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The impact of airport characteristics on airport surface accidents and incidents

Sabine Wilke *, Arnab Majumdar [1], Washington Y. Ochieng [2]

Imperial College London, Department of Civil and Environmental Engineering, Centre for Transport Studies, South Kensington Campus, Skempton Building, SW72AZ London, United Kingdom

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ABSTRACT

Introduction: Airport surface safety and in particular runway and taxiway safety is acknowledged globally as one of aviation's greatest challenges. To improve this key area of aviation safety, it is necessary to identify and understand the causal and contributing factors on safety occurrences. While the contribution of human factors, operations, and procedures has been researched extensively, the impact of the airport and its associated characteristics itself has received little or no attention. *Method:* This paper introduces a novel methodology for risk and hazard assessment of airport surface operations, and models the relationships between airport characteristics, and (a) the rate of occurrences, (b) the severity of occurrences, and (c) the causal factors underlying occurrences. *Results:* The results show for the first time how the characteristics of airports, and in particular its infrastructure and operations, influence the safety of surface operations.

1. Introduction

The safety of the airport surface and in particular the runways and taxiways (i.e. maneuvering area) is an area of great concern. With 30% of aviation accidents of commercial transport aircraft from 1995 through 2008 being runway-related (Flight Safety Foundation, 2009) and numerous incidents occurring on the maneuvering area every year (Federal Aviation Administration, 2010b), surface operations are the most vulnerable phase of flight.

To improve this key area of aviation safety, it is necessary to identify the causal factors that underlie accidents and incidents (i.e. occurrences), and to understand their impacts. Airport surface operations require the interaction of four main stakeholders: pilots, air traffic control (ATC), airport operator, and ground handling, and function under the umbrella of regulations. The complexity of surface infrastructure and related operations makes the system vulnerable. While the contribution of human factors, operational practices, and procedures has been researched extensively (European Organisation for the Safety of Air Navigation, 2011; International Civil Aviation Organization, 2007), the impact of the airport and its associated characteristics itself has received little or no attention.

A review of the literature on the causal factors that underlie airport surface safety occurrences highlighted the potential impact of airport characteristics, for example:

- The loss of pilot situational awareness may be caused by a complex layout of the airport surface and its related infrastructure, and eventually lead to an incursion, a situation involving the incorrect presence of an aircraft, vehicle, or person on the maneuvering area (European Organisation for the Safety of Air Navigation, 2011; International Civil Aviation Organization, 2007);
- The physical characteristics of runways, such as runway end safety areas, runway slope, runway condition (e.g., contamination), and surface operations and maintenance (e.g., snow and ice control and removal) might contribute to an excursion, an incident whereby an aircraft leaves the paved airport surface (Federal Aviation Administration, 2010b; Hall et al., 2008);
- Airport landscaping and surrounding land use seems to influence the occurrence of wildlife and associated risk of a wildlife strike (Transport Canada, 2008; United Kingdom Civil Aviation Authority, 2008); and
- Surface infrastructure, operations, and maintenance can lead to debris and eventually cause a Foreign Object Damage FOD (Bachtel, 2010; Federal Aviation Admnistration, 2009).

Likewise, airport characteristics (e.g., markings, signage, and lighting) have been identified as having an impact on airport surface occurrences during an analysis of safety data (Wilke, Majumdar, & Ochieng, 2012).

* Corresponding author. Tel.: +44 207 5942705.
E-mail addresses: s.wilke09@imperial.ac.uk (S. Wilke), a.majumdar@imperial.ac.uk (A. Majumdar), w.ochieng@imperial.ac.uk (W.Y. Ochieng).
[1] Tel.: +44 2075946037.
[2] Tel.: +44 2075946104.

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All these factors can be summarized under the topic of airport characteristics, and although mentioned frequently as 'causal factors,' quantitative studies that prove a relationship between airport characteristics and surface safety occurrences are missing in the literature.

A recent study by Galle et al. (2010) analyzed the impact of runway geometry on the rate of runway incursions. The authors clustered 80 airports from the United States Great Lakes Region into five clusters based on runway geometry. The study compared the rate of runway incursions across the clusters and found a similar median across the groups. The study concluded that runway geometry is not a significant predictor for runway incursions. While this study provides an initial attempt at analyzing the impact of airport characteristics on surface safety occurrences, it is however limited in several respects. The authors consider runway geometry simply as one variable and do not elaborate on the particular geometric characteristics used for the clustering. However, it may be that only certain geometric aspects are significant (e.g., number of runways, intersecting taxiways), and Galle et al.'s study does not test for this. In addition, their study considers only runway geometry and ignores the operation of the runway. Furthermore, Galle et al. focus on analyzing the impact of airport geometric characteristics on the rate of runway incursions. While airport characteristics may not influence the rate of occurrences, they may however impact on their severity, or their underlying causal factors (e.g., the type of human errors an airport is most likely to suffer). For instance, specific airport characteristics may influence the occurrence of pilot, ATC, or vehicle driver/pedestrian (V/PD)-related factors.

