the participants to call in the order, it can be argued that having the physical order in front of the line service technician to ensure the order being executed correctly, justifies the extra minute spent to input the order. There is also a learning curve associated with the use of the application. As users input more and more arrivals/fuelings, the faster they should, theoretically, get at inputting the information.

SECOND ITERATION

In the second trial, it was discussed about having a confirmation email for arrivals, to let the pilot know that the FBO is aware of their arrival. Instead of putting in a confirmation button, the design leans toward a message

box and email that will confirm any additional orders or reconfirm specific instructions on the ground. This will allow the FBO to send customized messages, instead of sending an encompassing “confirmation” email. Most of the discussion revolved around current methods similar to the SkyCSR model – FltPlan.com has a similar set up but without the weighing algorithm or ability to communicate directly with the FBO. FltPlan.com also lacks the infrastructure for FBO’s to see inbound aircraft, and instead relies on faxes built off of the input on their web form, that are then faxed to the arrival FBO.

Through the discourse, it was also mentioned that pilot have so many apps at their disposal that they are responsible for, that adding another one may inhibit their job performance. Pilots are responsible for weight and balance calculations, including runway calculations, airspeed, flight planning, and fuel loads. Adding an additional application, would potentially make it easier on them in the long term by making sure their ground support needs are recorded and performed, but adding an additional application to the process, may seem counterproductive, especially if they can just call the FBO ahead of time to advise on services.

Building off of this idea, it seems like the best market entry for a web application like this would be to associate it with an already existing application, such as ForeFlight or FltPlan.com. These websites that are ubiquitously in industry, are well known, and have already engaged the target audience for the SkyCSR web application (commercial and general pilots).

FBO’s typically keep track of customer service requests with a Customer Resource Management (CRM) tool such as Microsoft CRM or the Oracle application Corridor. Corridor is tailor specifically to the aviation industry and has many extremely useful applications. Unfortunately, Corridor is unable to be linked to a web application where pilot can arrange an arrival and services needed, and relies on the customer service agent inputting all applicable information into the database.

WEB APPLICATION EXPANSION

After the website had been reviewed a few times, there are a few modifications that will happen in the future. First is the addition of a cancel/modify button. This button will allow pilots and flight schools to cancel or modify fuel orders that they have already submitted. There are two possible methods to accomplish this, the first being that every time an email is sent confirming the fuel order there is a unique “fuel code” sent with the email that will allow the pilot to enter into the form and modify or cancel the existing request. The second way to do this would be to set up a pilot account similar to that of the FBO account, where the pilots would be able to login and view, cancel, or modify orders.

The next set for the web application is expansion and actual use. The web application, as noted in the interviews during the trials, would be the most helpful in smart phone application format, where pilots could just tap on the

app, fill out the form and send it, without having to open a browser. Going off this line of thinking, the application could potentially be incorporated into existing sites such as fltplan.com or foreflight, where they have the information about the airfield, flight plans, departure plates, arrival plates, and other aviation information, already loaded on, and now, with the addition of this web application, they would have a way for pilots using their app to communicate directly with the arrival FBO, via their application.

As the final idea for the future of this web application, it was expressed that maybe using the application as a communication and services manager for the FBO would be beneficial. Pilots could input needs and services but having the FBO web page tailored to either the customer service desk and the line service technicians would help the manage the communication of service needs. The customer service desk would still have the upcoming arrival and fuelings open to see and coordinate the inbound arrivals, but line service would be able to update, process, and complete fuelings all with the app, which would allow the customer service desk to observe from afar and not interrupt the line.

CONCLUSION

There is a clear technological crevasse between the needs of the pilot and the FBO's that provide the services. SkyCSR attempts to bridge the gap between pilot and FBO, where already existing applications such as ForeFlight, TraqPak, FltPlan.Com, and Corridor, fail to. Communication tends to breakdown as customer service agents become impacted by the number of requests and inbound flights, that it can be difficult for them to remember every detail to advise the line service technicians, which results in a less than satisfactory customer experience. The goal of this project was to create a new form of communication in which the needs of the inbound aircraft would be clear and explicitly understood, allowing for ground personnel to ready for the aircrafts arrival.

The first task was to conduct a survey to understand where the perceived deficiencies are, from the perspective of the customer, then exploit these deficiencies and provide a solution to solving the communication interruptions. Toward the beginning of the survey, it seemed as though a prototype of the web application would be unhelpful, and that the majority of issues came from lack of adequate training or just not enough personnel on the field. As the survey progressed, however, the prototype of a web application where the pilot can schedule fuel and arrival needs, without needing to contact the FBO, was justified by the responses to the survey. The web application was attempted using ASP.NET, and went through several iterations before being tested twice by both flight instructors and pilots.

The trials and initial testing of the application early on, proved to be extremely useful. The feedback received was both appreciative and constructive; meaning most of those who tested the application saw good potential for it and offered some productive critique. Between the trials, the largest difference was the addition of the

fueling page, which caters mostly to the local flight schools to schedule fuelings before and in between lessons. In addition to the fueling page, the FBO login page got a “scheduled fueling” gridview, which showed all upcoming fuelings. During the first iteration/testing, it was noted that there should be some kind of ability to confirm and notify the customer that their fuel order had been completed, which was added before the second round of testing.

Should this project happen again or something similar to it comes up again, it would be beneficial to spend more time with the development of the website especially during testing. Next time around, having a large pool to test with and reaching out to more pilots, flight schools, and FBOs would help in developing a useable and optimal prototype. In even industry application, there is always a need for more and continued testing and customer service feedback for improvement, but it’s unacceptable to continue testing a never release a product. In the future, 3 or 4 trials of the prototype would be ideal for testing with 3 to 4 people per trial. The small group keeps everyone on the same page and interacting with each other, allowing for a discourse about opinions of the web application and shared/varied experiences while flying. Having numerous trials just increases the opportunity for new ideas and creating an optimal prototype before live testing.

