Examining Airline Ground Operation Incidents by Airport Size

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Abstract

Evaluating ground operations incidents is a critical step for airlines from both a management and safety perspective. Analysis of incidents is useful in both safety management and in planning for training and recurrent training of airline employees. De-identified data was provided by a major U.S. airline for all reported ground operations incidents from 2010-2017. This ex post facto research examined the rate of ground operations incidents by airport size for this airline, using both the National Plan of Integrated Airport Systems (NPIAS) classification and the airline's classification of airport size, based on its operations at each airport. NPIAS recognizes all commercial, reliever, and public airports in the national airport system, and the airports in this study were all classified as small/non-hub, or large/medium hub. The airline's size classification was based on its operations at a given airport and assigned airports as small, medium, large, or mega stations. The analysis of ground operations showed that the rate of incidents per operations did not differ with airport size for either the NPIAS size categories or the airline's size classification.

1. Introduction

Many incidents occur on the ground when aircraft are either taxiing or parked. The multitude of moving parts at airports, from fuel trucks, catering, and baggage carts to maintenance and security vehicles, combined with moving aircraft generates opportunities for mistakes. Studying these ground operations incidents is important from both a safety and business perspective. Likewise, understanding the rate of ground operation incidents per operation is critical for determining where to invest in safety improvements.

The purpose of this research was to investigate the relationship between the rate of ground operation incidents and airport size for a major U.S. airline from 2010 to 2017. Airport size was defined in two different ways: 1) the NPIAS airport size categories (FAA, 2019), and 2) the airline's station size categories based on its operations at each airport. The rate of ground operations incidents was calculated as the monthly ground operations incidents per airline operations at a given station.

This study provided information on the rate at which ground operations incidents occurred at various airports by airport size for a major U.S. airline. Any relationship between airline ground operations incidents and airport size can be used to develop safety practices that minimize incidents, whether this includes changes to the airport design and environment, new procedures, and/or recurrent training for employees. The analysis of existing organizational data on ground incidents to understand patterns and potential causes is a challenge for airlines (Wenner & Drury, 2000). Determining a baseline of ground operations incidents by airport size would help move towards

improving safety for passengers and minimizing the impact of incidents on airlines' operating costs.

2. Ground operations incidents

Airports are complex environments with many moving parts that, while regulated, require the participation of various entities from pilots and ground crew to air traffic control and airport management. Safety in such complex systems requires a system approach involving all stakeholders (Wilke, Majumdar, & Ochieng, 2014).

Although accidents are well studied in aviation, the literature contains relatively few examples of research on airline ground operations incidents. There are at least two estimates of the frequency of ground incidents: a) "the figures range from 2.7 to 7.2 incidences per 10,000 departures" (Matthews, 2000, p. 4) and b) "100-200 reportable GDIs [ground damage incidents] each year" (Wenner & Drury, 2000, p. 178) at an airline. Wenner and Drury (1996, 2000) analyzed 130 ground operations incidents from an airline in order to determine typical patterns and types of ground operations incidents. Their analysis categorized the events into towing/taxiing, and parked incidents from either another object or vehicle striking the aircraft or the aircraft moving to contact an object or vehicle. These three main types of incidents accounted for 94% of the damage events studied (Wenner & Drury, 2000). However, this research spanned three years at a single airline and did not specify the number of operations.

Wilke, Majumdar, and Ochieng (2015) examined airport surface accidents in relationship to the airports' characteristics. While this study focused on more severe accidents (not incidents), and on runway related events in particular, the conclusion was that the airport design, specifically complexity, served as a predictor of severity in events (Wilke et al., 2015). Thus, airport characteristics warrant further study in relation to ground operations.

In addition to the obvious safety impacts, ground operations incidents are important in aviation because of their large costs. Aircraft repairs and damaged equipment are some of the direct or tangible costs associated with ground operations incidents. However, indirect, or latent costs, such as delays, disrupted travel, consumer perceptions, and aircraft time out of service (lost profit), must also be accounted for but are much more challenging to quantify (Matthews, 2000; Wenner & Drury, 2000). Matthews (2000) estimated an annual global cost of three billion dollars, when accounting for both direct and indirect costs. While the costs are high, these events are often preventable (Matthews, 2000; Wenner & Drury, 2000), and manageable (Matthews, 2000), indicating this is an area with potential research impacts, as well as a focal point for safety management efforts.

