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Copa Airlines: Study of Non-compliance Causes Based on Audit Findings

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Copa Airlines: Study of Non-compliance Causes Based on Audit Findings



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WPI



Copa Airlines: Study of Non-compliance Causes Based on Audit Findings

An Interactive Qualifying Project
Submitted to the Faculty of
Worcester Polytechnic Institute
in partial fulfillment of the requirements for the
Degree of Bachelor of Science

by
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Date: October 11, 2018

Report Submitted to:

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Copa Airlines

1. Abstract

Non-compliance is a pressing issue all airlines face. Copa Airlines tasked us with producing findings that would result in a higher understanding of non-compliance causes in their company using audit, employee rotation, delay, and high and low seasonal data. Due to the time limitations of the project we focused on non-compliance in Tocumen International Airport and El Dorado International Airport. Based on our analytical results, recommendations were made to Copa Airlines on how to improve data collection methods for further analysis.

2. Acknowledgments

Our team would like to thank the following individuals and organizations for all the guidance and contributions to the success of our project. Without the combined efforts of our sponsors and advisors, this project would not have been possible.

Members of the WPI Community

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Stephen McCauley for his guidance during our preparatory period.

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Yuri Vergara and Carolina Diaz Barrios from Copa Airlines, for sharing their vast knowledge, and answering our many questions.

Jaime Arosemena from Copa Airlines, for giving us a tour of Tocumen International Airport.

3. Executive Summary

3.1 Project Introduction

Non-compliance issues are a major problem for the airline industry across the globe. In 2005, a study by the Airline Safety Foundation estimated the cost of on-tarmac non-compliance issues and resulting personal injury to be ten billion dollars (Learmount, 2005). That figure, moreover, does not include costs resulting from non-compliance during flights or maintenance costs.

This project is sponsored by the Panamanian company Copa Airlines. The project analyzed non-compliance issues at two airports that Copa Airlines serves, Tocumen International Airport (PTY) and El Dorado International Airport (BOG). Tocumen International Airport is located in Tocumen, Panama just outside of Panama City, and El Dorado International Airport is located in Bogotá, Colombia. A reduction of non-compliance incidents at both of these airports would be beneficial to the airline's audit department and the company as a whole.

3.2 Project Objectives

In analyzing non-compliance issues, we had hoped to understand factors leading to non-compliance with the intent to help Copa reduce their occurrence in the future. We would have liked to examine as far back possible looking at all incidents Copa has recorded. However, due to the time limitations and the wants of our sponsor we only investigated PTY and BOG utilizing data from January of 2017 to early August of 2018. The project goal was to correlate Copa Airlines' internal audit findings to non-compliance, delay, human resources, and high and low season data. Afterwards, creating an analytical tool capable of recreating the type of higher

understandings that our team produced. Our project team, in collaboration with Copa Airlines, developed the following objectives to achieve the project goals.

1. To discover trends and develop understandings of the causes of the non-compliance issues based on audit findings;
2. To determine if personnel rotation affects the compliance of Copa's standard operating procedures;
3. To determine if the high and low seasons affect the compliance of Copa's standard operating procedures;
4. To determine if delays affect the compliance of Copa's standard operating procedures;
5. To understand the correlation between high and low seasons, personnel rotations, delays, and audit findings to discover non-compliance trends in operating areas.

3.3 Sponsor Perspective

Our team deemed it imperative to understand the values of Copa Airlines and align ourselves with the issues that the company considered most important. We were able to meet with a number of individuals from Copa who were able to assist us throughout our time in Panama. In addition, we toured Copa's headquarters receiving the opportunity to look at their war room and operations room. These activities helped us recognize that Copa "supports the integral development of the communities where [Copa] operates" (Copa, 2018) and how they go about fulfilling their pillars of responsibility.

While working with Copa Airlines, we visited Tocumen International Airport to view all the moving parts involved in getting a plane into the air. Our guide gave us a tour of the airport which showed us the operations at a typical airport and walked us through the process of conducting an audit. We met weekly with Copa staff in their Panama City office to share new information and touch base on the project. We also found it useful to understand the process of how the audit data is collected and then transferred to the Tableau spreadsheets. This gave us tremendous insight into how we should treat and further categorize the data on our own.

3.4 Preliminary Data Analysis

The flight data that Copa provided was broken down by our team into High and Low seasons. Months that were less than one standard deviation below the mean were labeled as low volume seasons and months that were greater than one standard deviation above the mean were labeled as high seasons.

We then took the broken-down audit data and put them separate categories in Excel, and looked for trends and percent increase due to different factors. The first two data sets that our team compared was the HR data and audit findings. We considered each HR department and looked at the percent increase in audit findings for months with an above-average turnover rate.

The next correlation that we observed was between the high and low seasons that we had created earlier. We looked at the percentage increase in audit findings in each month, paying specific attention high and low volume seasons.

Our team then used the broken-down data sets to find the Pearson correlation between the percent increase in delays per month and flights per month, delays per month and flights per month, percent increase in delays and turnovers per month, percent increase in delays and audit

findings per audit, and flights per month and audit findings per audit. This gave us the necessary background to establish the plan for the analysis tool.

3.5 Analysis Tool and Recommendations

Our team developed an analysis tool to help establish a long-term, automatic audit analysis system for Copa Airlines. After performing the necessary data analysis and generating recommendations we began work on the analytical tool. We created a Microsoft Excel document where the audit team can paste in the required data into the proper fields and it will automatically run an analysis on the given data points. We also included instructions with the file on how to use it and what the output values mean.

Our project also revealed minor flaws in Copa's audit system, including the methods of analysis and the ways that the data points are categorized. We recommended that they standardize and improve their data set, add new data fields, increase and standardize the number of audits, and invest in a tablet/software system to address most of these issues.

Our project was successful in helping Copa Airlines take the first steps towards the higher understanding of non-compliance causes. We designed a system to help them recreate the analysis that what we did while in Panama at any given airport. Our team is confident in the growth of Copa's auditing system and in the decrease of non-compliance issues.

4. Authorship

Kieran Bradley: Responsible for writing the Abstract, Executive Summary, the Introduction, Background sections 9.1, 9.2, 9.3, 9.4, 9.5.1, 9.5.2, 9.6. He also was responsible for editing all sections he did not write.

William Crafa: Responsible for writing the Abstract, Executive Summary, Background section 9.3, Methodology sections 10.1, 10.2, 10.3, 10.4, Finding sections, Reflection, Appendices A, C, D, F and the Analytical Tool. He also was responsible for editing all sections he did not write.

Patrick Flinn: Responsible for writing the Abstract, Background section 9.1, Methodology sections 10.1, 10.2, and 10.3, Finding sections, Recommendations, Appendix H, and the Analytical Tool. He also was responsible for editing all sections he did not write.

Athena LaJeunesse: Responsible for writing the Abstract, Executive Summary, Background sections 9.2, 9.3, 9.6, Conclusion, Recommendations, Reflection, and Appendices B, E, G. She also was responsible for editing all sections she did not write.

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7. Acronyms

ACI - Airports Council International
ATRS - Airport Transportation Research Society
BOG- El Dorado International Airport
BTS - Bureau of Transportation Statistics
CGO - Cargo
FAA - Federal Aviation Administration
FLT - Flight
FOD - Foreign Object Debris
GPU - Ground Power Unit
HR - Human Resources
IATA - International Air Transport Association
ICAO - International Civil Aviation Organization
IOSA - Operational Safety Audit
IQP - Interactive Qualifying Project
ISO - International Organization for Standardization
MNT - Maintenance
PTY - Tocumen International Airport
RVFP- Residual Variable Factor Productivity
SAB - Services on Board
SAP - Personnel Services
SEC - Security
SOCC- System Operation Control Center
WCTR-World Conference on Transport Research Society
WPI- Worcester Polytechnic Institute

8. Introduction

Airlines have an overall desire to be safe, efficient, and profitable. Incidents surrounding airplanes are a tremendous problem for airline companies. In 2004, one study estimated the total cost to the worldwide airline industry for incidents on the apron, or the docking port for airplanes, to be five billion dollars alone (Vandel, 2004). A second study the following year by the Flight Safety Foundation also factored in the expense of personal injuries and doubled that estimate; to ten billion dollars (Learmount, 2005). For comparison, a previous IQP with our sponsor, Copa Airlines, dealt with bird strikes (Cheng, 2015). That previous task was solving a 1.2-billion-dollar problem (Allan, 2016). Thus, the importance of our work presented here is stated. This non-compliance issue requires much more focus and dedication from the company as a whole to solve because of its larger impact on safety, efficiency, and the bottom line.

The first line of defense against non-compliance is the enforced training periods immediately after hiring. The second is the crew managers, who oversee technicians and other crew members. The manager's job is to make sure the employees adhere to company policy, and, if necessary, take corrective action against the employees. When non-compliance issues arise despite the efforts to the contrary, the audit team records the incident and brings the problem to light.

The reason that such audit systems are in place is to reduce possible injury to passenger or crew in addition to limiting costly accidents or delays. That system isolates ineffective technicians for retraining, as well as noting improper aircraft procedures, possibly removing the aircraft from service, and find any other areas in need of corrective action. This system

implements both the guidelines put into place in the manuals and the organizational tools used by technicians and crew. Auditors are responsible for the effectiveness of this system. In an effort to constantly improve the effectiveness of the system, they help diagnose systemic problems inherent in the audit process and propose manual and procedure changes (Dominguez, 2018). These qualified professionals are in charge of making sure that risk is properly managed, and that anything affecting safety or efficiency of flights is addressed and well documented.

The training structures at Compañía Panameña de Aviación, or Copa Airlines are very specific, and not all training at airlines across the world are similar. However, the goal of the auditors is universal. Our sponsor's auditors collect data across all their active airports on all audit incidents. The collected data is used to find areas within the airport that need reform to make the airline more efficient, reduce incidents, and improve the overall customer experience. This project involved using the audit data to find higher level understandings of the causes and factors that increase the occurrences of these non-compliances and reducing those irregularities for the airline. The factors that we examined in this IQP consist of the audit data, high and low season for flights, delays, and employee rotation data.

For Copa, this type of analysis was primarily an experimental project which afforded a great deal of autonomy as to how the results were presented. Past projects involved with Copa had no relevant information to deal with audits and non-compliances (Cheng, 2015; Cano, 2016).

The goal of this project was first to use the data provided to generate these higher-level understandings and what it meant for our sponsor. This project focuses only on those incidents occurring in two airports, El Dorado and Tocumen International Airport. We determined the non-compliance trends and how that was affected by employee rotation, fluctuations in flight volume, and delays. These understandings were then used to propose an analytical tool that may

be useful to managers and executives alike in both future decision making and current areas of concern. These discoveries were meant to continue to save the airline money and improve customer experience. To achieve this goal, we pursued the following objectives:

1. To discover trends and develop understandings of the causes of the non-compliance issues based on audit findings;
2. To determine if personnel rotation affects the compliance of Copa's standard operating procedures;
3. To determine if the high and low seasons affect the compliance of Copa's standard operating procedures;
4. To determine if delays affect the compliance of Copa's standard operating procedures;
5. To understand the correlation between high and low seasons, personnel rotations, delays, and audit findings to discover non-compliance trends in operating areas.

9. Background

We divided the background into six separate parts. In the first section, we will first take stock of the non-compliance issues in the workplace. The next three sections focus on factors that might affect non-compliance. Those sections parallel the three sets of data, delay data, high and low seasons, and employee rotation, which we examined to find factors of non-compliance. These sections provide an overview of how airlines have tried to solve the issue of non-compliance in the past and relevant information that might apply to our project. The following section is a brief history of our sponsor, their policies, and their goals. The final section examines in depth both the audit structures at Copa and the areas in which non-compliances are committed.

9.1 Non-compliance in the Workplace

Non-compliance in the workplace is a significant problem for many companies. An integral part of many companies is codifying procedures and manuals for their employees to follow, to reduce everything from legal consequences to upholding standards of efficiency (SKYbrary, 2018). Companies can also be creative and implement procedures from other organizations. For example, at Copa Airlines, some standard operating procedures are based on standard operating procedures of other companies (Diaz, 2018). All of this effort is in hopes to keep their company efficient, making money and following the regulatory guidelines set forth by their overseeing government agencies. With an ever-expanding set of rules constantly being changed by authorities, it has become harder and more costly for a company its employees to comply with these rules (Muresan, 2018). Following national and regional laws is tough enough, but international corporations have an even more difficult time. A recent study found that on

average, companies spend \$14.8 million dollars annually on non-compliance issues, a 45.5% increase since 2011 (Muresan, 2018). Since non-compliance issues can arise through lack of training, through training can prevent these issues.

9.2 New Employee Hiring

Regardless of the potential for cost reduction, the process of acquiring, training, and implementing new personnel is a difficult task riddled with pitfalls and chances for failure. Poor training is a common occurrence among new employees. The impacts of poor training or implementation of training can have a large effect on productivity, profitability, and high employee tenure. It can also create safety and legal consequences. Unsafe work environments can come from the improper training of employees which could result in an accident or lawsuit causing the company to spend more time and money to fix. Hence why training is so important to larger companies. With less training, employees can feel that they are undervalued which can drive them away from the company as a whole. Poor training is one of the leading causes listed for employees leaving a company (Harvard Business Review, 2016). A case study tested different methods of training on employees. It showed that operators who were handed paper training documents and expected to know and understand the material became very frustrated and were less likely to stay with the company. Employees were found to flourish more at the company in their job if they had received visual training, then completed hands-on training, and lastly, being observed doing the work (Darrah, 1995). Many find it easier to learn by observing the job in front of you rather than trying to understand a document. Many companies switched their training to include more physical hands-on processes to improve the training quality and the quality of the worker. This switch means all the effort spent to implement a new worker can

improve the odds of keeping workers, due to a thorough, effective training process (Darrah, 1995).