Another opportunity for improvement would be the addition of a schedule. Since this was a one-person project, it was easy to not set a schedule and keep a general idea of the schedule in mind, but having a Gantt chart with the due dates and deadlines, would have kept the project moving smoothly and not in spurts. Part of developing web applications is the consistent “mind block” –where looking at the same piece of code for longer than 20 minutes begins to have an adverse effect on performance. There were a handful of times the mental block would keep me away from programming, then a few days later, after thinking about the problem and attempting it again, the revision in code would work and then I would move on to the next issue. The web application is currently working, but could use further development. The layout needs an overhaul but the barebones of the application work. The goal is to either develop the application independently for a local fixed base operator, or try to appeal a larger application company to develop something further using this framework. The largest obstacle that the app would face if the application were to be a “stand alone,” is breaking into the market. Pilots aren’t interested in using another application in addition to their already stressful and multitask-oriented jobs, especially if it’s for only one airport. Integrating this application into an existing model would be the most successful path for this web application.

Overall, this was a great culminating project. The application of database programming to the aviation industry was an ideal intersection for my two favorite things: ASP.NET and airplanes. This senior project was a interesting learning experience for me, especially with having to establish my own deadlines and set my own

pace. It provided an incredible overall learning experience, and proved to be a great ending that brought together most of what I have learned over my Cal Poly career.

WORKS CITED

- Association, G. A. (2015). *General Aviation Market Data*. Retrieved from Aeroweb.
- Association, G. A. (2015). *General Aviation Statistical Databook and 2015 Industry Outlook*. General Aviation Manufacturers Association.
- Aviation International News. (2011). 2011 FBO Survey. *FBO Survey: The Americas*.
- Bachman, J. (2014, February 11). *Yes, There's a Pilot Shortage: Salaries Start at \$21,000*. Retrieved from Bloomberg Business.
- Cheung, A., Ip, W., Lu, D., & Lai, C. (2005). An Aircraft Service Scheduling Model Using Genetic Algorithms. *Journal of Manufacturing Technology Management*, 16(1), 109-119.
- Ewalt, D. M. (2013, February 13). *Thirty Amazing Facts about Private Jets*. Retrieved from Forbes.
- Federal Aviation Administration. (2016). Federal Aviation Regulations/Aeronautical Information Manual. Washington D.C.: United States Government, Federal Register.
- Finance, A. (n.d.). *Hypothetical Operating Cost Calculation*. Retrieved from Aircraft Owner and Pilot Association.
- Fleet*. (2016). Retrieved from NetJets: <https://www.netjets.com/Home/>
- FlightAware. (2015, March 17). *About FlightAware*. Retrieved from FlightAware.
- Grundig, J. (2013, August 20). *Understanding Part 135*. Retrieved from Sherp Report.
- Herring, W. L., & Herrmann, J. W. (2012). The Single Day Surgery Scheduling Problem: Sequential Decision-Making and Threshold-based Heuristics. *OR Spectrum*(34), 429-459.
- Martin, C., Jones, D., & Keskinocak, P. (2003). Optimizing On-Demand Aircraft Schedules for Fractional Aircraft Operators. *Interfaces*, 33(5), 22-43.
- Matter, G. (2012). Why Waiting Is Torture. *The New York Times*.
- Norman, D. (2008). *The Psychology of Waiting Lines*.
- Prince, R. A. (2013, June 11). *Eight Trends In Private Jet Travel*. Retrieved from Forbes.
- Rauner, M. S., Schaffhauser-Linzatti, M. M., & Niessner, H. (2012). Resource Planning for Ambulance Services in Mass Casualty Incidents: a DES-based Policy Model. *Health Care Management Science*, 15, 254-269. doi:10.1007/s10729-012-9198-7
- Ravizza, S., Atkin, J. A., & Burke, E. K. (2014). A More Realistic Approach for Airport Ground Movement Optimisation with Stand Holding. *Journal of Scheduling*, 507-520.
- Shetty, K. I., & Hansman, J. R. (2012). *Current and Historical Trends in General Aviation in the United States*. Cambridge, MA: Massachusetts Institute of Technology.

- Sud, V. P., Tanino, M., & Wetherly, J. (2009). Reducing Flight Delays Through Better Traffic Management. *Interfaces*, 39(1), 35-45.
- The FAA's Impact on Small Businesses In the General Aviation Industry, 113-053 (Committee on Small Business, US House of Representatives February 5, 2014).
- Van Allen Group. (2012, February). *Cessna Citation XLS+*. Retrieved from Van Allen Group.
- Visenini, M. S., Borenstein, D., Li, J.-Q., & Mirchandani, P. B. (2014). Review of Real-time Vehicle Schedule Recovery Methods in Transportation Services. *Journal of Scheduling*, 541-567.
- Vossen, T. W., & Ball, M. O. (2006, February). Slot Trading Opportunities in Collaborative Ground Delay Programs. *Transportation Science*, 40(1), 29-43.
- Yang, W., Karaesmen, I. Z., Keskinocak, P., & Tayur, S. (2008). Aircraft and Crew Scheduling for Fractional Ownership Programs. *Annals of Operations Research*, 415-431.

