Journal of Air Transport Management 65 (2017) 54–62

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

Statistical modelling of runway incursion occurences in the United States

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ARTICLE INFO

Article history:
Received 10 February 2017
Received in revised form
5 September 2017
Accepted 6 September 2017

Keywords:
Runway incursions
Severity
Mixed-logit
Random parameters
Mitigation
Airport safety

ABSTRACT

Runway incursions are an important aviation safety concern; between 2002 and 2015 there were 16,785 runway incursions at United States airports ranging in size from small general aviation (GA) to large commercial airline hubs. When examining airports with the 50 highest incursion count over the past 5 years, the predominant categories were large hubs, which accounted for 21 airports and general aviation (GA) airports which accounted for 16 airports. In June 2015, the Federal Aviation Administration (FAA) announced the Runway Incursion Mitigation (RIM) program to identify airport risk factors that might contribute to a runway incursion and develop strategies to help airport stakeholders mitigate those risks. Different size airports serve different aircraft fleets, serve different operating volumes, and have different resources available (both funds and technologies) for incursion mitigation. Therefore, it is valuable to determine the correlating factors that affect incursions at different size airports. This paper uses econometrics based modelling techniques to identify statistically significant factors in data provided by the (FAA) public web sites on runway incursions. The model identified statistically significant variables that correlate with incursions, based on severity, for airports categories defined by the National Plan of Integrated Airport Systems (NPIAS).

The model results indicate that operational incidents (OI) are more likely at large hub airports. In contrast, at GA/non-hub airports, pilot deviations (PD) were significant for less severe incursions (severity C and D). Only one variable, "number of years since 2002", was found to be significant for all the three airport categories; this variable was correlated with severity A incursions and indicated a statistically significant reduction in severity A incursions, despite an overall 80% increase in incursions between 2002 and 2015.

1. Introduction

Although aviation is the safest mode of transportation (US Department of Transportation, 2015), the FAA continues to examine additional ways to improve aviation safety and one of their highest priorities is runway safety (Federal Aviation Administration, 2016) and the reduction of runway incursions. The FAA defines a runway incursion as, "any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft" (Federal Aviation Administration, 2015a).

The annual number of runway incursions reported through the FAA's Aviation Safety Information Analysis (ASIAS) database has increased by nearly 80% since 2002; this is especially noteworthy since there has been a decrease in the total operations over this period (Fig. 1). Over the years, as total operations declined, the incursion rate per 100,000 operations increased from 1.5 in 2002 to more than 3.5 in 2015. According to the FAA Runway Safety Report 2011–12, this increase in the number of incursions is a direct result of the safety culture enhancements adopted by the FAA which encourage the reporting of the incursions through the Air Traffic Organization's (ATO) Safety Management System (Federal Aviation Administration, 2012).

In the 2015 National Runway Safety Plan, the FAA states, "the goal for runway safety is to improve safety by decreasing the number and severity of runway incursions" (Federal Aviation Administration, 2015b). There are thousands of airports in the

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http://dx.doi.org/10.1016/j.jairtraman.2017.09.003
0969-6997/

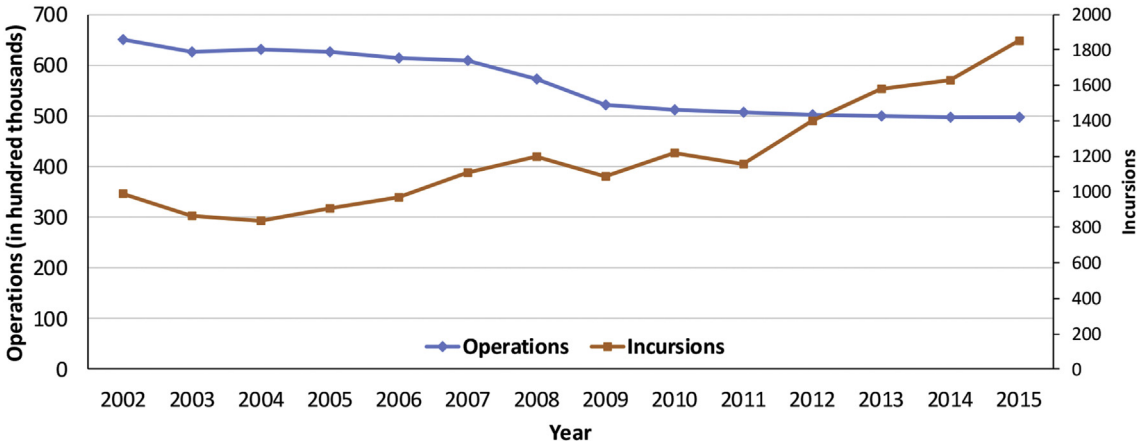

Fig. 1. Runway incusrions and operations from 2002 to 2015.