Some studies show that only 13% of employees are actually engaged at work (Gallup, 2013). An effective training program means that all these issues can be avoided and new hires can be efficient and more effective sooner. With everything in its place, the acquiring, training and implementation of a new worker can move smoothly. This understanding explains the need for a study regarding the impact of training new employees.

9.3 High and Low Seasons

High and low seasons can stem from a variety of problems. For example, these could be related to the holiday schedule, the seasons, vacation times, and even weather (Shields & Shelleman, 2013). When considering the high and low seasons of an airline company, the big things that stick out are the demand for the flights at a certain time of the year and the weather. It is highly likely that when an airline has more flights there is a greater risk for non-compliances to occur.

We can compare the high-volume seasons to Black Friday, which is one of the busiest shopping days in many different countries. This period of high volume calls for plenty of training and planning. Before the Black Friday season, there is a steep increase in hiring to deal with the increase in customers. The increase is due to the fact that the stores need more employees to help shoppers (Davison, 2011). While hiring people in bulk is often necessary to deal with an increase of customers, it also leads to training issues. Many times, the training process is rushed and its effectiveness wavers due to the increase of people hired at once.

9.4 Delays

A multitude of factors can impact an aircraft's on-time performance. The IATA defines a flight departing on time if the plane leaves within 15 minutes from the scheduled time. Copa Airlines defines a flight departing on time if the plane leaved exactly on, or before the scheduled time. A study by the American Institute of Physics attributes the main causes of delays in airport to the lack of traffic flow control, weather, and individual airlines. They used a chromosomal genetic model to simulate the most efficient-running airports and most important factors in ensuring on-time performance (Zang, 2017). Despite accuracy of such models, some elements, such as weather, can only be predicted to a certain extent. While foreseeable, it is near impossible to accurately predict weather 100% of the time and so, delays are inevitable.

9.5 Copa's Airport Hubs and Copa Airlines

The Panama Aviation Company and Tocumen International Airport were both inaugurated in 1947 by President Enrique Jimenez. The initial flight was the Douglas DC-3 / C47 aircraft. In under 20 years, the airline expanded to include international flights to San Jose, Costa Rica, and later Colombia, Nicaragua, and other Southern and Central American countries. In 1992, the first flight connections center created within Tocumen earned it the name 'The Hub of the Americas.' In 1998, the Panama Aviation Company was rebranded as Copa Airlines. In 2005, Copa acquired 90% of AeroRepublica out of El Dorado and in 2010, it was rebranded as Copa Colombia. Copa and Copa Colombia, along with its recent subsidiary Wingo, all have been expanding their destinations to this day (Copa, 2007).

As of 2018, the fleet is gradually being changed over from old Embraer 190's to Boeing planes because of its superior ease of maintenance and ubiquitous use in the airline industry

(Arosemena, 2018). Still, there is a significant amount of maintenance, paperwork, and overall processes that surround even the most trouble-free aircraft. According to the Boeing commercial manual, the turnover from arrival to departure of a typical passenger Boeing 737 flight takes a minimum of 25 minutes (Boeing, 2013). This time allows for fueling, maintenance checks and unloading and loading of baggage, cargo, and passengers. If allowed to, planes can take longer times and incorporate more extraneous processes. Within that specific time frame, the plane can undergo numerous processes including technical checks, cleaning, catering, placement and removal of chocks, connection to a Ground Power Unit (GPU), and many more (Boeing, 2013). The expansion and evolution of Copa Airlines procedures over the years speaks to the tremendous growth it has sustained for over seven decades. The living monument to that hard work exists as Tocumen International Airport. (De Pagés et al., 2017).

9.5.1 Tocumen International Airport

The history of recent growth at Tocumen is telling of the full story of the airport. Tocumen has gone from flying 12.6 million people in 2016 to 13.5 million people in 2017, meaning an average growth of about a million passengers a year (Copa, 2018). Tocumen has experienced more than just growth in passengers over the last few years. The airport also boasts growth in revenue and size. Between 2013 and 2017 the airport increased its revenue by nearly 80 million balboas, ballooning from 153.3 million in 2013 to 233.6 million in 2017 (de Pages et. al., 2018).

Tocumen has served as the main base for Copa and has acted as a central hub for the region for nearly 30 years. The airport was also formerly under of the umbrella of the Panamanian government. The Civil Aeronautics Authority controlled Tocumen International

Airport until the passing of Law No. 23 on January 29th, 2003. The law relinquished direct control of the airport from the government and established the airport as a stand-alone under Tocumen S.A., a private holdings corporation (Copa, 2007). All shares of Tocumen S.A., however, are held by the Panamanian government (Kasarda, 2011). With government ownership comes even more incentive to expand and encourage growth of the surrounding economy. For example, an \$800 million construction project, slated to finish in 2018, is currently underway called Terminal 2, or “T2” which will expand the airport to accommodate an increase in traffic. The Tocumen airport had been described as a ‘little city’ by residents in Panama (Arosemena, 2018). Retail, security, restaurants, and even a hospital have all been built around the shuffling of tens of thousands of people through the doors of Tocumen (Property News, n.d.). While Tocumen handles an impressive volume of passengers yearly, it is not uncommon for Latin American airports to deal with high volume of passengers. El Dorado International Airport, for example, handles around ten times the number of passengers than that of Tocumen.

9.5.2 El Dorado International Airport

El Dorado International Airport, located in Bogotá, Colombia, serves far more than Tocumen’s 14.7 million passengers and is the second largest airport in all of South America. Much like Tocumen, El Dorado has grown significantly since the early 2000’s from just over seven million passengers in a year to 35.8 million passengers in 2016 (El Dorado, 2016). The airport also currently handles the highest volume of cargo in Latin America, carrying over 770,000 tons of cargo annually. El Dorado is a hub for Avianca, their flag-carrier airline, Copa Airlines Colombia, and a few cargo companies. This specific airport is owned by the Colombian government and run by a few different companies and engineering firms. El Dorado has maintained a highly rated status for many years because of its commitment to service, employee

courtesy, and general efficiency. El Dorado, much like Tocumen, decided to expand in 2007 to keep up with the demand and swelled from 173,000 square meters to 235,000 square meters (Expansion Works, n.d.).

The audit structure helps maintain the two strategies for Copa Airlines. Their first strategy is to “continue to focus on keeping our costs low” Copa’s second strategy is “*Emphasize superior service and value to our customers*”(Copa, n.d.). Our team’s work on this project will allow management to be better prepared for incidents, allowing them to provide a better customer experience. The ways that Copa already improves their operations as a whole is by frequently auditing their ground operations, their maintenance crew and all other relevant areas. Copa has implemented strict guidelines in order to provide ease of use and reference.

9.6 Copa Audit Information

The practice of auditing your operations is an important step in order to continue following important guidelines. Those guidelines were set in place by international and national organizations for the protection and wellbeing of workers, customers, the environment, and equipment. Copa Airlines follows many guidelines for standard operating procedures but draws from the International Air Transport Association, the IATA, primarily. IATA is an international trade association that ensures that the international aviation network continues to be safe and secure, as well as sustainable. IATA provides very specific standards in the IATA Operational Safety Audit (IOSA) program. The IOSA program allows airlines “To assess the operational management and control systems of an airline” (Operational, 2018). This organization together provides a list of processes airlines undertake and how they should be handled. The International Organization for Standardization (ISO) has also set guidelines for auditing management systems

to standardize this process to make sure that airlines go about the process properly. Specifically, auditors are looking for non-compliance in the work being done. Non-compliance is defined as a failure to comply with a law or regulation (Harper, 2010). The type of non-compliance issues they specifically look for are issues related to the safety of employees, the physical states of their planes and equipment, and any other process that occurs in and around the planes. Copa Airlines, like all airlines, has their own audit process, that adheres to relevant guidelines like that of the ISO, that collects findings in order to improve their processes across the globe.

In addition to IATA and ISO, Copa has a bevy of internal manuals and guidelines. The Operating Procedures Manual, Document Control Manual, and equipment servicing specifications are a few examples of what supplement IATA and ISO. These manuals are then referenced in the checklists that Copa uses as a guideline for auditing. These checklists are used to ensure quality and efficiency through all parts of the airline (Dominguez, 2018).

Copa's process begins annually when the company creates a yearly plan determining the scope of their audits for the year, including the number of audits and location of audits. Copa's audit process from start to finish is detailed below in Figure 1: Copa Audit Process Timeline. This figure shows that once an audit is scheduled, the station subjected to an audit receives a 15-day notice prior to the beginning of the audit. After the official start date of the audit, the auditor has seven days to file an official report detailing their findings. The subject is then required to create and submit a plan to fix the problem and prevent the issue from occurring again in the future within 15 days of the official report being filed. The subject is also required to, within 90 days of the beginning of the audit, provide evidence that the issue has been resolved and a new plan is in place (Dominguez, 2018).

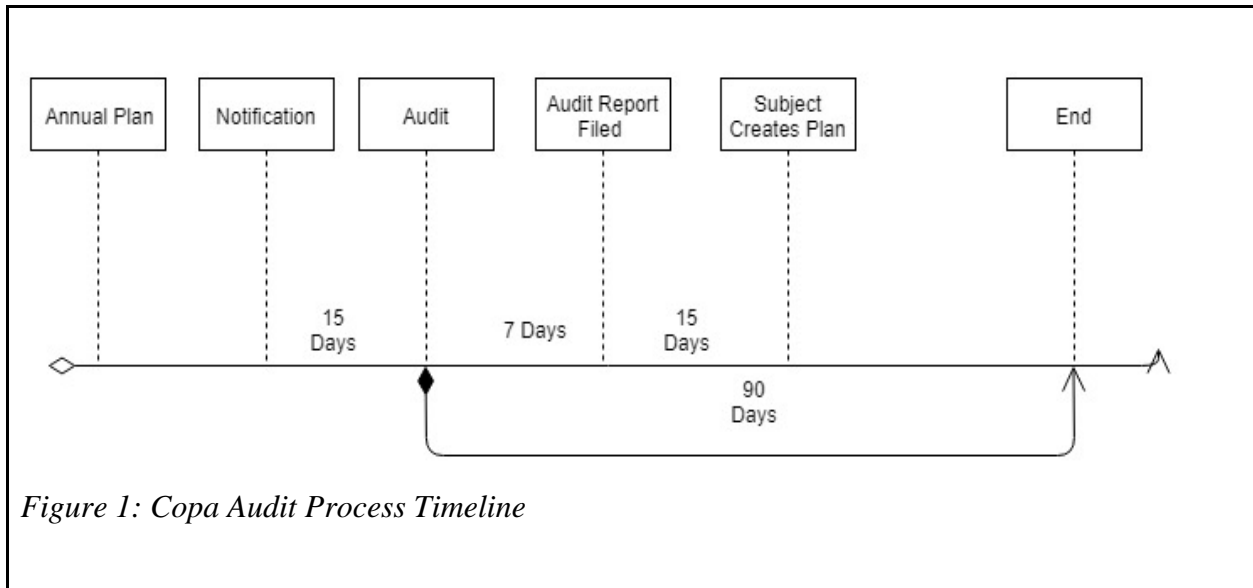


Figure 1: Copa Audit Process Timeline

Another important part of the audit process at Copa Airlines is Tableau software. Tableau is a business intelligence and analytics software that allows companies to easily summarize and graph data (Tableau, 2018). The software allows Copa and its team of auditors to easily store, access, and analyze their audit findings. This entire process, the running of audits and reporting into Tableau, is handled by one team out of Copa's headquarters in Panama City.

This team travels to airports all around the world to perform audits to ensure Copa follows the same company standards no matter their location on the globe. This team has the regulations from the manual memorized and completes audits without aid of the checklists. The checklists are discretionary, used only in case a member of the team needs a quick reference. Regardless, every non-compliance issue is noted, including involved personnel, date, location, and description of the incident. This system ensures quality and efficiency through periodic audits using those checklists (Dominguez, 2018).

Another objective of the audit team is to investigate any incidents that happen outside of audits. They expose issues on the ground and are able to bring them not only to the attention of the company but also to get the issues resolved in a timely manner. This gives Copa an early

warning system allowing them to reduce risk created by non-compliance issues. This audit data is what we focused on to find underlying correlations between all datasets we received from Copa.

10. Methodology

The overall goal of this project was to explore the correlation between high and low season data, new hiring employee data, flight delays, and audit findings for Copa Airlines, specifically at Tocumen Airport and El Dorado Airport. Based on the results we get from the analysis detailed below, our team created recommendations to improve the auditing process and data collection. As well, we created a basic analytical tool to perform a similar data analysis to what we did while in Panama.

Based on the objectives presented in the introduction, a methodology was developed in order to accomplish the project goals. These methods include data analysis and researching of possible causes of non-compliance. The following sections details how our teams completed these objectives.