APPENDICES

APPENDIX A – GENERAL AIRCRAFT/AIRPORT INFORMATION



Figure 2 Cessna Citation XLS

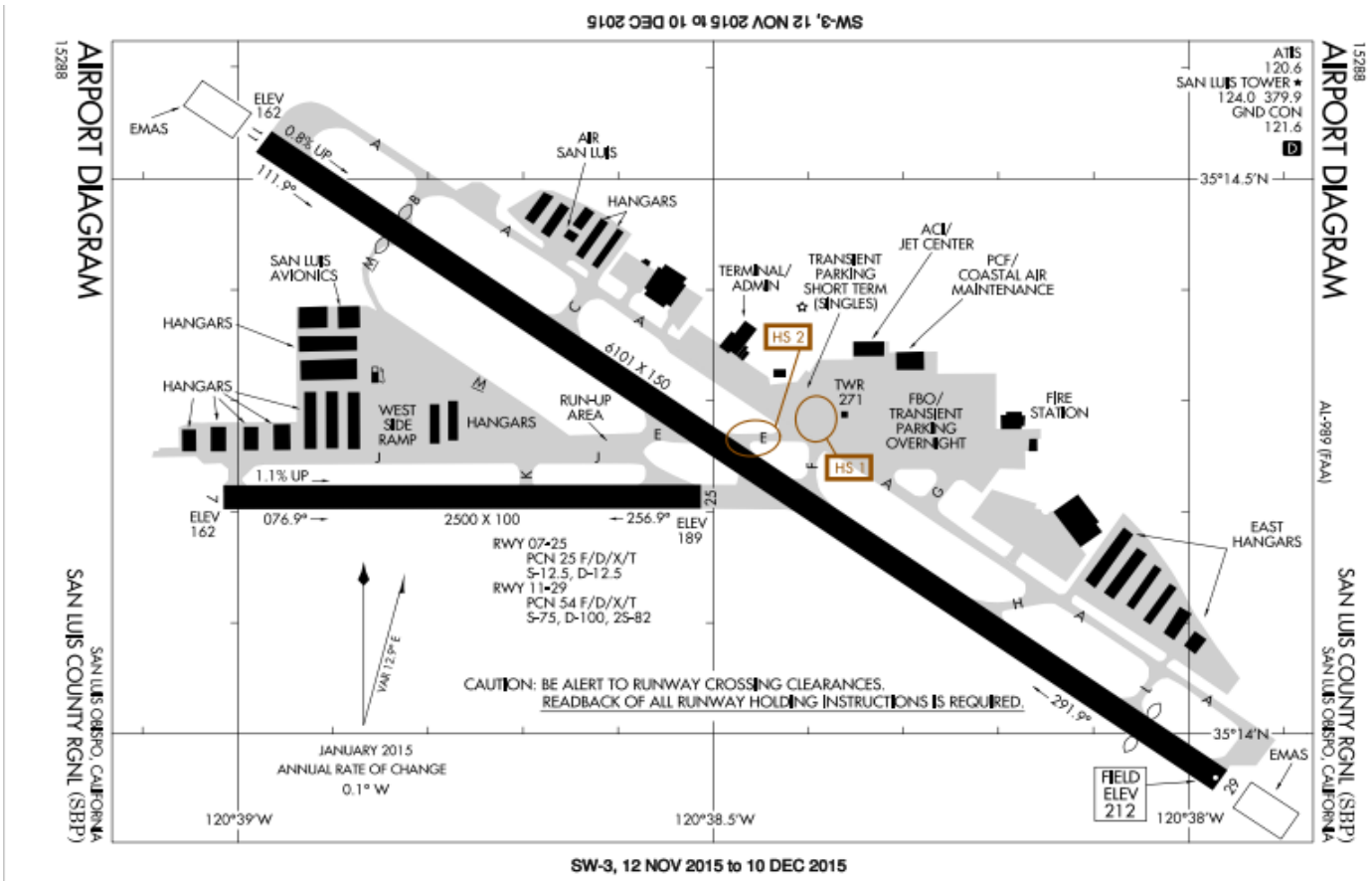


Figure 3 Airport Diagram - Commonly used by pilots to denote where FBO's, Flight Schools, Terminals, Taxi ways, etc. are located on the field