In order to minimize the costs from ground operations incidents for airlines and maximize the safety for airline passengers and employees, research on the actual rates of ground operations incidents is critical. Understanding how the rate of incidents varies with airport size will aid in planning to these ends. This study addressed the question of whether there is a difference in the rate of ground operations incidents per operations at a major U.S. airline using both the NPIAS (FAA, 2019) and airline's airport size classifications.

3. Methodology

The methodology used for this research was an ex-post facto design. The data were received from a major U.S. airline and included all of the airline's archived data on ground operation incidents in the U.S. between January 1, 2010 and June 30, 2017. The data were deidentified with three letter airport identifiers re-coded to randomly assigned numbers, and aircraft tail numbers and employee names removed. The IRB exemption was approved (17-136) and included confidentiality, ensuring that the data were deidentified, presenting the data in in aggregate, and storing the data on

password protected devices.

After the deidentified data was received from the airline, unknown stations that did not have an airline size classification were removed from the dataset. The dataset contained 84 stations and a total of 5,497 incidents during the 7.5 years examined.

The NPIAS size classification (Table 1) and the airline's size classification (Table 2) were used as categorical size variables for airports. The rate of ground operations incidents was calculated as the number of incidents per month divided by the number of operations (flights) that the airline conducted at the airport. Results were reports as number of incidents per 10,000 operations. Descriptive statistics were calculated in Microsoft Excel. Inferential statistics were calculated in RStudio v.1.1.383. An independent t-test was used for the NPIAS classification of airport size, and a one-way ANOVA was conducted for the airline classification.

Table 1. NPIAS airport classification by boardings that are continuations

NPIAS Size	Boardings/Year	Percentage of boardings
Nonhub primary or Small Hub	at least 2,500 to more than 10,000	at least 2,500 to 0.24%
Medium Hub	More than 10,000	at least 0.25%
Large Hub	More than 10,000	1% or more

Note. Group 1 includes both Non-hub and Small hub airports; group 2 (gray shading) includes medium and large hubs. Adapted from FAA (2019).

Table 2. Airline station size classification by number of operations at airport

Station Size	Mean Daily Ops.	Mean Weekly Ops.
Small	9.3	65
Medium	38.8	272
Large	72.7	509
Mega	159.6	1117

4. Results

The deidentified data file of ground operations incidents received from the major U.S. airline contained 5,497 incidents over a 7.5-year period from 2010 to 2017. For the purpose of this research, 3,039 incidents were missing information on the ground incident, specifically the location of the incident. Therefore, these incidents were excluded from analyses. There were 84 stations with incidents that were included in the analyses. All of the stations were associated with a NPIAS airport size classification (Table 1) as well as an airline airport (station) size classification (Table 2), based on the airline's number of operations at each airport.

Overall, the average incident rates were low, in the range of two to four ground operation incidents per 10,000 flights. For the NPIAS classification, the sample size was 32 airports in the Small or non-hub category and 52 stations in the large or medium hub category. Table 3 shows the descriptive statistics for ground operations incidents per 10,000 operations by NPIAS classification of airport size. The average rate of incidents for small and non-hub airports was 2.8 per 10,000 operations, while the rate for large and medium hubs was 4.3 per 10,000 operations, almost two times the average rate at small/ non-hub airports. There was a larger range for ground operations incident rates at large and medium hubs in comparison to small and non-hub airports. This larger standard deviation for large and medium hubs is reflected in both Table 3 and Figure 1 (error bars)

and overlapped the distribution of rates at small/non-hub airports.