10.1 Objective 1: Understanding Non-compliance in Copa Auditing

In order to recommend a solution to prevent non-compliance issues, we first had to analyze the existing data provided by Copa Airlines. The first objective was to use the audit findings to determine the causes of non-compliance issues by studying the trends within the data. Copa provided audit findings from 2016, 2017, and 2018 from all airports to which Copa flies. For our research, we were asked by Copa to only look at audit findings from Tocumen Airport (PTY) and El Dorado Airport (BOG) for January 2017 through August 2018. The audit data was organized by month, operational area, finding status, and finding department. The operational areas were defined by the type of non-compliance issue and in which aspect of air travel it occurred. The areas, shown below in Figure 2: Copa Audit Filters, were Cargo (CGO), Flight

(FLT), Maintenance (MNT), Services on Board (SAB), Personnel Services (SAP), and Security (SEC). We were also able to sort the data by year, month and which audit department the finding was in. The finding status was either closed, open or overdue.

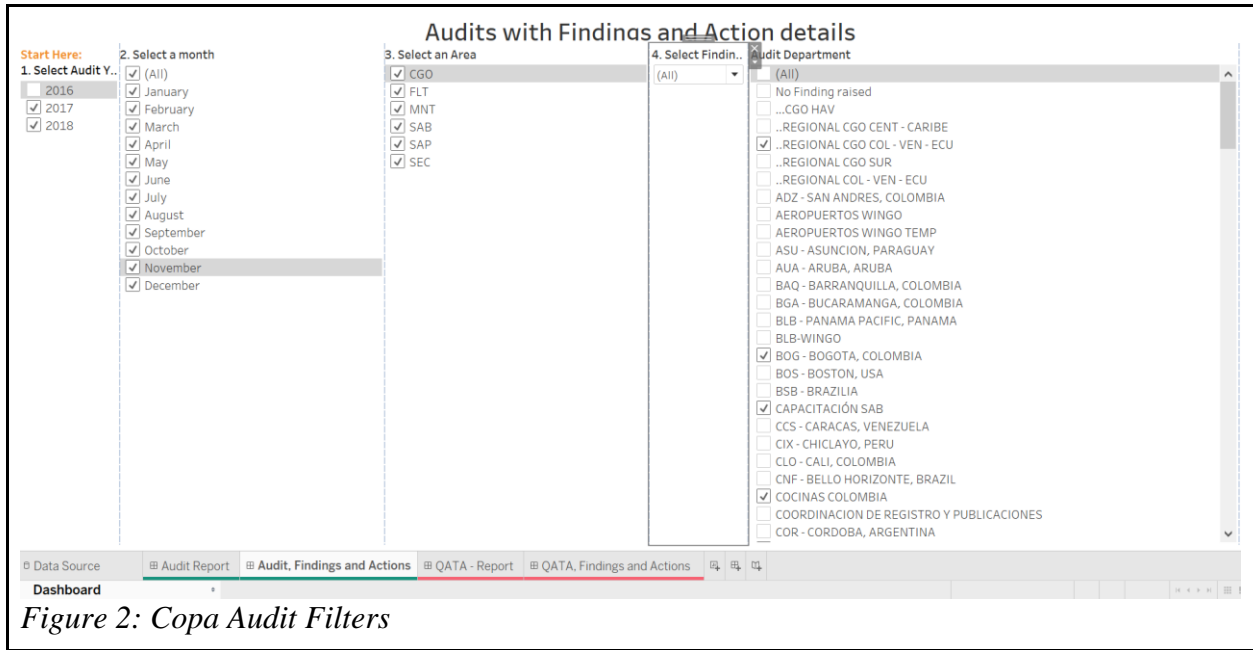


Figure 2: Copa Audit Filters

Due to the limitations of our project, we were not able to receive access to the full Tableau software as we had originally hoped. However, we were able to use the trial version and export the audit data and findings from Tableau to Excel. In Tableau, we were able to use the filters to receive only the relevant information. We manually exported each individual month to an excel tab with all the operational areas selected and the filtered the departments that were under the scope of our project.

The following list Figure 3: Department Listings shows the departments given to us by Copa Airlines to refer to when looking at the audit data. It helped us filter the correct information so we could only see audits that pertained to PTY and BOG. However, we quickly learned that this list also included some audits that pertained to other airports. This required us to manually go through and delete any audits that did not mention PTY, HUB, or BOG.

Department
..REGIONAL CGO COL - VEN - ECU
BOG - BOGOTA, COLOMBIA
Capacitación SAB
Crew Records
Depto. De Hub Control - HCC
Depto. Soporte Equipo Tierra (GSE)
Dir Abastecimiento Abordo y Compras (AAB)
. De Aeronavegabilidad y Cumpl. Regulatorios (QC & NDT Departmer
Dir. de Capacitacion (VPSAP)
Dir. de Operaciones Terrestres PTY
Dir. de Servicio a Pasajeros
Dir. Sr. Auditoría y Seguridad (CM)
Gerencia de Despacho CM
Gerencia de Hangar
Gerencia de Mantenimiento Pesado
Gerencia MCC P5
Gerencia QC P5
Gerencia Servicio de Alimentos y Comida (Servicio Abordo)
Gerencia Sr de Planificacion
Gerencia Sr. de Almacén (Stockroom)
Gerencia Sr. de Mantenimiento de Estaciones
Gerencia Sr. de Mantenimiento en Linea
Logística P5
Mantenimiento - P5
Tool Room
VP TO
Dir. de Estandáres y Calidad
Depto. De Rampa PTY
Gerencia Sr. de Aprovisionamiento y Contratos
Cocinas Colombia
Dir. Sr. Auditoría y Seguridad (P5)
Depto. Seguridad Estaciones
Depto. de Itinerarios de Tripulantes (Itinerarios CM)
Depto. De Tripulaciones Técnicas - FLT OPS - P5
Depto. De Entrenamiento - FLT OPS P5
Direccion de Operaciones de Vuelo P5
Gerencia de Talleres
Depto. De Records Tecnicos - P5
Dir. SOCC P5
Gerencia de Avionica y Sistemas
Gerencia Sr. De Reparación y Modificación de Componentes
Dir. Sr. Carga y Courier (CGO H)

Figure 3: Department Listings

Before starting analysis, it was important to familiarize ourselves with the criteria that Copa uses to audit itself. We used said audit criteria to help us understand exactly what each logged issue was referring to. We used the checklists that the auditors use and cited the specific checklists and item number that was broken. This helped add context to the audit and add more information to the data set. Currently, Copa auditors are not required to state the checklist that

they are referencing in the audit, however, some checklist numbers appear in the raw, unfiltered data. We then went back into the data and tried to provide all the audits with a checklist number. From there, we intended to sort the audit findings by checklist number and show the frequency that each checklist appeared in. However, we quickly determined that this was not the best course of action. This was due to two main factors.

The first issue was our limitations with Spanish. Most of the audit findings were written in Spanish. Since none of our project members speak Spanish, we used a macro to Google-translate the findings. Many times, the audit findings did not translate well, which made it very hard to categorize into checklist numbers. Furthermore, many checklists were written in Spanish as well and we were limited to the translation Google provided.

The second limitation was the overlapping nature of the checklists. When we could understand what the audit was saying, we often found multiple different checklists could apply to the same finding. Between these two limitations, initially, it was difficult for us to create a well-defined classification of the audit findings.

10.2 Objective 2: Breakdown Audit Data

After coming to a better understanding of the audit findings, we parsed through the data and recorded different factors that may be useful for analysis later. We broke down each audit finding into one of seven categories:

1. Flight operations
2. Flight attendants/Service on board
3. Airports/Ramp, Ground support equipment, Passenger service

4. Maintenance
5. Security
6. Cargo and Courier
7. Operations/ Dispatch, SOCC

Copa separates their HR data for Personnel Rotation into these categories. Once we separated the audits based on the department responsible, we were able to analyze whether an increase in personnel rotation affects trends in non-compliance issues.

The information we intended to record was as follows: date of occurrence, the checklist of standards broken and which item number on the list is broken. We also cross-referenced this data set with the number of flights each month to show high and low seasons. This breakdown of the data allowed us to create findings and present those findings in an organized manner. The purpose of this breaking down of data was to allow us to analyze the three correlations that Copa wishes to know more about. One is the correlation between audit findings and high and low seasons. The second is audit findings and delays. The final is the correlation between audit findings and newly hired personnel. With better understanding of these correlations, we were able to present to Copa areas of concern.

10.3 Objective 3: Testing for Correlation Between Data Sets

The next step of our analysis was to test to see if there were any correlations between the audit data, flight delay data, personnel rotation, and high and low season data. We used two main methods in order to achieve this goal.

Both methods started out with the same basic direction; to analyze the data in a repeatable fashion in order to allow the creation of an analytical tool further down the line. However, that is where the similarities end. Each method takes their own approach to achieving our analytical goals. The first method relied on the categories from the audit findings and correlated them with the HR and flight volume data provided to us by Copa.

10.3.1 Method 1: Percent Increase

First, this method set out to look for a correlation between the HR data and the audit findings. The HR data we received told us how many people were hired and left the company in a given month for 2017 and for the first eight months of 2018. Those numbers were added together for each month resulting what we called total turnover. After finding total turnover for each month of the data, we found what the average turnover was for the year and then proceeded to designate months that were above this average. We then correlated this data between the number of audit findings in a month looking for percent increases or decreases during months of above average turnover. The expectation was that there would be a percent increase during these months. If this were true this would show the company has trouble transitioning people into or out of the company.

The next data set, flight volume data, was broken down and analyzed much the same way as the first data set. The high and low traffic seasons, as defined earlier in this paper, were assigned to each month from January 2017 to August 2018, as that is where the data stopped. Much like with the HR data, we looked to see if there was a percent increase or decrease during high and low traffic seasons. The expectation being there would be a percent increase during high traffic seasons and a percent decrease during low traffic seasons. This could possibly point to employees needing better training to deal with a higher volume of flights.

10.3.2 Method 2: Pearson Correlation

For the second method, we found the Pearson Correlation coefficient between each data set, showing the statistical correlation between the two sets of data. The sample correlation coefficient is denoted as r . The formula for finding r is shown in the Figure 4: Pearson's Coefficient Formula below. The r value ranges from -1 to +1 which signifies the direction and magnitude of the linear association between the two variables. For example, an r value of -.9 shows a strong, negative association between the two variables while a value of .1 shows a weak, positive association. If the r value is 0, then there is no correlation between the variables and they are completely independent.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Figure 4: Pearson's Coefficient Formula

The first step in analyzing this data was to take the unfiltered data provided by Copa and format it in a way that would be advantageous for our project. Copa provided a file of the on-time performance values for each month of the year.

The only data that was useful for our project was the Month, Vuelo Origen (Flight Origin), and Dep00. This data was categorized as shown in Figure 5: On-Time Performance Categories below. The Dep00 column shows the percentage of flights that departed on time from the airport. Copa wanted our team to only look at findings from flights departing from PTY and

BOG, so we filtered the data by airport. Next, we subtracted the Dep00 from 1 so that we had the data for percentage of flights delayed per month. Having the data in this form worked better because we wanted to look at increases in the percentage of flight delays, not the increases in flights departing on time. We then started two tables, one for PTY and one for BOG which was organized by month and added in the new Dep00 data.



Next, we added the number of flights per month for each airport to the table. This data only included flights from Copa and Copa-affiliated airlines. We then multiplied the percentage of flights delayed per month by the number of flights per month, which created an array of the number of delays per month. The next column of the table implemented the HR personnel rotation data given to us by Copa. This data was separated into Hires and Leaves, but for our project, we decided that it made sense to combine the two numbers to get the total number of turnovers in a month. Finally, we took the number of audit findings per month and divided it by the number of audits that were taken. This gave us the average number of findings per audit. Since it is hard to quantify audit findings and analyze them against other data, we thought that this would be the best way to quantify more non-compliance issues occurring over time.

Finally, we began to look for correlations between the sets of data. Using Excel's =CORREL function, we were able to input two arrays of data and find the r value for correlation. The data sets that we tested against each other were: Percent Delays Per Month VS Flights Per Month, Delays Per Month VS Flights Per Month, Percent Delays VS Turnovers Per Month, Percent Delays VS Audit Findings Per Audit, and Flights Per Month VS Audit Findings Per

Audit. These were the only combinations that we tested because these analyses would show us the relevant information we were looking for. Once we had all of the r values, we squared them, and this gave us the r^2 . The r^2 value shows the percentage of variable variation that can be explained by the linear model. This value is on a scale from 0 to 1. A value of 0 represents that none of the variations can be explained, while a value of 1, means that all of the variations can be explained, and the data matches the linear regression model perfectly. Under the scope of our project, we hope to find high r^2 values.

10.4 Objective 4: Recommendations and Proposition of Analytical Tool

After processing the data and generating an overarching understanding of the data, we then creating a list of recommendations for Copa to use in future data collection. Ideally, these recommendations will help facilitate the analysis process and show trends in the non-compliance issues in audit data in the future.

We then worked to create a proposed analytical tool that can produce an automatic analysis of the data collected similar to the one we produced. In addition, the tool would create a continuous data stream reporting on factors leading towards non-compliance and delays in the already analyzed airports, such as BOG and PTY. It would show if high and low seasons created an increase in certain non-compliance problems, which would allow the Copa Team to investigate further and fix the issue at its source. It would also be able to look at problems that arise when new personnel are hired or leave the company in a department. Shedding light on issues in their training program. For future decision making, this tool would allow easier comparison with previous year's data.

The tool would take multiple Excel files' data in order to function, namely audit findings data, HR data, high and low seasons data, and on time departure data. It should also be able to accept new data whenever an audit occurs. The tool would be able to show trends in audit findings department by department, across several years, and across different months. With each of these different filters, it will be easier for Copa to study their audit data at any of their airports.