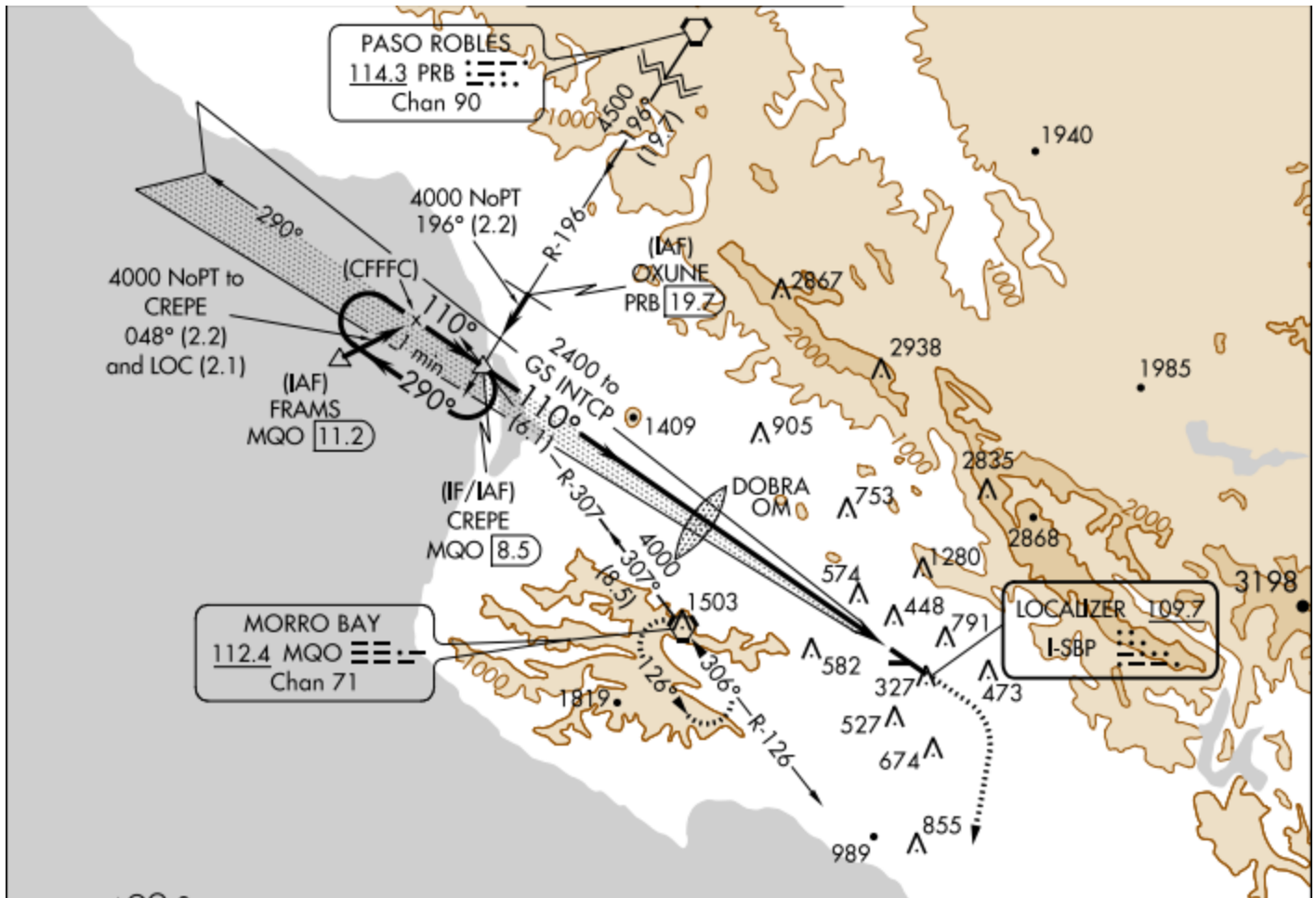


Figure 4 Cropped image of an "Instrument Flight Rules" Arrival Plate. The important part of this picture is to note the tall mountain ranges that occur north of the San Luis Obispo Airport. These mountains interfere with broadcasts regularly.

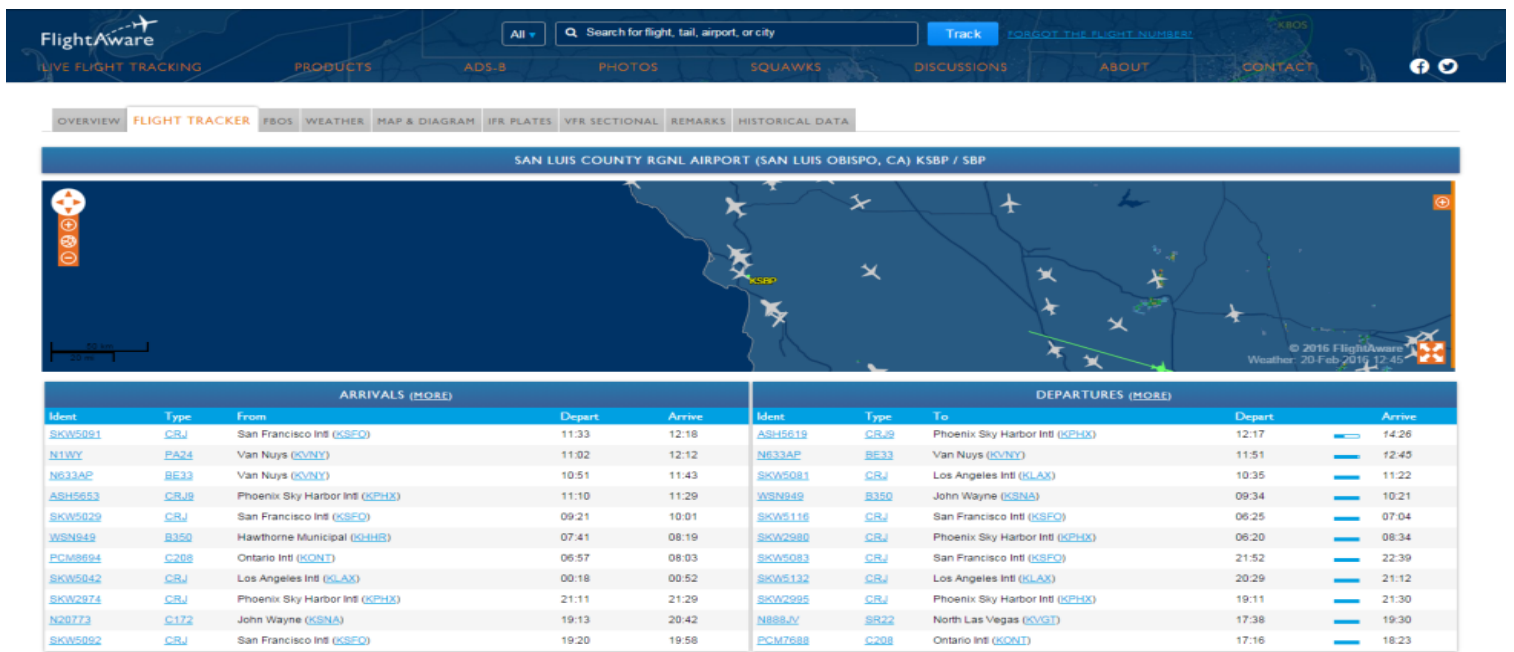


Figure 5 Screenshot of FlightAware

AOPA KSBP GO Fuel Uplift Rpt FBO Rpt CTU Rpt Depart Rpt GA Com Region Cargo

The screenshot displays the TraqPak interface. On the left is a map of California with a red pin over San Jose. On the right is a table titled 'Arrivals' under the 'Export Arrivals' section. The table has columns for CTU, FID, Type, ETE, Arr(L), PC, SC, N, Dep, Dep(L), and Fuel. Below the table, it says 'Showing 1 to 18 of 18 entries'. At the bottom right, there is a 'Departures' section with a sub-header 'Export Departures'.