Table 3: Descriptive statistics for the rate of ground operations incidents per 10,000 operations by NPIAS airport size

NPIAS Size	Mean	Median	Mode	Std. Deviation	Minimum	Maximum
Small/Non-hub	2.8	2.7	4.3	1.6	0.6	7.1
Large/Medium Hub	4.3	2.6	NA	10.4	0.9	76.9

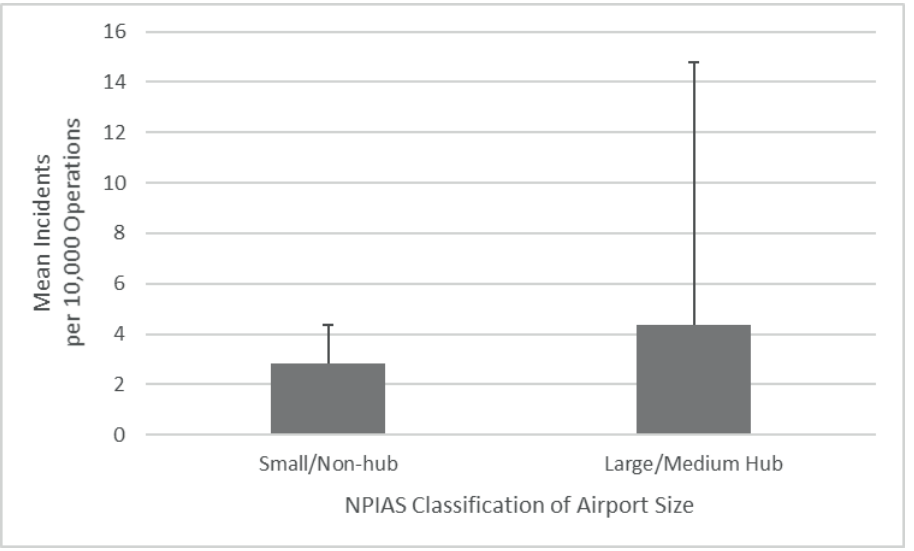

Figure 1. Ground operations incidents per 10,000 operations by NPIAS classification.
The rate of incidents is the average number of monthly incidents per operations at an airport averaged by NPIAS airport size category, and then reported as incidents per 10,000 operations. Error bars represent one standard deviation.

Descriptive statistics for ground operations by airline size category (Table 2) also indicated low rates of incidents, between 1.6 and 4.7 incidents per 10,000 operations, and the rates were consistent across the medium, large, and mega size categories (Table 4). The highest average rate of ground operation incidents occurred at small airport stations, and the large stations had slightly lower average rates of incidents than other sizes. The small stations also had the largest standard deviation (Table 4, Figure 2). A mode was only found for the small station category.

Table 4. Descriptive statistics for the rate of ground operations incidents per 10,000 operations by airline size classification

Airport Size	Mean	Median	Mode	Std. Deviation	Minimum	Maximum
Small	4.7	3.1	4.3	10.7	0.6	76.9
Medium	2.8	2.6	NA	1.0	1.0	4.3
Large	1.6	1.6	NA	0.5	1.1	2.6
Mega	2.5	2.6	NA	0.6	1.3	3.3

The major U.S. airline classified stations by size, using the number of operations conducted at each airport. The rate of ground operations was calculated as monthly incidents divided by the monthly operations at each airport, and then reported as incidents per 10,000 operations.