11. Findings/Analysis

After sifting through the data and pulling it apart, we found that correlations between the given sets of data do not exist. We attacked the problem from two different directions and neither method of cutting up the data provided us with results we were expecting. Beyond just the main objectives of correlation between the data sets, we unable to find any form of pattern or any distinguishable meanings from the data. While this was not the expected outcome it does shed light on ways to improve the general collection of audits going forward to improve the chances of finding meaning in this data set.

11.1 High and Low Season Findings

The first step in our analysis process was to define the High and Low seasons that Copa wanted us to analyze. The definition we decided to create for high volume season, or peak season, is any month where the number of flights was more than one standard deviation above the yearly average. We made the middle season is any season that is within one standard deviation of the mean. The low volume season, or offseason, is defined as any month where the number of flights is more than one standard deviation lower than the yearly average. We tested other methods for determining the high and low seasons, such as doing it based upon above yearly average and below yearly average. However, we did not think that this method would work because it did not allow for months that were in between the shoulder seasons. At PTY for 2017, we found that there was an average of 4885.75 flights per month with a standard deviation of 230.97. All months that were more than one standard deviation under the average were labeled as a low volume month. The low months for PTY in 2017 were February and September.

All months that were more than one standard deviation over the average were marked as high-volume months. For PTY, these months were July, August, and December. When we looked at the 2018 data for PTY, we found that it had a higher average number of flights per month, 5038.86, and a slightly lower standard deviation, 230.15. Yet, through July, we found that all it had the same distribution with the exact same high and low seasons. We expected to see a higher volume of travel during the summer and around the holidays and a lower amount of flights during February due to it being a shorter month. The analyzed data confirmed our hypothesis.

At BOG for 2017 and 2018, we found very similar data for Jan-July with the same low and high seasons, despite the number of flights being significantly less. In 2017, BOG had an average number of flights of 401.25 with a standard deviation of 33.47. For 2018 so far, BOG has an average of 422 flights and a standard deviation of 26.82. For BOG, the high month seasons are July, October, and December. Overall, we found consistent patterns in the high and low seasons except for the months of August-October. If we had more years of data, we would probably see that this pattern would continue in other years. The high and low seasons that we calculated are the same ones that we used for data analysis later. The table below, Table 1: High and Low Seasons, shows the complete flight data set for both airports. The table also shows the average, standard deviation and high and low season cut-offs. It also shows the visible trends in high and low season across each year and airport which are marked with red x's.

PTY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg	STD DEV	AVG-STD DEV	AVG + STD DEV	
17	5105	4511	4844	4690	4808	4899	5237	5156	4583	4889	4788	5119	4885.75	230.9723	4654.777697	5116.722303	
18	5150	4638	5099	4841	5114	5084	5346						5038.857	230.1539	4808.703261	5269.011025	
LOW 17		X							X								
MID 17	X		X	X	X	X				X	X						
HIGH 17							X	X									
LOW 18		X															
MID 18	X		X	X	X	X											
HIGH 18							X										
BOG	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg	STD DEV	AVG-STD DEV	AVG + STD DEV	
17		386	333	373	375	387	387	441	432	410	437	414	440	401.25	33.4776	367.7723955	434.7276045
18		432	371	426	405	432	433	455						422	26.82039	395.1796097	448.8203903
LOW 17		X															
MID 17	X		X	X	X	X		X	X		X						
HIGH 17							X			X		X					
LOW 18		X															
MID 18	X		X	X	X	X											
HIGH 18							X										

Table 1: High and Low Seasons

11.2 HR Data and Audit Findings

The Percent Increase analysis method, as described in more detail in the Methodology, used Excel to pull out data, into different categories looking for trends and percent increases due to independent factors. The first correlation looked at the relationship between the HR data and the audit findings from 2017. The result was not we had expected to see. During periods of above average personnel turnover, only one of the seven hiring departments had a positive percent increase in audit findings. The expectation was that most of the departments would have a percent increase telling us turnovers in that department could be handled better. The only department with a percent increase was Cargo and Courier, which had a 60% increase in audit findings during periods with a high turnover rate. However, a closer look at the department will show that there was only one audit finding throughout the entirety of 2017 and it just happened to fall into one of the five months with a high turnover rate. While 60% percent would normally be something of interest, in this case, the lack of data makes it impossible to make any confident conclusions or assertions in the real world. When you look at 2017 as a whole, looking across all departments, there was 70.42% decrease during months with an above average number of employee turnovers. While this would seem to indicate that turnovers are actually decreasing the

number of audit findings we found the data set as a whole to be lacking enough data to make any true assertions.

Next, was the correlation between the HR data and the audit findings from 2018. Before we even started looking at the 2018 data we knew the results would be skewed. This was because of the data only included up to August of 2018. Despite this, we continued with the analysis and found that out of the given months there was a percent increase in three departments in months with an above average turnover rate. The hiring departments were, as seen in Table 2: 2017 and 2018 Findings Increase due to Turnovers, Flight Operations with a 100% increase in audit findings, Flight attendants / Service on board with a 46.67% increase, and Operations/Dispatch, SOCC with a 41.18% increase. While this seemed more promising, the departments suffered problems much like that of Cargo and Courier in 2017. Operations/Dispatch, SOCC had only three people leave or join their department throughout the entire year and all were hired in May which resulted in skewing the results even further. The department could have hired those three people in 4 of the 8 months and still ended up with at least a 41.18% increase in findings meaning that there was nothing particularly different about the month they hired these people. Flight Operations had only two audit findings from the entire year and they happened to fall on months where there was an above average number of turnovers. Again, there seemed to be a lack of data to really act on. Finally, there is Flight attendants / Service on board which does not fall victim to the same data problems as the other departments. However, because we do not have the whole years' worth of data and the previous year's data showed 0% increase during high turnovers over the course of the year, we cannot say in good faith that turnover increases the number of audit findings. Much like in 2017, when you look at the overall percent increase

throughout the year across all departments, there is a 70.80% decrease in audit findings during periods of high turnover.

2017 Findings Increase due to Turnovers			2018 Findings Increase due to Turnovers		
Department	Avg. # of Findings	% Increase during above Avg. Turnover	Department	Avg. # of Findings	% Increase during above Avg. Turnover
Flight Operations	1.125	-46.67	Flight Operations	0.25	100
Flight attendants / Service on board	1.5	0	Flight attendants / Service on board	1.5	46.66666667
Airports / Ramp, Ground support equipment, Passenger service.	5	-28	Airports / Ramp, Ground support equipment, Passenger service.	2	0
Maintenance	7.625	-8.196721311	Maintenance	7.625	-51.91256831
Security	0.375	-46.66666667	Security	0.125	-100
Carga y Courier	0.125	60	Carga y Courier	0	0
Operations/Dispatch, SOCC	5.625	#DIV/0!	Operations/Dispatch, SOCC	4.25	41.18
Overall	21.875	-77.79591837	Overall	17.75	-70.42253521

Table 2: 2017 and 2018 Findings Increase due to Turnovers

Overall, for the two years of data, the only assertion that can be made confidently is that the data set needs to be changed to better suit this type of analysis. This assertion goes for both data sets, the problems with the audit findings data were spoken about briefly earlier in the paper but there was also a large issue with the HR data. The problem is that the data states when people leave or are hired, but that does not represent the day workers actually start their job or leave their job. If the data were to show these numbers, it would be a figure more representative of actual factors affecting non-compliance.

11.3 Peak Volume and Audit Findings

The next correlation examined through this method was between peak volume periods and audit findings. The categories created to organize the flight volume, high, mid, and low, were assigned to each month of the year based on the flight volumes data we received from our sponsor. This allowed us to break up the audits by the number of flights and airport to see if the number of non-compliances was affected by the number of departures through an airport. What

we had expected to see was an increase in findings when there were more flights and fewer findings when there were fewer flights. However, when we broke up the data there did not seem to be such a correlation.

The first airport we used this method on was PTY. Beginning by breaking down the 2017 data, we found results that were more in line with our previous expectations than the correlation between the HR and audit data sets. We found a 66.93% decrease in the average number of findings per month during low volume seasons and a 33.86% decrease during high seasons. The latter of the two findings disproved our thoughts about high seasons but the first finding did show some promise for our idea that low flight numbers would bring with it a lower number of audit findings and therefore non-compliances. When looking at each individual hiring department, we were able to find that four departments, Flight Operations, Flight attendants / Service on board, Maintenance, and Security, all had a 100% decrease in audit findings during low traffic seasons.

Moving next to 2018 we again assumed our data would be skewed considering we lacked a full year of data. However, we ended up with similar results as those of 2017; during high seasons there was a percent decrease of 18.02% and during low seasons there was a percent decrease of 62.16%, as seen in Table 3: Peak Times Impact on PTY Audit Findings. Despite the consistency, we did not feel as if it was possible to make the assertion on flight volume impacting audit findings. In order to make that assertion, we would have needed for there to be both an increase during high volume seasons and decrease during low volume seasons. That being said it seemed as if it would be right to say, at the very least, that low volume seasons did mean a drop in non-compliance, which started to open the ideas on how to drop non-compliances across the board. Yet, this idea did not stick once you looked at the data more scrupulously.

Peak Times Impact on PTY Audit Findings						
Department	Avg. # of Findings 2017	% Increase During High	% Increase During Low	Avg. # of Findings 2018	% Increase During High	% Increase During Low
Flight Operations	0.5	-100	-100	0.142857143	-100	-100
Flight attendants / Service on board	0.666666667	0	-100	1.714285714	-100	-41.66666667
Airports / Ramp, Ground support equipment, Passenger service.	2.416666667	-44.82758621	-58.62068966	1.571428571	154.5454545	-100
Maintenance	4.25	-5.882352941	-100	8.714285714	3.278688525	-54.09836066
Security	0.083333333	300	-100	0.142857143	-100	-100
Carga y Courier	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!
Operations/Dispatch, SOCC	2.166666667	-84.61538462	15.38461538	1.428571429	-100	-100
Overall:	10.58333333	-33.85826772	-66.92913386	15.85714286	-18.01801802	-62.16216216

Table 3: Peak Times Impact on PTY Audit Findings

In looking at 14 different scenarios analyzed, one scenario per year per department, only four departments in during each volume seasons. Two scenarios only had one finding for the entire year. Our findings began to look even shakier when you consider the fact that Copa does not take regular scheduled audits, but instead performs them when there is a budget for them. This starts to impact the data even more once you consider the seasonal flight data. In 2017 high traffic seasons accounted for about 25% of the year, but in 2018 accounted for 14.3% of the year. For low traffic seasons in 2017, they accounted for about 16.67% of the year and in 2018 accounted for 14.3% of the year. This means there was a highly likely chance that there was a percent decrease in high and low seasons simply because it was less likely that Copa decided to audit during one of those months.

The story for BOG was very much the same with less data. As shown in Table 4: Peak Times Impact on BOG Audit Findings for 2017, there was a 50% decrease during high seasons and a 10% decrease during low seasons. For 2018, there was a 111.76% increase during high seasons and 100% decrease during low seasons. The 2017 results did not make any sense and while the 2018 results looked promising, we found that the BOG sample size was too small to

make draw any meaningful conclusions. Of the fourteen scenarios analyzed, one scenario per year per department like those in PTY, ten scenarios had less than four findings and six had no findings at all.

Peak Times Impact on BOG Audit Findings						
Department	Avg. # of Findings 2017	% Increase During High	% Increase During Low	Avg. # of Findings 2018	% Increase During High	% Increase During Low
Flight Operations	0.25	-100.00	-100	0.14	600	-100
Flight attendants / Service on board	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!
Airports / Ramp, Ground support equipment, Passenger service.	0.583333333	-100	414.29	0.142857143	-100	-100
Maintenance	0.75	-100	-100.00	0	#DIV/0!	#DIV/0!
Security	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!
Carga y Courier	0.083333333	-100	-100.00	0	#DIV/0!	#DIV/0!
Operations/Dispatch, SOCC	1.5	-100	233.33	2	0	-100
Overall:	3.333333333	-50	-10	1.416666667	111.7647059	-100

Table 4: Peak Times Impact on BOG Audit Findings

11.4 Trends in Non-compliance Data

The second data analysis method consisted of testing the four main data sets that Copa provided, against each other to see if there are any correlations between them. As mentioned in the Methodology, we found that the most applicable statistics method to use for our project was the Pearson Correlation. Table 5: Pearson Correlations Between Different Data Sets below shows the complete list of all r and r^2 Pearson Correlation coefficients between the data sets that we tested. When we tested the percent increase in delays and the number of flights, we found that there is a moderate, positive correlation with an r -value of .466. This means that there is a slight correlation when the number of flights per month increases, because the percentage of flights being delayed also increases. This is an area that Copa can focus their attention on, to find out why this is occurring. At BOG, this value drops to .26, which shows that there is only a slight correlation at that airport. We also looked at the r^2 values to show the percentage of variable

variation that can be explained by the linear model. For this category, there were r^2 values of .21 and .07. There is also a moderate, positive correlation between the delays per month and the number of flights, which has an r-value of .62 at PTY and .46 at BOG. This confirms what we previously expected, which is that more flights means more delays. Between delays per month and number of flights, the r^2 value at PTY and BOG are .38 and .22, respectively. The r^2 values show that the data we tested is a decent fit for the linear regression model between the two data sets.