CTU	FID	Type	ETE	Arr(L)	PC	SC	N	Dep	Dep(L)	Fuel
	N243BT	C182	52	13:38				KSQL	12:14	21
	N862GS	C510	116	14:42				KHWD	13:45	93
<input type="checkbox"/>	N1WVY	PA24	-35	12:11				KVNY	11:02	14
<input type="checkbox"/>	N833AP	BE33	-85	11:41				KVNY	10:51	13
<input type="checkbox"/>	WSN949	B350	-269	8:17				KHHR	7:41	69
<input type="checkbox"/>	N207Z3	C172	-94	20:42				KSNA	19:13	10
<input type="checkbox"/>	PKV8752	CL60	-907	20:19			*	KSJC	19:41	18
<input type="checkbox"/>	N335AP		-1085	19:01				KSMO		0
<input type="checkbox"/>	N335AP		-1087	18:39				KSMO		0
<input type="checkbox"/>	N815D		-1171	17:15				MUVT		0
<input type="checkbox"/>	N87298	C182	-1196	16:50				KSNA	15:28	20

Showing 1 to 18 of 18 entries

Export Departures

Figure 6- Screenshot of TraqPak

APPENDIX B – SURVEY

Ground Support Services

The goal of this survey is to understand the problems associated with ground support services within the Private Aviation/General Aviation sector. Please refer to pilot/passenger experiences in aviation that are **NOT** Part 121/Airline related. This survey is to draw on experiences at all airports, not just base airports.

1. What best describes your interest in flying? (Recreational, hobby, flight instructor, Part 121, Part 135, etc.)

2. How often are you delayed (waiting longer than 10 minutes) due to ground services? (i.e. fuel order was forgotten, airplane was fueled incorrectly.)

Little (happens only a few times a month)

Moderate (2-5 month)

Consistently (over 6 times per month)

Other

Figure 1 Beginning questions of the survey

3. In your experience, what is the delay caused by? This is excluding late passengers.

- Incorrect Fuel Order is executed
- Too few ground service equipment
- Under-trained staff
- Not enough line personnel
- Fuel order is forgotten
- Coffee/Ice/Papers being late/forgotten
- Other (please specify)

4. Is there a specific example of a ground delay caused by ground services that you can recall? (If not, you can skip.) Please be as detailed as possible.

5. What, if any, are some of the recurring problems associated with ground support?

Next

Figure 2 - second set of questions in survey. Most of the answers allow the respondent to answer more than one.

Depending on the feedback received by the survey, there may be an application produced to ameliorate the cause of delays. If you are interested in being a part of a beta test for an application that schedules ground support needs, please fill out the information below.

Thank you for your feedback and time!

6. Email

Email Address

7. Primary Airport Information

Primary Airport ID:

Primary FBO used:

Prev Done

Figure 3 Final page, just contact information and primary airport ID

APPENDIX C – WEB APPLICATION SCREEN SHOTS

Arrival ICAO:

Arrival FBO:

Name (Company/Personal):

Email:

Tail Number:

Airplane Type:

Quickturn? Yes

Arrival Date:

January	February 2016						March
Sun	Mon	Tue	Wed	Thu	Fri	Sat	
31	1	2	3	4	5	6	
7	8	9	10	11	12	13	
14	15	16	17	18	19	20	
21	22	23	24	25	26	27	
28	29	1	2	3	4	5	
6	7	8	9	10	11	12	

Arrival Time (LOCAL):

Services Needed? Jet A 100LL GPU AIRSTART LAV RENTAL CATERING Coffee, Ice, Papers

Notes:

Figure 4 - Schedule an arrival

Schedule a Fueling

ICAO:

FBO:

Type of Fuel:

Fuel Request:

Date:

≤	February 2016						≥
Sun	Mon	Tue	Wed	Thu	Fri	Sat	
31	1	2	3	4	5	6	
7	8	9	10	11	12	13	
14	15	16	17	18	19	20	
21	22	23	24	25	26	27	
28	29	1	2	3	4	5	
6	7	8	9	10	11	12	

Time fueling needs to be completed by: ASAP

Account:

Tail Number:

Special Request:

Figure 5 - Schedule a Fueling Page for Pilots/Flight Schools

Tell us about yourself...

AIRPORT ICAO:

FBO NAME:

FREQUENCY MONITORED:

MAIN EMAIL:

PASSWORD:

CONFIRM PASSWORD:

TELEPHONE:

SERVICES PROVIDED:

Figure 6 FBO Profile Creation Page

- Home
- Scheduled Arrivals
- Scheduled Fuellings
- Quick Links
- Logout

Scheduled Arrivals

January	February 2016						March
Sun	Mon	Tue	Wed	Thu	Fri	Sat	
31	1	2	3	4	5	6	
7	8	9	10	11	12	13	
14	15	16	17	18	19	20	
21	22	23	24	25	26	27	
28	29	1	2	3	4	5	
6	7	8	9	10	11	12	

	LEVEL	ID	ARRIVAL	ICAO	ARRIVAL	FBO	Name	Email	TailNumber	AirplaneType	QuickTurn	Arrival	Date	Arrival	Time	JETA	100LL	GPU	AIRSTART	LAV	RENTAL	CATERING	CIP	Notes
Select	LOW	11	SBP		ACIJET		Jared Bender	jeliseburke@gmail.com	N74GG	GVISP	NO	2/23/2016	1600		JET		GPU							

Name: ACIJET

Email: Jared Bender

Figure 7 FBO side of web application that shows scheduled arrivals for inbound aircraft on a particular day

- Home
- Scheduled Arrivals
- Scheduled Fuelings
- Quick Links
- Logout

Scheduled Fuelings

January		February 2016					March
Sun	Mon	Tue	Wed	Thu	Fri	Sat	
<u>31</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	
<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	
<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>20</u>	
<u>21</u>	<u>22</u>	23	24	<u>25</u>	<u>26</u>	<u>27</u>	
<u>28</u>	<u>29</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	
<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>	

ID	ICAO	FBO	TYPE	REQUEST	FUEL DATE	FUEL TIME	ACCOUNT	TAILNUMBER	SPECIAL REQUESTS	ASAP	CONFIRMED	FINISHED
Select	11	SBP	ACIJET	100LL	15/15	2/23/2016		Burke	N566JB		YES	CONFIRMED FINISHED

Order Details

Tail Number: N566JB
 Fuel Type: 100LL
 Fuel Request: 15/15

CONFIRM

FINISH

Figure 8 FBO side of the web application that shows the upcoming fuel orders.