United States, ranging from small general aviation (GA) airports to large hub airports. In order to better identify the different characteristics associated with incursions at these different size airports, this research models incursions by grouping airports based on their National Plan of Integrated Airport Systems (NPIAS) classification.

The purpose of this paper is to use statistical methods to examine the factors that correlate with runway incursions for different airport categories. This paper provides an updated analysis from previous work (Mathew et al., 2016), incorporating additional 2015 data, additional literature, and addition of a new variable (local time when the incursion took place).

2. Background

There are 3331 airports in the NPIAS (Federal Aviation Administration, 2014a). For commercial service airports, NPIAS categorizes airports based on the annual passenger enplanements; there are 389 primary airports (large hub, medium hub, small hub and non-hub) and 2942 non–primary airports (GA, reliever and non-primary commercial service). Operating characteristics, financial resources, infrastructure and the deployment of technologies can vary across and within these airport categories. Between 2002 and 2015, there were 16,785 runway incursions reported at United States airports. Incursions occurred at airports of every size, from GA to large hubs (Federal Aviation Administration, 2015c).

FAA categorizes incursions based on severity and causation. Severity designations reflect four major categories, with A being the most severe and D being the least severe (Federal Aviation Administration, 2012):

- *Category A*: an incident in which a collision is narrowly avoided.
- *Category B*: an incident in which the separation decreases and there is a significant potential for collision, which may result in a time critical corrective/evasive response to avoid a collision.
- *Category C*: an incident characterized by ample time and/or distance to avoid the collision.
- *Category D*: an incident which meets the definition of runway incursion, such as the incorrect presence of a vehicle/person/aircraft on the protected area of a surface, designated for landing and take-off of the aircraft, but with no immediate safety consequences.

FAA also categorizes incursions based on the cause, reflecting the following three incident types (Federal Aviation Administration, 2012):

- *Operational incident (OI):* the action of an air traffic controller resulting in less than required minimum separation between two or more aircraft or between an aircraft and obstacle.
- *Pilot deviation (PD):* the action of a pilot that violated Federal Aviation Regulation, such as entering the runway without permission.
- *Vehicle/pedestrian deviation (V/PD):* entry of vehicles or pedestrians into the airport movement areas without air traffic controller (ATC) authorization.

Runway incursions occur for a number of reasons. Previous research reveals that more than 70% of all aviation accidents are caused by human error (Bureau of Air Safety Investigation, 1996; Li et al., 2002). According to the FAA, 65% of the 1264 runway incursions in 2014 were due to PD (Federal Aviation Administration, 2014b). Lack of situational awareness is one of the most common factors leading to PD (Chang and Wong, 2012). Some of the factors that lead to an OI incursion include call sign confusion, poor readback procedure, and incorrect phraseology (Eurocontrol, 2012).

Cardosi and Yost (2001) synthesized previous research regarding runway incursions. Their findings generally reflect a human factors perspective and include:

- "Failure to anticipate the required separation or miscalculation of the impending separation,
- Forgetting about an aircraft, the closure of a runway, a vehicle on the runway, and/or a clearance that was issued,
- Communication errors, readback/hearback errors, issuing an instruction other than the one the controller intended to use, and
- Lack of, or incomplete, coordination between controller" (Cardosi and Yost, 2001).

In recent years, statistical modelling has been used to identify factors linked to runway incursions. Green (2014) developed a Bayesian Belief Network (BBN) to examine the contributing factors to a runway incursion, including airport issues, weather issues, operational issues, and communication issues. Wilke et al. (2015) examined the "airport surface system architecture" based on regression analysis, and concluded that the geometric characteristics of an airport affect the runway incursion severity. Johnson et al. (2016) confirmed the impact of airfield geometrics on incursions, reporting that airports with runway intersections (taxiway or another runway) have a higher occurrence of incursions than airports without runway intersections.