Airport	PTY		BOG	
	r	r^2	r	r^2
Percent Delays Per Month VS Flights Per Month	0.466254267	0.21739304	0.261410697	0.068335552
Delays Per Month VS Flights Per Month	0.62066749	0.38522813	0.465566608	0.216752266
Percent Delays VS Turnovers Per Month	-0.160650764	0.02580867	-0.390131406	0.152202514
Percent Delays VS Audit Findings Per Audit	0.203262613	0.04131569	-0.270843474	0.073356187
Flights Per Month VS Audit Findings Per Audit	-0.019853482	0.00039416	-0.481435886	0.231780513

Table 5: Pearson Correlations Between Different Data Sets

We also looked at the correlation between percent increase in delays and turnovers per month. We wanted to see if, as more turnovers occurred, the airport became less efficient, and the percentage of delayed flights increased. This did not occur, and there was a weak, negative correlation between turnovers per month and percent increase in delays with an r-value of -0.16 at PTY and -0.39 at BOG. This r-value shows that as the turnover rate increases, the percentage of flights delayed decreases. This does not mean that there is a proven negative correlation between these two data sets because there is not enough data to show real trends. The r^2 values

for this data set are .02 and .16. Neither of these values shows a strong trend in the data.

At PTY there is a weak, positive correlation between percent delays and audit findings per audit, with an r-value .203. This shows that there could be a possible correlation between the percent increase in delays and the number of non-compliance issues that occur. However, this trend does not continue at BOG, where the opposite trend exists, as it has a r-value of -0.27, and which is a weak, negative correlation.

At PTY, when we looked at the correlation between flights per month and audit findings per audit, we found that there is no correlation. There is an r-value of -.02, which shows that there is almost no correlation. However, at BOG, flights per month and audit findings per audit has a moderate, negative correlation of -.48. It is possible that there is only a correlation at BOG, and as the number of flights increases, the number of audit findings per audit goes down. This does not fit what we expected to find, but more analysis would need to be done in future years to accurate results. At PTY, the r^2 value is 0, which shows that none of the variations in the variable can be explained but at BOG, this number jumps up to .23.

These results summarize the correlations between the audit and supplementary data as a whole. We took what learned from our results and findings and transitioned them into meaningful recommendations for Copa moving forward.

12. Recommendations

12.1 Improving the Data Set

One of the main challenges our team encountered while analyzing the data was the lack of a consistent audit plan on the side of Copa. Copa Airlines designs their audit plan yearly based more on a budget than the needs or anticipated needs of the company or airports. Having a consistent yearly plan or a long-term plan for audits would allow for easier analysis and a better understanding of the data. With these types of plans the audit data would be more meaningful and less random and allow for year to year comparison of data. Currently, doing such a comparison would result in no meaningful analysis due to the inconsistency of the data.

Another way to improve data and yield better analysis would be to increase the number of audits performed. While looking into BOG, and to some extent PTY, we noticed a severe lack of datum removing any credit our results could have. Increasing the number of audits removes the issue of a lack of datum thereby giving more credibility to any results found in the future.

Beyond just looking at the macro scale of audits, Copa can also make improvements on the way they take individual audits. To start off, a standardization of certain audit finding categories would greatly improve the data set as a whole. In multiple instances we came across audit findings that lacked vital pieces of information for the analysis of the data set. We saw findings that were missing the start date or end date of the audit. It is our recommendation that if there are columns to be filled out that, they are filled out during every audit. Also, we found there to be a lack of consistency between notes written for each finding. Some included causes of the non-compliance, others did not. Some stated the exact issue found and others offhandedly mentioned only the part of a manual broken in its place. Having a set way to write each notes

section makes them easier to follow for someone not fully acquainted with the ins and outs of the company's writing style and easier to classify from an analytical standpoint.

While standardizing the report writing will increase and improve the data sets we have, we believe there are a few important pieces of information overlooked by the current auditing process. The first is the hiring department directly responsible for the non-compliance issue. We recommend that during auditing procedure if non-compliance is found that the hiring department and each responsible sub department the issue falls under is recorded. In order to do our analysis of the data, this data column had to be created manually based on our limited knowledge of the Copa audit checklists and the information provided in the note section of each audit. This was a time-consuming step and only let us delve as deep as the hiring department. However, if in the future further sub departments are recorded, then a better understanding of what departments need improving or what type of training needs to be enhanced. The second piece of information we suggest that auditors include is areas checked during audits that do not result in any findings. Being able to check where departments do not comply is just as important as knowing where they do. Checking where a company does comply, allows Copa to better understand a department's growth, the company's growth, and areas in need of improvement or better training.

12.2 Change the Scope of the Project

At the end of our analysis, while reviewing our results, we came across a common problem with what we were finding; that we lacked data. Many departments in both BOG and PTY simply did not have enough data for us to truly give a result in the form that we had originally planned on. The lack of data points and the fact that we only received seven and half

months of data from 2018, skewed the data and truly gave us little to no results that we were confident in.

In order to fix these issues, our group recommends that Copa broaden the scope of the project. We recommend Copa do a similar analysis that we have already done but use multiple years' data for data points under a single analysis. In theory, this should average out outliers and bad years' worth of data and bring your understanding closer to what is truly going on in the company. Moving forward, we also recommend not using a partial years' worth of data. For our analysis, we only received partial of 2018's data which skewed the data and did not help us get a true picture of what was going on.

While audit findings were the main focus of the project, we would also recommend changing the scope of the HR data used in the analysis to drastically improve the results of the project. The data we received detailed the number of people who were hired and the number of people who left the company from each hiring department. While informative, the data does not give a good snapshot of what we needed to see. The idea with the HR data was to see if turnovers in the company led to an increase in audit findings in hopes to understand areas that need better training or areas that really hurt after someone left the company. However, in order for us to find this out, the HR data would need to be representative of the date employees began their first day and finished their last day at work. In some scenarios, there are multiple months of training between the day the company onboards the employee and when they actually start working. So, just knowing when a person is hired or when they leave a company is not necessarily representative of when they actually start working or leave.

In an effort to further return meaningful results, we also recommend broadening the horizons of the project past individual airports. While looking at individual airports will still

result in interesting information, we recommend also looking into all areas affected by a training center. What this means is analyzing all findings in the same departments across all airports that were trained in the same place. That would allow for the best understanding of training issues and where they can improve in the future.

12.3 Analytical Tool

Our next recommendation is the creation of an analytical tool. We created a basic tool as a starting point for future development of a better tool. The hope being the future analytical tool is a fully integrated program that can repeat all of the analysis we have completed over the course of this project instantaneously. The tool we created and passed to Copa is partially able to do our analysis automatically. In its current state it requires a user to copy in the data from Tableau and other areas and has a few limiting factors. One of these factors is the lack of customization. Currently, the tool only produces certain graphs with certain results and does not allow for manipulation of the results or data. Another one of these limitations is on the years of data. The current tool does not distinguish between years of data. While this allows it to be used to check multiple years at once seeing an overall view of non-compliance, it does not allow for you to see trends or changes between years. That being said, the currently made tool can provide a higher understanding for Copa Airlines management.

12.4 Implement a Tablet System

Through our findings, we found that an effective way to facilitate a standardized and streamlined audit process would be to introduce a mobile tablet and accompanying audit software. By implementing a system where auditors check boxes in an application, it will reduce

the variability in wording, which will create a more complete and automatic classification system. This would also decrease time between the recording of the report and when it is entered in the system. Currently, the auditors have 7 days to file their report, but this tool would allow for automatic submission. Ideally, this would also increase both accuracy and speed of audits. Using tablets would open up paths to other information gathering methods limited by the previous system. The ability to take pictures and attach them to the audit finding, for example, would be helpful for not only the audit itself but to help address future corrective action plans.

If Copa decided to go this route they would have a choice of several off-the-shelf software packages if they chose to not create a personalized software. Most current audit software has standard 5S audits and ISO audits. There is an audit software called Aviation Audit Software which is capable of holding both internal and external audits to ensure that there are no non-compliances. In said software, you are able to create audit checklists, schedule audits, assign personnel to an audit, and log and track audit findings. Finally, it will keep track of your performance and generate trends (Aviation Safety Management Software, 2007). Software like this will help data analysis in the future be more accurate and improve the speed and quality of future audit reports.

13. Conclusion

This project was intended to help Copa Airlines find higher understanding of their audit data. We successfully broke down the data provided, analyzed and correlated the data, and began the implementation of an analytical tool. With an understanding of the Copa audit system and their audit checklists, the data was then able to be sorted and categorized. We then looked for correlations in the data, and from these findings we were able to create a basic analytical tool. Based on our analytical tool, we developed a foundation for Copa to improve their data collection and their data analysis. We suggest that Copa plan to standardize the audit process including scheduling, sorting by hiring departments, and the amount of years they analyze. With time, Copa would then begin to see stronger correlations in their data. The goal of this project is to be a useful tool for upper management to find higher understanding of audit findings for many years to come.

14. Reflection

Our team had a very knowledgeable and successful project with Copa Airlines. We had three spectacular Copa employees that we were able to ask questions to and who supported us in every step of the project.

If we were able to redo this project, there are some steps that we would take differently. First, we did not realize that there would be a waiting period when receiving the data from Copa. One file in particular, the HR personnel rotation data, took a couple weeks for us to receive because Human Resources had to compile the data. If we were to do this project again, we would start the process of asking for the data during our prep term, so that when we arrived at the project site, we could immediately start working.

Also, if another group works with Copa in the future, we would suggest that they nail down the objectives and scope of the project better than we did during the prep term. The Copa sponsors do a great job of explaining the problem and what they are hoping to accomplish during the seven weeks, if you ask them the right questions. We had some communication issues early on about details in our project that were easily avoidable. We suggest that the next team has more phone conferences with the Copa sponsors during the prep term, stays in contact with them over the summer break, and knowing Spanish would be helpful,

Contrarily, many parts of the project worked well. Some examples include having a designated place to work at the Copa Airlines headquarters. Using Excel as the software to make the analytical tool due to our vast knowledge of that software.

Overall, we learned a lot about Copa Airlines, how companies work, and how our group works together. We learned many lessons along the way of this process. We want to thank Carol Dominguez, Yuri Vergara, and Carolina Diaz for all their help.

15. Bibliography

- “Airplane Characteristics for Airport Planning.” Boeing PDF, 2013, www.boeing.com/assets/pdf/commercial/airports/acaps/737.pdf.
- Allan, J. R., & Digital Commons @ University of Nebraska - Lincoln. (2000). Costs of bird strikes and bird strike prevention
- Almonte, L. C., Burner, C. S., Ring, J. G., Simpson, V. L., & Zarate, S. A. (2016, November 07). Responding to Challenges following the Panama Canal Expansion Project. Retrieved March 23, 2018, from <https://web.wpi.edu/Pubs/E-project/Available/E-project-110716-193156/>
- Arosemena, Jaime. (2018). General information about Tocumen airport and tour [Personal Interview].
- Aviation Safety Management Software. (2007). Retrieved September 25, 2018, from <https://www.asms-pro.com/Home.aspx>
- Botteron, E., Surpless, J., & Wilhelmsen, S. (2000) Air Travel in Worcester: A Study on The Improvement of the Worcester Airport. Retrieved from Worcester Polytechnic Institute Electronic Projects Collection: <https://web-wpi-edu.ezproxy.wpi.edu/Pubs/E-project/Scanned/00B008I.pdf>
- Cano, T., Drakontis, C., Moniz, J., & Ramos, J. (2016) Preventing Bird Strikes at Tocumen International Airport An Approach through an Improved Waste Management System (Undergraduate Interactive Qualifying Project E-project-102417-194400). Retrieved from Worcester Polytechnic Institute Electronic Projects Collection: https://web.wpi.edu/Pubs/E-project/Available/E-project-102416-194400/unrestricted/WPI_Panama_COPA_IQP_2016.pdf
- Chang, W. (n.d.). Logistic Regression. Retrieved from http://www.cookbook-r.com/Statistical_analysis/Logistic_regression/
- Cheng, E., Hlavenka, T., & Nichols, K. (2015) An Analysis of Bird Strike Prevention Methods at Panama City’s Tocumen International Airport (Undergraduate Interactive Qualifying Project E-project-102915-205833). Retrieved from Worcester Polytechnic Institute Electronic Projects Collection: <https://web.wpi.edu/Pubs/E-project/Available/E-project-102915-205833/unrestricted/CopaBirdStrikePreventionMethodsInPanama.pdf>
- Copa Airlines. (n.d.). Company Profile. <http://investor.shareholder.com/copa/overview.cfm>