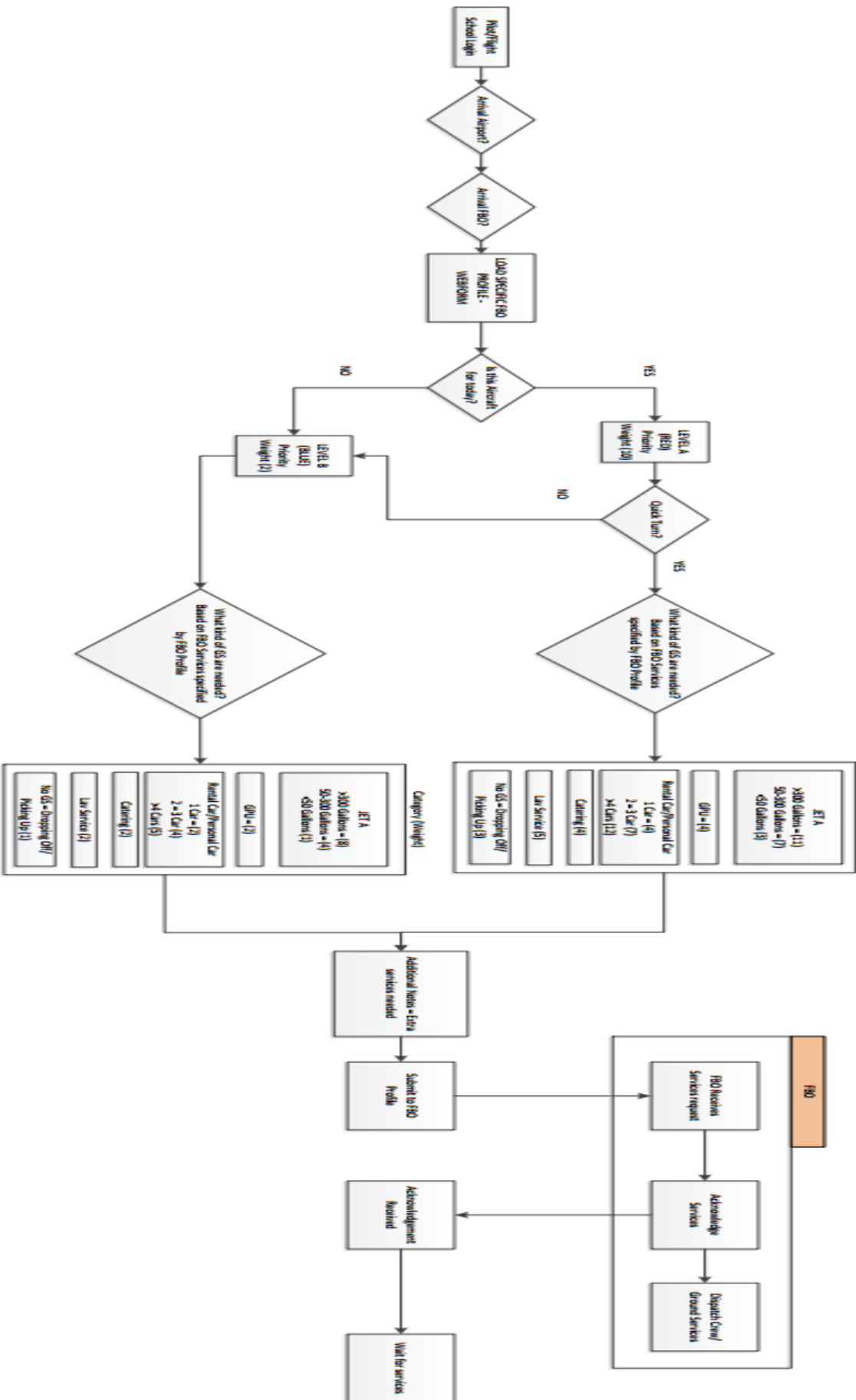


Figure 9 Logic developed in the first quarter to design the algorithm calculating the weights. There is a slight difference between this algorithm and the algorithm utilized, is that this algorithm looks at the actual amount of fuel being taken. This was omitted after pilot interviews responded that they didn't always know how much, and they weren't sure what form to put it in (bring up to so many pounds on board, put on pounds, put on gallons, etc.)

APPENDIX D - DATA COLLECTION SAMPLES

Date: JUNE 1st, 2013

Tail #	Request	Dispatch Time	Meter(s)	Gallon Total	Caps	Time	LST	Case	Ticket	POS	QB
9635K	T10	-	0340.2	10.1	✓	-	JO	X	X	X	X
3518B	✓	-	0353.8	13.6	✓	0635	MS	X	X	X	X
8153C	6	-	0370.2	6.0	✓	0833	MS	X	X	X	X
3397R	T10	0810	0364.2	10.4	✓	0817	MS	X	X	X	X
137PE	TABS	0834	0399.2	29.0	✓	0846	MS	X	X	X	X
3010W	MCP	0853	0404.2	5.0	✓	0900	MS	X	X	-	-
8153C	5	-	0409.2	5.0	✓	0956	GR	X	X	X	X

Figure 10- Example of the Fuel Dispatch Log Used to record fuelings, times, dates, customers, gallons sold, and the responsible fueller.