The present paper proposes a framework for an integrated risk assessment of airport surface operations, and analyzes the impact of airport characteristics on the occurrence of airport surface accidents and incidents and their causes in North America, Europe, and Oceania. The paper is organized in three parts. The next section provides a detailed outline of the methodology. Subsequently, the results are presented, before part three concludes the paper.

2. Methodology

The safety of airport surface operations is modeled in three steps and Fig. 1 provides a detailed outline of the methodology. First, accident and incident data from North America, Europe, and Oceania are collected and analyzed for their causal factors. The corresponding airport characteristics data are subsequently collected using a survey methodology. Last, the relationships between airport characteristics and safety occurrences are modeled, and safety mitigation strategies outlined.

2.1. Safety data collection and analysis

The highest priority for selecting safety data is quality. This is because of the direct relationship between statistical modeling accuracy and the quality of the data used. Research has shown that safety culture (defined as "the product of individual and group values, attitudes perceptions, competencies and patterns of behavior that determine the commitment to and the style and proficiency of an organization's health and safety management;" Advisory Committee on the Safety of Nuclear Installations, 1993) is the basis for successful Safety Management Systems (Chaudhry, Fang, & Sherif, 2007). Therefore, countries and organizations with a good safety culture are also likely to be a good source of good quality data. In addition, the selected data should be representative in terms of global air traffic (i.e., traffic volume). The overall aim, therefore, was to identify relevant countries in terms of air traffic, known for a good safety culture.

Studies from Airbus (2011) and Boeing (2012) show that the three dominant regions, currently and in the future, in terms of global air traffic are North-America, Europe, and Asia-Pacific. In order to identify countries within North America, Europe, and the Asia-Pacific region that are known in the aviation industry for a good safety culture, Subject Matter Experts (SMEs) from the European Organisation for the Safety of Air Navigation (EUROCONTROL) and the Federal Aviation Administration (FAA) were consulted. EUROCONTROL was chosen because of its commitment to air traffic management (ATM) safety enhancements through its involvement in research and facilitation of safety-related rule-making and formulation of regulations in European aviation. Similarly, the FAA is the regulatory body responsible for ensuring safe and efficient operations in the United States, the busiest country in terms of surface operations in North America. Senior experts in aviation safety with a minimum of 15 years of international experience were selected for consultation. The following experts were consulted:

- The FAA's Runway Safety Program Manager;
- EUROCONTROL's Head of Safety Unit;
- EUROCONTROL's Head of Safety Regulation (retired); and
- EUROCONTROL's Senior Safety Expert.

The initial consultation resulted in inclusion of the United States in the analysis. Furthermore, in Europe, Scandinavian countries were in particular recommended for their safety culture and efforts to promote reporting. In addition, the consultation determined that Asian data should be excluded since most Asian countries still execute a punitive culture (i.e., a culture in which "those involved in occurrences are fearful of management or regulatory authority;" International Civil Aviation Organization, 2008). It was advised to include Oceania, which promotes a positive safety culture, instead. Therefore, safety data from the regulatory authorities of the following four countries were collected: United States (U.S.), United Kingdom (UK), Norway (NO), and New Zealand (NZ).

Regulatory safety data were selected as the reporting of accidents and incidents is mandatory in each of the four considered countries (e.g., United Kingdom Civil Aviation Authority Safety Regulation Group, 2011) and therefore the chosen databases should encompass all the reports made by the relevant aviation stakeholders. In addition, a common regulatory viewpoint ensures a standardized data collection.

Airport surface safety occurrences (i.e., incursions,[3] excursions,[4] and FOD[5]) were collected from each country and the following databases were available:

- Federal Aviation Administration (FAA) Incursion (RI) database and Accident/Incident Data System (AIDS) for excursions and FOD;
- United Kingdom Civil Aviation Authority (UK CAA) Mandatory Occurrence Reporting Scheme (MORS);
- Civil Aviation Authority — Norway (CAA — Norway) European Coordination Centre for Accident and Incident Reporting Systems (ECCAIRS); and
- Civil Aviation Authority New Zealand (CAA New Zealand) Aviation Safety Monitoring System (ASMS).

The data were normalized using the annual number of movements per airport.

Subsequently, the accidents and incidents were analyzed for their causal factors. To do so, the descriptive narrative of each occurrence report was analyzed and one or more causal factors extracted. The safety data were coded using a new taxonomy of causal factors developed by Wilke and Majumdar (2012). A new taxonomy was required as there

[3] An incursion is defined as any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the maneuvering area (definition adapted from International Civil Aviation Organization, 2007).

[4] An excursion is defined as an occurrence (accident or incident) where an aircraft on the ground departs from a runway or taxiway. Excursions may occur on take-off, taxiing or landing, and be either intentional or unintentional (definition adapted from Australian Transport Safety Bureau, 2008).

[5] A FOD is defined as any damage attributed to a foreign object that can be expressed in physical or economic terms, which may or may not degrade the product's required safety and/or performance characteristics (definition adapted from Federal Aviation Administration, 2010a).