- Copa Airlines expande su flota y amplía su red de destinos en 2018. (2018, January 29). Retrieved from <https://www.copaair.com/es/web/us/copa-airlines-expande-su-flota-y-amplia-su-red-de-destinos-en-2018>
- “Copa Airlines - Member Airline Details.” Star Alliance, Star Alliance, May 2007, www.staralliance.com/en/member-airline-details?airlineCode.
- Darrah, C. (1995). Workplace Training, Workplace Learning: A Case Study. *Human Organization*, 54(1), 31-41. Retrieved from <http://www.jstor.org/stable/44126570>
- Davidson, A. (2011, November 16). The Trouble With Black Friday. Retrieved October 8, 2018, from <https://www.npr.org/sections/money/2011/11/16/142386652/the-trouble-with-black-friday>
- De Pagés et al., (2017). Tocumen Aeropuerto Internacional Panama Annual Report 2016. Retrieved April 24, 2018, from http://tocumenpanama.aero/transparencia/data_2017/Otros/pdf/annual_report_2016_aitsa.pdf
- De Pagés et al., (2018). Tocumen Aeropuerto Internacional Panama Annual Report 2017. Retrieved Oct 9, 2018, from http://tocumenpanama.aero/transparencia/data_21-05-2018-updates/Otros/pdf/annual-report-2017-aitsa.pdf
- Diaz, C. (2018). General information about Copa Airlines [Personal Interview].
- Domínguez, C. (2018). General information about Copa Airlines [Personal Interview].
- El Dorado. 2016, March 16). El Dorado es reconocido como el Mejor Aeropuerto de Suramérica. Retrieved April 24, 2018, from <https://eldorado.aero/dorado-reconocido-mejor-aeropuerto-sura>
- Expansion Works. (n.d.). Retrieved April 24, 2018, from <https://eldorado.aero/en/about/expansion-works/>
- Gallup, Inc. (2013, October 08). Worldwide, 13% of Employees Are Engaged at Work. Retrieved October 8, 2018, from <https://news.gallup.com/poll/165269/worldwide-employees-engaged-work.aspx>
- Gorsuch, R. L. (2003). Factor Analysis. *Handbook of Psychology*. doi:10.1002/0471264385.wei0206
- Harper, D. (2010). Non-compliance. Retrieved September 19, 2018, from <https://www.dictionary.com/browse/non-compliance>
- Harvard Business Review. Why People Quit Their Jobs. (2016, August 23). Retrieved September 20, 2018, from <https://hbr.org/2016/09/why-people-quit-their-jobs>

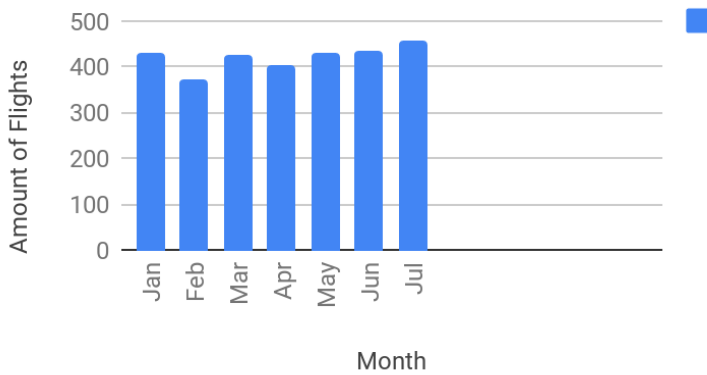
- HSE. (n.d.). Human factors: Shift handover. Retrieved April 24, 2018, from <http://www.hse.gov.uk/humanfactors/topics/shift-handover.htm>
- Kasarda, J. D. (2011). "Big plans for Panama." *Airport World*, 16(03), 01-07.
- Lacagnina, Mark. "Defusing the Ramp." *Aerosafety World*, May 2007, pp. 20–24. https://flightsafety.org/wp-content/uploads/2016/09/asw_may07_p20-24.pdf
- Learmount, David. "Ramp Damage Costs Airlines \$10bn." *Flight Global*, *Flight International*, 15 Nov. 2005, www.flightglobal.com/news/articles/ramp-damage-costs-airlines-10bn-202880/.
- Magalhães, L. (2014, February). *Depicting Airport Processes: Definitions, Activities, and Modelling* [Scholarly project]. In INSTITUTO SUPERIOR TÉCNICO UNIVERSIDADE DE LISBOA. Retrieved April 23, 2018, from https://fenix.tecnico.ulisboa.pt/downloadFile/1126518382133622/depicting_airport_processes.pdf
- Muresan, R. (2018, April 2). *Costs of Non-Compliance are Getting Higher*. Retrieved September 23, 2018, from <https://businessinsights.bitdefender.com/costs-of-non-compliance-getting-higher>
- "OAS Safety Terms & Definitions." U.S. Department of the Interior, 9 May 2017, www.doi.gov/aviation/safety/safety_terms.
- Operational Safety Audits. (2018). Retrieved April 23, 2018, from <http://www.iata.org/whatwedo/safety/health/Pages/index.aspx>
- Paine, L. S. (2014, August 01). *Managing for Organizational Integrity*. Retrieved September 08, 2018, from <https://hbr.org/1994/03/managing-for-organizational-integrity>
- Property News Panama. (2017, September 15). *New Tocumen Terminal Scheduled to Open in 2018* –. Retrieved from <https://www.puntapacificarealty.com/panama-news/new-tocumen-terminal-scheduled-open-2018/>
- Reference Manual for Audit Programs. (2014). Retrieved 2018, from https://www.iata.org/whatwedo/safety/audit/issa/Documents/IRM_Ed_5.pdf
- Responsabilidad social empresarial - Comunidad. Copa Airlines. (2018). Retrieved September 24, 2018, from <https://www.copaair.com/es/web/ca/rse-comunidad>
- Rosato, N. S., & Baer, J. C. (2012). Latent Class Analysis: A Method for Capturing Heterogeneity. *Social Work Research*, 36(1), 61-69. doi:10.1093/swr/svs006

- Shields, J., & Shelleman, J. (2013). Small Business Seasonality: Characteristics and Management. *Journal of Small Business Management*, 9(1), 1-2.
doi:10.1111/jsbm.2013.51.issue-4
- SKYbrary Wiki. (2018, July 27). Retrieved from
https://www.skybrary.aero/index.php/Operations_Manual
- Tableau Software. (2018). Retrieved from <https://www.tableau.com/>
- Tocumen Intl Airport. (2004). Retrieved April 25, 2018, from http://www.airports-worldwide.com/panama/tocumen_intl_panama.php
- Training and Development Institute IATA. (n.d.). IATA Airport Operations. Retrieved 2018, from <https://www.iata.org/training/courses/Documents/apt-ops-2nd-toc.pdf>
- Vandel, Bob. "Equipment Damage and Human Injury on the Apron." ISASI Gold Coast, ISASI, 2004, www.asasi.org/papers/2004/Vandel_Ramp%20Damage_ISASI04.pdf.
- Vergara, Yuri, personal communication, 2018
- Wald, Matthew L., Poor Airplane Maintenance Is Said To Have Led To Crash. *New York Times*. Feb 2004, pp A00018.
- Yu, C. (2017). 2017 ATRS Global Airport Performance Benchmarking. Retrieved April 25, 2018, from <http://www.atrsworld.org/docs/Key Findings of 2017 ATRS Benchmarking.pdf>
- Zang, Y. (2017). Analysis and improvement measures of flight delay in China. *AIP Conference Proceedings*. doi:10.1063/1.4977363

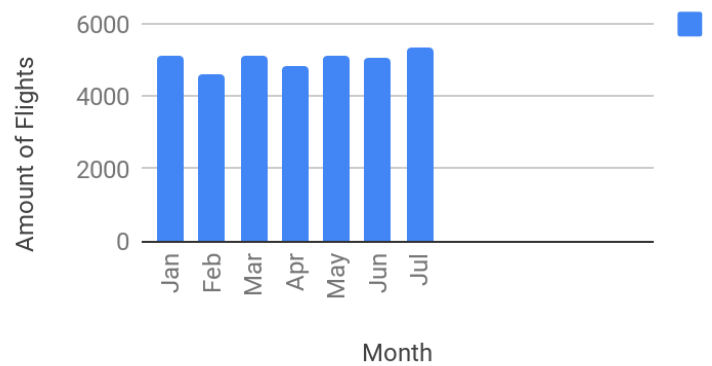
Appendix A. High vs. Low Season Data

The following graphs show the number of flights out of PTY and BOG that Copa and Copa-affiliated airlines flew for 2017 and 2018. Displaying the data Copa provided in graph form was the first step in visualizing the high and low seasons. We can see a uniform distribution between each month's data. This is important because a large portion of our analysis looked at the relationship between flights per month and non-compliance.

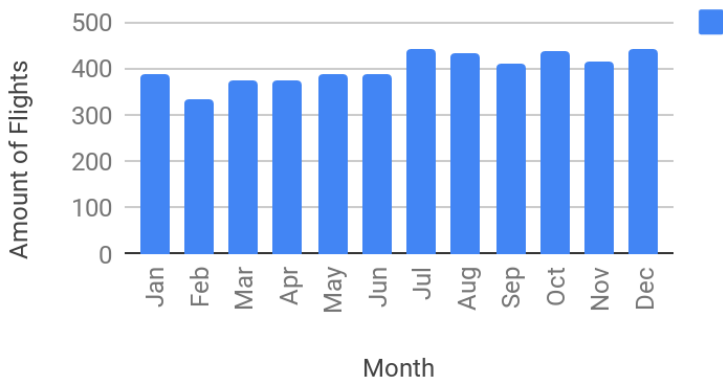
BOG Flights per Month 2018



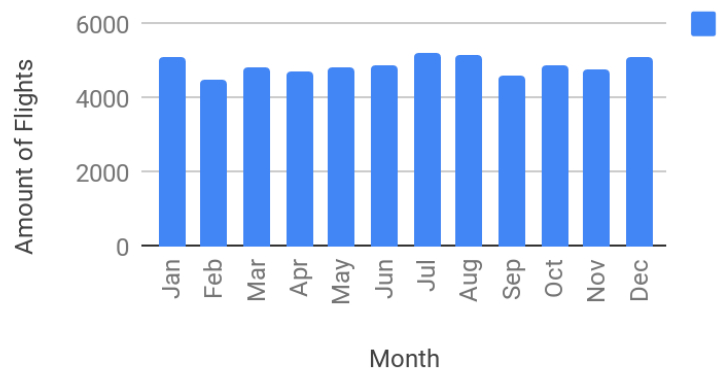
PTY Flights per Month 2018



BOG Flights per Month 2017



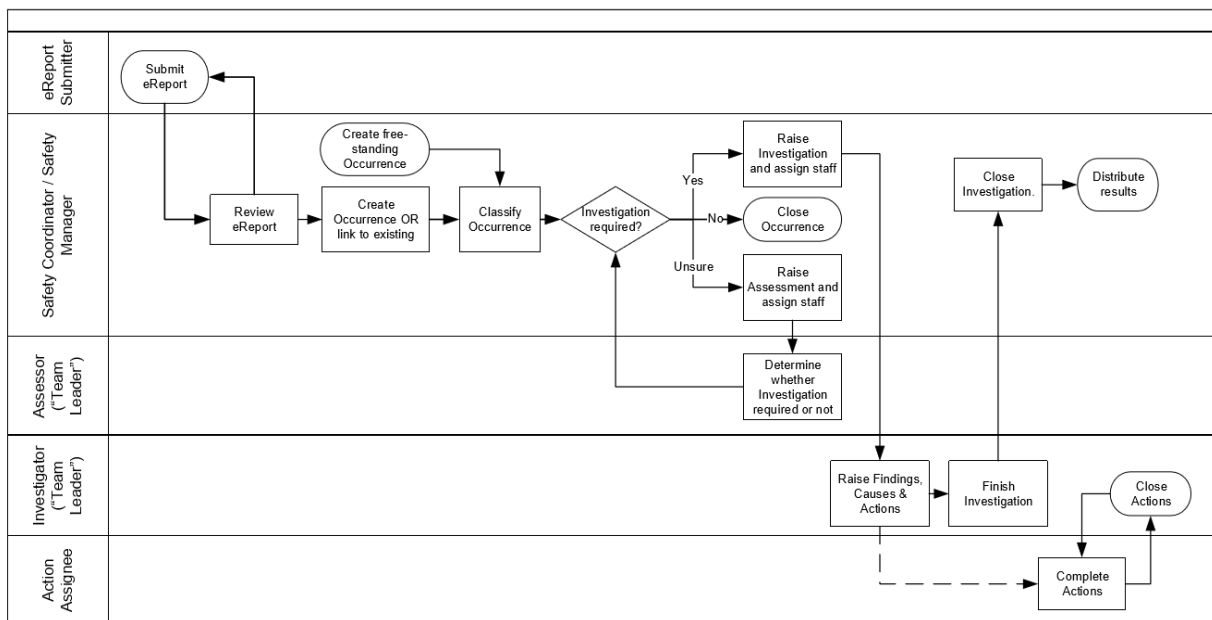
PTY Flights per Month 2017



Appendix B. Safety Process

The following flow chart explains the safety process for Copa Airlines when there is an incident. We can see that the process starts with a report which can be linked to an audit finding. It is then classified and the safety manager has to decide if an investigation is required. If yes, then they will finish an investigation with findings. If no, they will close the investigation.

Sample VisiumAQD Safety Process - Summary



Appendix C: Seasonal Flight Data

The following data and charts show the trends of flight data after removing the seasonal factor. Since there is an incomplete data set, we focused on Jan-July of 2017 and 2018. This data analysis method is known as deseasonalization of a time series. Overall, it allows us to see secular trends in the data, without the interference of seasonal patterns. After the analysis, we were able to see that there is a slight increase in flights over time. This is one indicator for the overall growth of the company, and it was something that we kept in my when presenting our findings and recommendations. The first table below is the Seasonal Flight Data for PTY (Jan-July). This is the raw flight data that Copa provided.