100LL FUEL SHEET

Truck: AU #2

Date: 06/01/13

Aircraft ID	Meter Start	Meter Stop	Gallons Sold	Gallons in Truck	Caps	Fueler
	0330.1			1000.0	CAPS	MC
9635K	0330.1	0340.2	10.1	989.9	CAPS	JO
3518B	0340.2	0353.8	13.6	976.3	CAPS	MS
3397R	0353.8	0364.2	10.4	975.9	CAPS	MS
8153C	0364.2	0370.2	6.0	969.9	CAPS	MS
137PE	0370.2	0399.2	29.0	940.9	CAPS	MS
3010W	0399.2	0404.2	5.0	935.9	CAPS	MS
8153C	0404.2	0409.2	5.0	930.9	CAPS	GR

Figure 11 Example of the truck sheets used by line service technicians to record gallons sold, meter numbers and gallons left in the truck.

JET-A FUEL SHEET

Truck: JET #1

Date: 06/01/13

Aircraft ID	Meter 1	Meter 2	Gallons Sold	Gallons in Truck	CSR - Code	Caps	Fueler
	9622	3474		3000			MC
47HF	9622	3474	532	2468		CAPS	MS
789XJ	0154		170-	2298		CAPS	JO
911TT		3474	31-	2267		CAPS	JO
886FE	0324	0354	30+	2237		CAPS	JO

Figure 12 Example of the Jet Truck sheet. It's is used for the same purpose at the 100LL sheet, but with Jet A

ROUTE MAPPING

Line service technicians are constantly driving, walking, running, marshaling, towing, or riding on golf carts/tugs to accomplish tasks. They spend most of their down time in the line shack where the radios and breakroom is, but then spread out to the commercial terminal to fuel airlines, to the west side to fuel transient aircraft, and to Site November and Site Mike (see Appendix, Figure 4) to fuel/tow other aircraft. Their routes vary significantly from day to day, and not always in the most efficient manner.

The route revealed how often and long the ground service technicians walking/riding/running to fulfill an order, whether it is for fuel, GPU, APU, lavatory service, or something else. The route begins when the order is initially called out and will end when the task is complete on a particular aircraft. The route map also looks at the general movement of aircraft, the movement of golf carts, the movement of fuel trucks and the movement of personal/rental cars as they enter and exit the ramp.