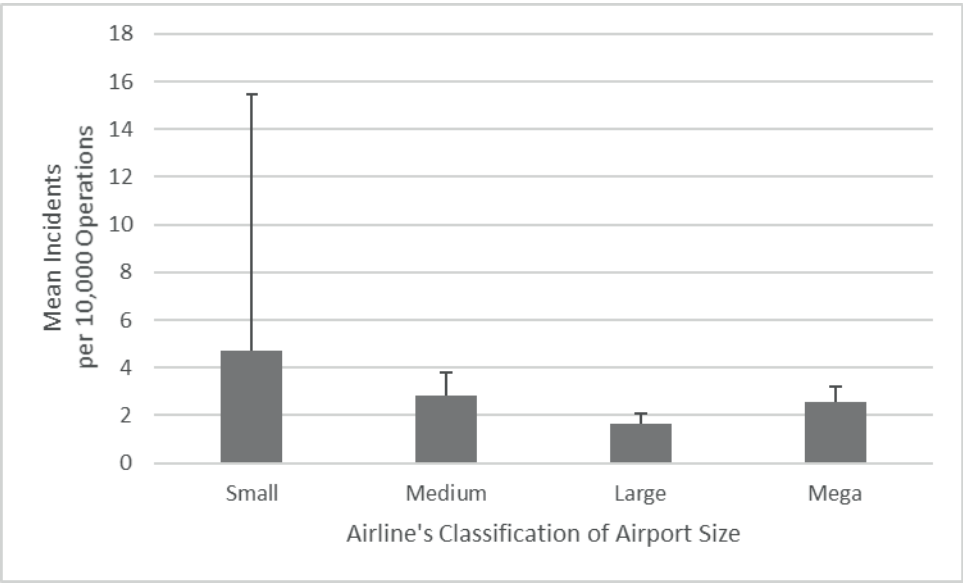

Figure 2. Ground operations incidents per 10,000 operations by airline classification.
The rate of incidents is the average number of monthly incidents per operations at an airport averaged by airport size category, and then reported as incidents per 10,000 operations. Error bars are one standard deviation.

The inferential statistics demonstrated that there were no significant differences in rate of ground operations by airport size, regardless of the size categorization used. An independent t-test showed that there was no significant difference in rate of ground operations incidents between NPIAS size classes: t (84) = 1.05, df = 54.7, p = .3. Cohen's d indicated a small effect size (0.2). A one-way ANOVA found no significant difference in rate of ground operations incidents by the airline's size classification: F (3, 80) = 0.06, p = .64. The eta squared was 0.02, which is a negligible effect size.

5. Discussion

The average incidents per operations for large and medium sized hubs (2.8 per 10,000 operations) and small and non-hub airports (4.3 per 10,000 operations) were relatively low rates and not significantly different (p= .3). The rates of ground operations incidents by airline size classification were also not significantly different (p= .64). The small effect sizes indicate that there is no practical difference in the rate of ground operations incidents with airport size.

The ground operations incident rates (1.6 to 4.7 incidents per 10,000 operations) were overlapping the range estimated by Matthews (2000), although slightly lower than Matthews' estimate of 2.7 to 7.2 per 10,000. The results were contrary to the initial hypothesis that larger airports would have higher rates of incidents. However, the support for the null hypothesis is promising from both a business and safety perspective: there is no airport size category that has a greater frequency of ground incidents. This is interesting because airport design varies, and often larger airports have more complicated designs that might introduce opportunities for mistakes and incidents.

Ex post facto research has inherent limitations because when using archival data the researcher has no control over data collection. Thus, reports with missing information, in this case the location field for where airport damage occurred, necessarily must be excluded. We were unable to use incidents if there was no location given. It is possible that the results would change, if there were

access to location data for more of the incidents.

The largest variation in frequency of ground operations incidents occurred in the large/medium hub airports in the NPIAS classification but in the small station category of the airline's size classification. This is possible because an airline could have a small number of operations at a large hub airport, or alternatively, a large number of operations (mega airline category) at a small hub airport. Thus, a given airport may fall into different size categories in the two classification systems. However, examination of both methods of defining airport size is important to understanding ground operations. Further study of stations with higher variations in frequency of ground operations incidents is warranted.

This study examined the ground operations incidents at all U.S. stations of a major U.S. airline over a period of 7.5 years and concluded that there was no difference in rate of incidents between airports of different sizes as classified with either NPIAS or airline size categories. This is a positive outcome from the perspective that it suggests the airline does not have an issue with ground operations at a particular size of airport. Future research should compare trends in ground operations incidents for the airline over time, and if data is available, compare ground operations incidents between multiple airlines. Other avenues of inquiry include examining which specific stations have the highest rates of ground operations incidents, as these stations may need extra recurrent training to minimize risk.

6. References

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