Seasonal Flight Data for PTY (Jan-July)

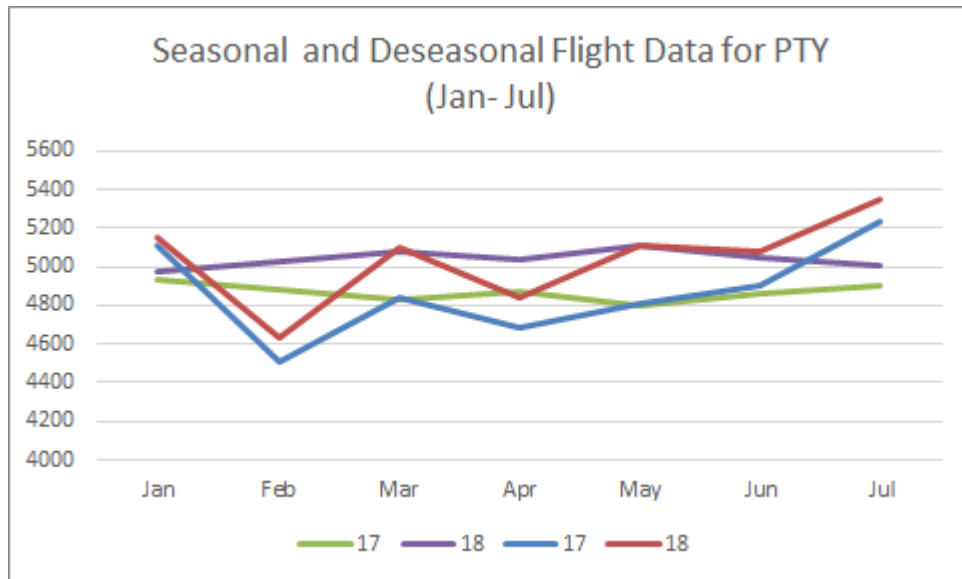
	Jan	Feb	Mar	Apr	May	Jun	Jul	Avg
17	5105	4511	4844	4690	4808	4899	5237	4870.571
18	5150	4638	5099	4841	5114	5084	5346	5038.857

The next table is the Deseasonalized Flight Data for PTY (Jan-July). After the process of deseasonalization, these are the adjusted flight numbers.

Deseasonalized Flight Data for PTY (Jan-July)

	Jan	Feb	Mar	Apr	May	Jun	Jul
17	4931.917	4885.679	4828.355	4876.122	4803.039	4863.024	4903.126
18	4975.392	5023.227	5082.532	5033.115	5108.723	5046.665	5005.177

The graph below is a visualization of the two previous tables. The Deseasonalized Flight Data trends are shown in green and purple and the Seasonal Flight Data trends are shown in blue and red.

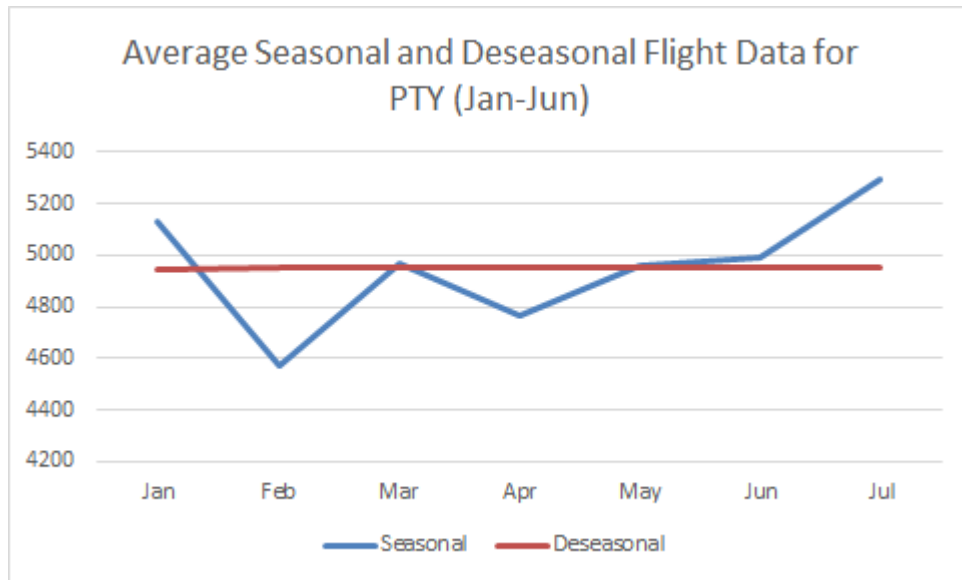


The next step that we took was to take the average of 2017 and 2018 to show the overarching trends from month to month. The adjusted data is shown in the table below.

Average Seasonal and Deseasonal Flight Data for PTY (Jan-Jun)

	Jan	Feb	Mar	Apr	May	Jun	Jul
Seasonal	5127.5	4574.5	4971.5	4765.5	4961	4991.5	5291.5
Deseasonal	4953.654	4954.453	4955.444	4954.618	4955.881	4954.845	4954.152

The graph below is a visualization of the above table. From this graph, we can tell that there is a slight linear increase in the number of the flights per month as the year progresses.



Next, we repeated the process for the BOG airport. The table Seasonal Flight Data for BOG (Jan-July) shows the total number of Copa flights at BOG airport.

Seasonal Flight Data for BOG (Jan-July)

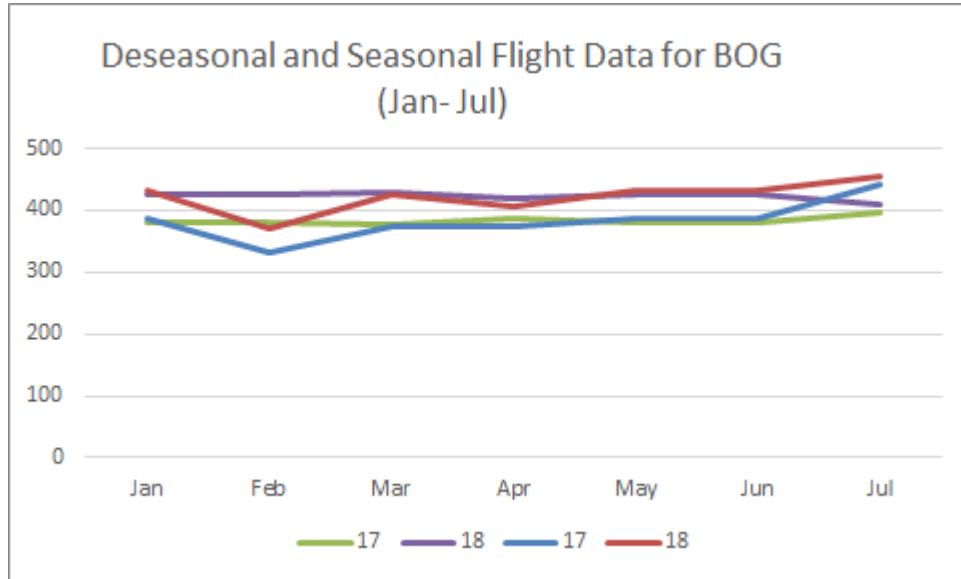
	Jan	Feb	Mar	Apr	May	Jun	Jul	Avg
17	386	333	373	375	387	387	441	383.1429
18	432	371	426	405	432	433	455	422

Deseasonalized Flight Data for BOG (Jan-July) shows the adjusted number of flights per month after removing the seasonal variable.

Deseasonalized Flight Data for BOG (Jan-July)

	Jan	Feb	Mar	Apr	May	Jun	Jul
17	380.0795	380.9471	376.1966	386.9045	380.5752	380.1323	395.6566
18	425.374	424.4185	429.6508	417.8569	424.8281	425.3159	408.2171

The graph below shows the Seasonal Flight Data and Deseasonalized Flight Data for BOG (Jan-July). The Deseasonalized Flight Data values are shown in green and purple. The Seasonal Flight Data values are shown in blue and red.

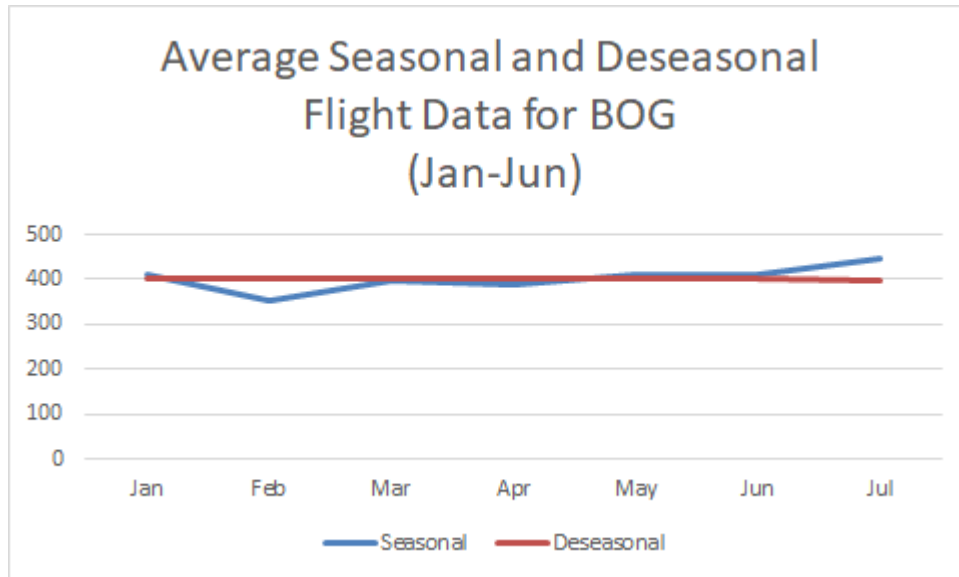


Just as we did with the PTY, we took the average for both years, so that we could compare the seasonal and seasonal values.

Average Seasonal and Seasonal Flight Data for BOG (Jan-Jun)

	Jan	Feb	Mar	Apr	May	Jun	Jul
Seasonal	409	352	399.5	390	409.5	410	448
Deseasonal	402.726	402.6828	402.9237	402.3807	402.7016	402.7241	401.9369

The graph below compares the seasonal and deseasonal flight data from BOG for Jan-July. This graph shows that BOG is not as affected by seasonal patterns as PTY, but both follow a similar long-term trend with a slight increase in flights per month as the year goes on.



Appendix D: Employee Turnover Rates PTY Data

This table shows the turnover rates at PTY for 2017 within each department. It was useful for us in our analysis to know how many employees were in each department because it helped contextualize how many non-compliance issues were happening based on department size. Also, it was useful to know which departments had a high turnover percentage.

Number of employees and turnover rates for the past 2 years

Operational area	2016 year		2017 year	
	Number of employees	Turnover %	Number of employees	Turnover %
Flight crew	986	11.6%	1099	9.5%
Cabin crew	1827	4.0%	1981	4.2%
Maintenance personnel	603	5.8%	633	7.0%
Ground staff	1302	30.6%	1289	27.7%
Safety organization	33	8.8%	33	2.9%

Appendix E: Number of Flights Per Month

The tables below show the flight volume. The top table is related to PTY and the bottom table is related to BOG. Both tables show the amount of flights per month. We can see that there is a fairly consistent number of flights each month. For PTY that ranges from around 4500-5300 flights per month and for BOG it ranges from 300-500 flights per month. We can also see how exactly the data is broken down by CM, P5 and Wingo which are all subsets of Copa Airlines.

Saliendo de PTY													
2017													
Aerolínea	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CM	4142	3644	3926	3793	3895	3988	4239	4162	3709	3951	3899	4172	47520
P5	888	797	833	815	831	828	902	898	783	850	815	869	10109
Wingo (BLB)	75	70	85	82	82	83	96	96	91	88	74	78	1000
	5105	4511	4844	4690	4808	4899	5237	5156	4583	4889	4788	5119	58629

2018								
Aerolínea	Jan	Feb	Mar	Apr	May	Jun	Jul	Total
CM	4196	3808	4203	3952	4143	4124	4349	28775
P5	869	761	816	813	894	875	909	5937
Wingo (BLB)	85	69	80	76	77	85	88	560
	5150	4638	5099	4841	5114	5084	5346	35272

Saliendo de BOG													
2017													
Aerolínea	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
CM	31	28	32	30	32	31	30	32	32	33	30	32	373
P5	187	166	185	180	185	180	185	182	176	186	178	185	2175
Wingo	168	139	156	165	170	176	226	218	202	218	206	223	2267
	386	333	373	375	387	387	441	432	410	437	414	440	4815

2018								
Aerolínea	Jan	Feb	Mar	Apr	May	Jun	Jul	Total
CM	31	28	31	30	31	30	31	212
P5	185	167	179	175	184	178	186	1254
Wingo	216	176	216	200	217	225	238	1488
	432	371	426	405	432	433	455	2954

Appendix F: Delay Data

This table shows the on-time performance data for Copa flights departing and arriving at PTY and BOG for 2017. The original data included information of all airports that Copa flies to, but this is the filtered version. For our project, we were only interested in the Dep00 column, which shows the number of flights that departed on time from the Airport that month. Our sponsor wanted us to focus only on flights departing from PTY and BOG.