Table 4 - Average Number of AvGas Purchases Per Hour, Separated by quarter

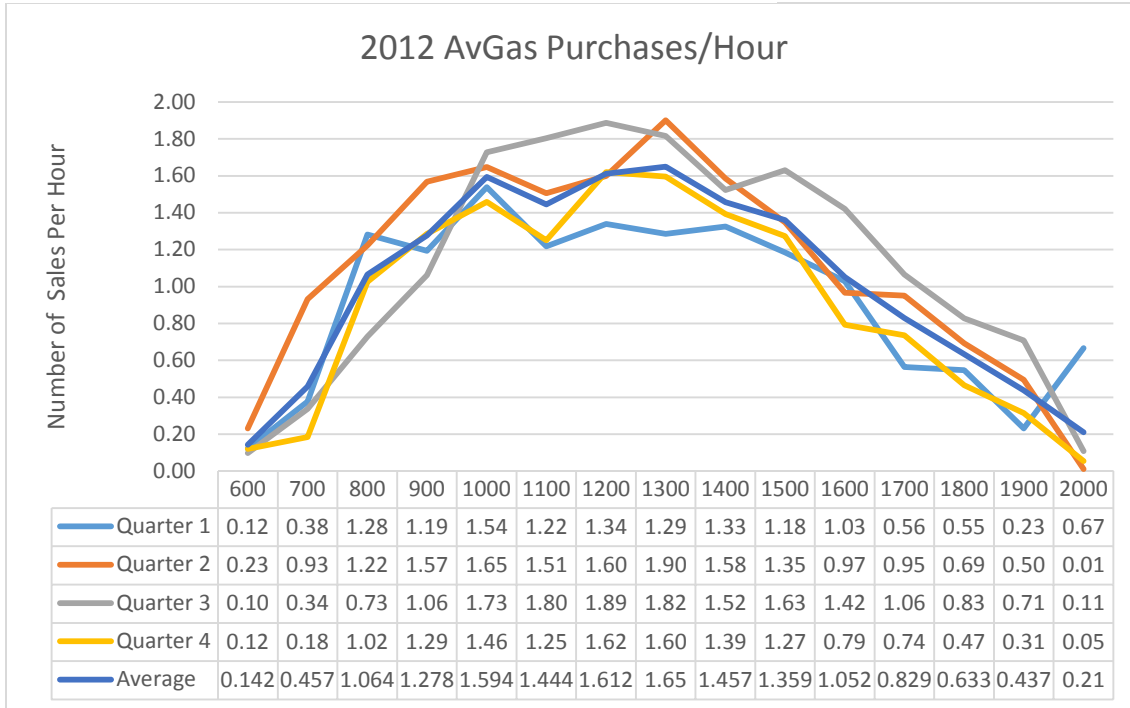


Table 3 - Average yearly sales/hour

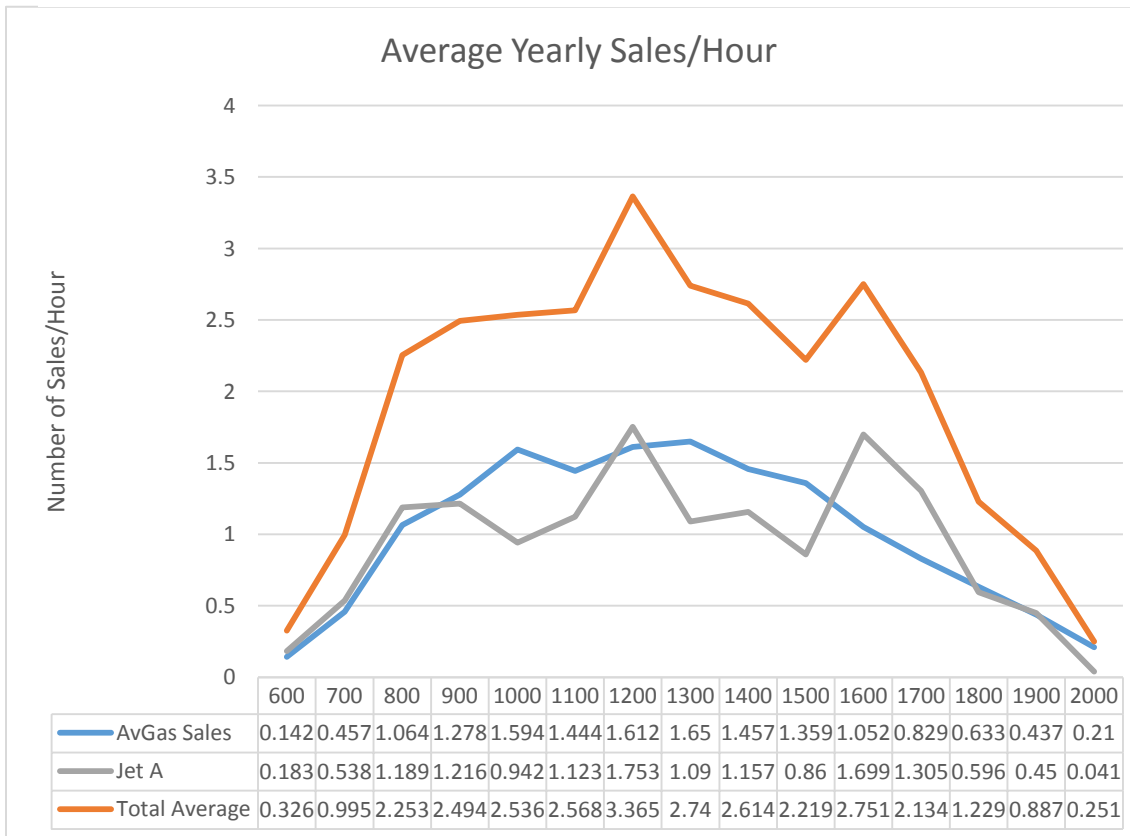


Table 5 - Average Number of Jet A Purchases/Hour

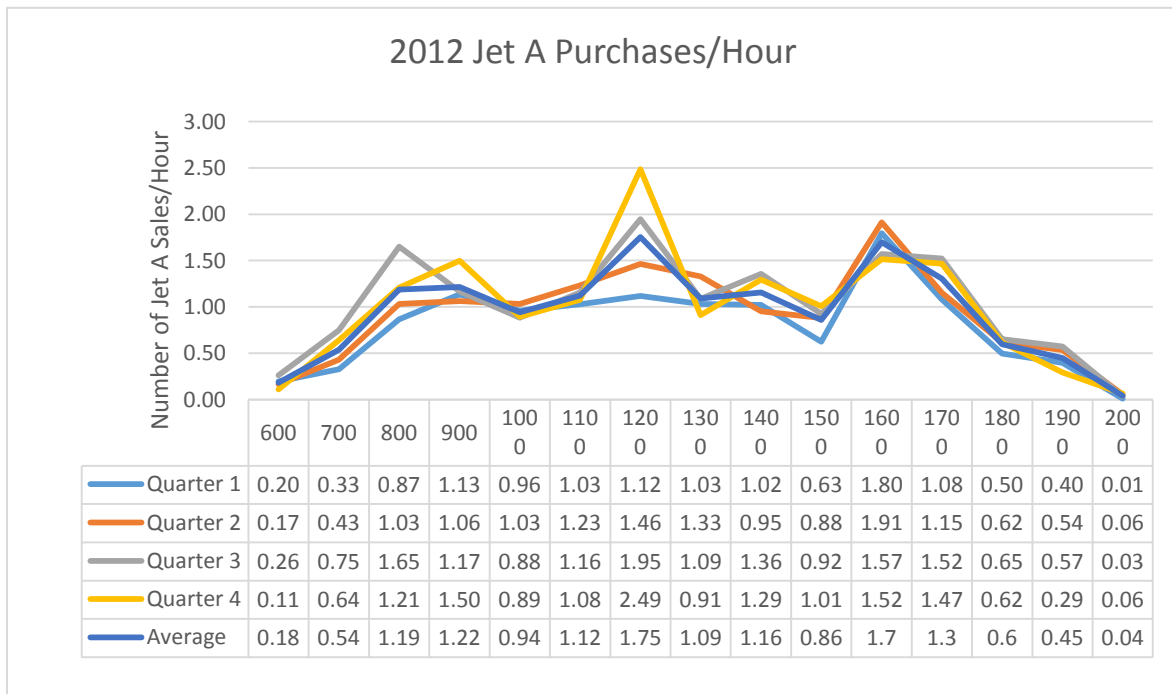


Table 6 Average, Max, Min of 100LL and Jet Uplifts and Gallons of fuel per uplift

100LL			Jet		
Gallons Of Fuel	Uplifts Per Day		Gallons Of Fuel	Uplifts Per Day	
Q1			Q1		
Min	29.7	6	Min	8	5
Max	111	32	Max	2583	18
Average	42.4	19.1	Average	370	10
Q2			Q2		
Min	19.2	5	Min	4	1
Max	70.5	29	Max	3189	20
Average	38.7	16.3	Average	395	12
Q3			Q3		
Min	19.8	7	Min	10	4
Max	46.6	40	Max	1952	24
Average	34.9	21.9	Average	346	13
Q4			Q4		
Min	21.9	8	Min	5	3
Max	57.3	28	Max	3760	21
Average	36.3	19.1	Average	362	12