Month	VueloOrigen	Dep00	Arr00	Arr14	CompletionFactor
January	BOG	77.42%	70.97%	100.00%	100.00%
January	PTY	73.24%	56.98%	84.17%	100.00%
February	BOG	75.00%	57.14%	89.29%	100.00%
February	PTY	79.30%	62.79%	86.88%	99.92%
March	BOG	80.65%	70.97%	90.32%	100.00%
March	PTY	77.35%	58.90%	85.49%	99.90%
April	BOG	80.00%	53.33%	90.00%	100.00%
April	PTY	74.68%	55.48%	83.59%	99.95%
May	BOG	74.19%	58.06%	90.32%	100.00%
May	PTY	73.46%	52.65%	82.75%	99.77%
June	BOG	80.00%	61.29%	93.55%	100.00%
June	PTY	67.39%	49.82%	79.94%	99.68%
July	BOG	74.19%	45.16%	83.87%	96.77%
July	PTY	68.00%	58.45%	84.41%	99.88%
August	BOG	83.87%	61.29%	87.10%	100.00%
August	PTY	57.01%	53.99%	77.07%	99.74%
September	BOG	90.00%	76.67%	90.00%	100.00%
September	PTY	65.76%	63.59%	83.27%	95.64%
October	BOG	70.97%	45.16%	80.65%	100.00%
October	PTY	69.84%	64.27%	87.33%	99.87%
November	BOG	80.00%	50.00%	83.33%	100.00%
November	PTY	67.37%	59.84%	82.85%	99.67%
December	BOG	58.06%	51.61%	77.42%	100.00%
December	PTY	69.69%	55.33%	83.55%	99.88%

Appendix G: Audits by Operational Division

This table shows the number of audits per each operation division at Copa Airlines. The table shows the data from 2017 and up to July 2018 from all airports that Copa flies to. The number of audits change every month depending on how much money is in the budget.

Number of Audits by Operational Division

	2017												2018							Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	
MNT	29	17	21	15	19	18	12	14	11	15	11	7	19	19	19	15	17	17	15	310
SAP	14	3	8	4	6	7	9	9	9	8	2	0	3	3	10	9	7	16	9	136
CGO	7	0	3	2	4	2	5	2	5	4	0	0	0	2	5	5	2	1	5	54
SAB	13	1	5	2	7	7	7	2	7	6	2	0	0	4	8	8	2	6	8	95
SEC	7	0	4	1	4	5	3	2	7	4	0	0	0	3	7	4	2	5	8	66
FLT	2	2	0	2	0	1	1	0	0	1	3	0	0	0	2	1	0	1	4	20
Total	72	23	41	26	40	40	37	29	39	38	18	7	22	31	51	42	30	46	49	681

Appendix H: Analytical Tool and Manual

Below is the written-out manual provided to Copa airlines on how to use the excel tool sent to them. The manual details the two main limitations of the tool, how to add data, how to narrow the data input to one airport, and informs the user what the color-coding means.

Basic Analytical Tool

How to use

Data Limits:

- Only able to determine 1-years' worth of data at a time
- Requires manual determining of certain data columns

Adding Data:

1. Export Data from Tableau to excel.
2. Copy Columns Audit ID, Finding Department, Response Status, Finding Status, Finding ID, Response_Due_Date, Findings Descriptions.
3. Paste Data into excel sheet in tool labeled <Exported Data>.
4. Manually put data into Columns labeled Airport and Hiring Department.
 - a. User must determine proper label for each finding.
5. Highlight top row of orange data to the right of the data just placed into <Exported Data> and double click bottom right corner of right most highlighted box.
 - a. This step copies formulas in the first orange row into all rows where data is pasted in.
6. Export Audit Findings to Excel
7. Copy All Columns of Audit Findings into top left most cell in excel sheet labeled <Copy of Findings>.
8. Take a copy of HR data from the following Hiring departments: Operaciones de Vuelo, Servicio a Bordo, Servicios Aeroportuarios, Operaciones Tecnicas, Seguridad, Carga y Courier, and Operaciones.
9. Paste the previous stated columns into excel sheet labeled <HR Data>.
10. Copy columns Month, VueloOrigen, and Dep00 from on time departure data and paste into sheet labeled <On Time Departure>
11. To fill out flight volume data copy monthly total of flights and paste into yellow boxes in excel sheet labeled by month

Data Analysis:

- If wanting to look at a specific airport put airport code into the golden box in excel spreadsheet labeled VOLUME&AIRPORT BREAKDOWN or <On Time Departure>
 - o Changing the box in VOLUME&AIRPORT BREAKDOWN to an Airport code means the tables in that sheet will only record audit findings from that specific airport
 - o Changing the box in <On Time Departure> will make the entire of the excel sheet only look departure percentages from that airport

General Knowledge:

- Yellow boxes are for pasting in data
- Blue boxes are labels and titles
- Green boxes contain results
- Orange boxes require user manipulation for tool to work properly

Below is a snapshot of the first excel sheet in the analytical tool. The sheet is called “<Copy of Findings>”. The manual asks users to paste in excel data from exported audit findings.

INSERT DATA INTO TOP LEFT MOST YELLOW BOX

VP	Checklist_Code	Owner	Finding ID	Title	DESCRIPTION	Due	Response Status	Department	ASDF	Assigned to	Risk	DAY	MONTH	YEAR	Entered By	Audit_ID	Category	Actual Start Date	Audit Department	Audit Title	Entered on	Findings	

Below is a snapshot of the second excel sheet in the analytical tool called “<Exported Data>”. The manual asks the user to export data from Tableau and paste specific columns into the yellow columns in this sheet. Users then must manually input in the relevant hiring department and airport location to each finding, as Tableau does not currently include this information.

INSERT DATA INTO TOP LEFT MOST YELLOW BOX
ON FAR RIGHT DOUBLE CLICK BOTTOM RIGHT CORNER OF TOP ORANGE BOXES TO COPY DOWN FORMULAS

BELOW BOXES DONE MANUALLY

Audit #	Finding Department	Response Status	Finding Status	Finding	Response Due Date	Findings Description	Airport	Hiring Department	Actual Start Date	Entered	Length of Audit	Start Day	Start Month	Start year	Enter Day	Enter Month	Enter Year	

Below is a snapshot of the third excel sheet in the analytical tool called “<HR Data>”. The manual asks the user to paste the relevant HR data into the yellow boxes. On the far-right side, not shown in this snapshot are the yearly totals calculated for each hiring department.

INSERT DATA INTO TOP LEFT MOST YELLOW BOX
GREEN BOXES WILL CALCULATE TOTALS

Descr Unidad Negocio	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Se	
	Entrada	Salida	Entrada	Salida	Entrada	Salida	Entrada	Salida	Entrada	Salida	Entrada	Salida	Entrada	Salida	Entrada	Salida	Entrada	
Operaciones de Vuelo																		
Servicio a Bordo																		
Servicios Aeroportuarios																		
Operaciones Tecnicas																		
Seguridad																		
Carga y Courier																		
Operaciones																		
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Below is a snapshot of the fourth excel sheet in the analytical tool called “<On Time Departure>”. The manual asks the user to paste on time departure data into the yellow boxes. The gold box allows for users to select what airport’s on time departure values they wish to look at.

INSERT DATA INTO YELLOW BOXES
INSERT AIRPORT CODE INTO GOLD BOX

Month	VueloOrigen	Dep00	Specific Airport?	Month	Dep AVG.
				January	#DIV/0!
				February	#DIV/0!
				March	#DIV/0!
				April	#DIV/0!
				May	#DIV/0!
				June	#DIV/0!
				July	#DIV/0!
				August	#DIV/0!
				September	#DIV/0!
				October	#DIV/0!
				November	#DIV/0!
				December	#DIV/0!
				Average	#DIV/0!
				Standard Deviation	#DIV/0!
				Average-STDEV	#DIV/0!
				Average+STDEV	#DIV/0!

Below is the fifth excel sheet and the last one that accepts data. This sheet is called “<Flight Volumes>” and accepts flight volume data. It then takes the data and calculates and assigns high and low to seasons to each month of the year.

INSERT DATA INTO TOP YELLOW BOXES

Month	Total Number of Flights	Airport	Low	Normal	High
January	0	Jan	X		
February	0	Feb	X		
March	0	Mar	X		
April	0	Apr	X		
May	0	May	X		
June	0	Jun	X		
July	0	Jul	X		
August	0	Aug	X		
September	0	Sep	X		
October	0	Oct	X		
November	0	Nov	X		
December	0	Dec	X		
Total	0				
Average	0				
Standard Deviation	0				
Average-STDEV	0				
Average+STDEV	0				

The following 4 tables are from the sixth excel sheet and the first result only sheet. The table with “Operations Dispatch, SOCC” is only one of seven tables detailing each departments relationship between audit findings and turnover. The table titled “Total” shows the total number of audit findings across all departments and displays the number of audit findings that did not have a hiring department assigned to them. The tables titled “Audits” shows the number of audits taken each month and the average number of findings per audit. The final table gives only two numbers. The first is the average number of findings per month for the whole year and the second details the average number of findings per month during periods of high turnover.

Operations/ Dispatch, SOCC				Audits			Total	
Month	# of Findings	% of Findings	Turnover Over Avg. Leaving over Average	Month	# of Audits	Avg. # of Findings Per Audit	Month	# of Findings UnCategorized
Jan	0	0.00		Jan	0	#DIV/0!	Jan	0
Feb	0	0.00		Feb	0	#DIV/0!	Feb	0
Mar	0	0.00		Mar	0	#DIV/0!	Mar	0
Apr	0	0.00		Apr	0	#DIV/0!	Apr	0
May	0	0.00		May	0	#DIV/0!	May	0
Jun	0	0.00		Jun	0	#DIV/0!	Jun	0
Jul	0	0.00		Jul	0	#DIV/0!	Jul	0
Aug	0	0.00		Aug	0	#DIV/0!	Aug	0
Sep	0	0.00		Sep	0	#DIV/0!	Sep	0
Oct	0	0.00		Oct	0	#DIV/0!	Oct	0
Nov	0	0.00		Nov	0	#DIV/0!	Nov	0
Dec	0	0.00		Dec	0	#DIV/0!	Dec	0
Total	0	0.00	0	Total:	0	#DIV/0!	Total:	0
Avg:	0	0.00	0	Avg:	0	#DIV/0!	Avg:	0
Month	Hires	Leaves	Total					
Jan	0	0	0					
Feb	0	0	0					
Mar	0	0	0					
Apr	0	0	0					
May	0	0	0					
Jun	0	0	0					
Jul	0	0	0					
Aug	0	0	0					
Sep	0	0	0					
Oct	0	0	0					
Nov	0	0	0					
Dec	0	0	0					
Total	0	0	0					
Avg:	0	0	0					

Avg # of Findings Throughout the Year	0
Avg # of Findings During High turnover	#DIV/0!

Below is a snapshot from the sixth excel sheet called “Volume&Airport Breakdown”.

This excel sheet looks at the correlation between the hiring departments and high and low seasons. Despite there only being one department shown, there is a separate table for each of the seven hiring departments and one table looking at the totals between all departments. The gold box allows users to change what the airport the findings are coming from. By default, it looks at all findings input.

INSERT AIRPORT CODE INTO GOLD BOX

Month	Season
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

Flight operations			
Month	# of Findings	% of Month's Findings	Season
Jan	0	0.00	
Feb	0	0.00	
Mar	0	0.00	
Apr	0	0.00	
May	0	0.00	
Jun	0	0.00	
Jul	0	0.00	
Aug	0	0.00	
Sep	0	0.00	
Oct	0	0.00	
Nov	0	0.00	
Dec	0	0.00	
Total:	0	0.00	
Avg:	0	0	

Seasonal Volume			
Season	# of Findings	% of Group's Findings	Seasonal Avg
High	0	#DIV/0!	#DIV/0!
Mid	0	#DIV/0!	#DIV/0!
Low	0	#DIV/0!	#DIV/0!

Below are three tables from the seventh and final excel spreadsheet titled “Overall”. The three tables look at the data as whole rather than looking at each individual month. The table titled “Findings Increase due to Turnovers” looks at each hiring department and looks to see if there’s a percent increase in average findings during periods of high turnover. The table titled “Peak Times Impact on Audit Findings” looks to see if there is a percent increase in audit findings during the high and low seasons we defined. The third and final table titled “Statistical Correlation” looks for the Pearson correlation between the labeled categories.

Statistical Correlation			Findings Increase due to Turnovers			Peak Times Impact on Audit Findings			
Category	r	r ²	Department	Avg. # of Findings Per Month	% Increase during above Avg. Turnover	Department	Avg. # of Findings	% Increase During High	% Increase During Low
Percent Delays Per Month VS Flights Per Month	#DIV/0!	#DIV/0!	Flight Operations	0.0	#DIV/0!	Flight Operations	0	#DIV/0!	#DIV/0!
Delays Per Month VS Flights Per Month	#DIV/0!	#DIV/0!	Flight attendants / Service on board	0	#DIV/0!	Flight attendants / Service on board	0.0	#DIV/0!	#DIV/0!
Percent Delays VS Turnovers Per Month	#DIV/0!	#DIV/0!	Airports / Ramp, Ground support equipment, Passenger service.	0.0	#DIV/0!	Airports / Ramp, Ground support equipment, Passenger service.	0.0	#DIV/0!	#DIV/0!
Percent Delays VS Audit Findings Per Audit	#DIV/0!	#DIV/0!	Maintenance	0.0	#DIV/0!	Maintenance	0.0	#DIV/0!	#DIV/0!
Flights Per Month VS Audit Findings Per Audit	#DIV/0!	#DIV/0!	Security	0.0	#DIV/0!	Security	0.0	#DIV/0!	#DIV/0!
			Carga y Courier	0.0	#DIV/0!	Carga y Courier	0.0	#DIV/0!	#DIV/0!
			Operations/Dispatch, SOCC	0.0	#DIV/0!	Operations/Dispatch, SOCC	0.0	#DIV/0!	#DIV/0!
			Overall	0.0	#DIV/0!	Overall	0.0	#DIV/0!	#DIV/0!