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Modelling runway incursion severity

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ABSTRACT

Analysis of the causes underlying runway incursions is fundamental for the development of effective mitigation measures. However, there are significant weaknesses in the current methods to model these factors. This paper proposes a structured framework for modelling causal factors and their relationship to severity, which includes a description of the airport surface system architecture, establishment of terminological definitions, the determination and collection of appropriate data, the analysis of occurrences for severity and causes, and the execution of a statistical analysis framework. It is implemented in the context of U.S. airports, enabling the identification of a number of priority interventions, including the need for better investigation and causal factor capture, recommendations for airfield design, operating scenarios and technologies, and better training for human operators in the system. The framework is recommended for the analysis of runway incursions to support safety improvements and the methodology is transferable to other areas of aviation safety risk analysis.

1. Introduction

Runway incursions occur due to the incorrect presence of an aircraft, vehicle, or person on a runway (ICAO, 2007) and pose one of the biggest challenges to the safe operation of the airport surface (i.e. runway and taxiway system). At their extreme, such incursions can result in a collision accompanied by a major loss of life, e.g. in 1977 in Tenerife (574 fatalities) and 2001 in Linate, Italy (118 fatalities) (Agenzia Nazionale Per La Sicurezza Del Volo, 2004; Raad Voor De Luchtvaart, 1977). This type of surface incident occurs frequently, for instance, there were 1241 runway incursions in FY2013 alone in the United States (U.S.) (FAA, 2014a). Although most runway incursions are of low severity involving only a single aircraft that presents no risk of collision, a small number of serious runway incursions challenge the safety of the air transport system every year (e.g. 0.200 Category A and B runway incursions per million operations in FY 2013). These occur mainly at controlled airports and present the potential for the occurrence of an accident (collision). Therefore, the development and implementation of effective safety risk mitigation strategies, in particular to prevent the most severe of these occurrences at controlled airports, are essential.

Yet despite this recognised need, there is currently no framework to both determine the causal factors associated with each component of the airport surface system and to model their relationship with severity in order to derive effective mitigation measures. A robust approach to modelling runway incursion severity based upon their causes, however, is essential to prioritise safety budgets and safety risk mitigation measures.Therefore, this paper both develops and implements such a framework in order to identify the most critical causes for the occurrence of high-severity runway incursions. The next section reviews previous runway safety research. Section 3 builds on the review to specify the architecture of the framework, which is implemented in Section 4. The results are presented in Section 5 and recommendations are outlined subsequently. Section 7 discusses the integration of this new framework into current Safety Management Systems (SMS), before conclusions are drawn in the final part of the paper.

2. Current status of runway incursion analysis

To ensure the highest level of safety for airport surface operations organisations are required to implement a Safety Management System (SMS). A SMS is a systematic approach to safety that strives to assess and continuously improve the safety of an entire system. It therefore requires the assessment of all system components and their interactions for hazards and associated safety risks. The management of safety comprises of two core operational activities: safety risk management, and safety assurance, and their supporting organisational arrangements

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(safety policy and objectives, safety promotion). ICAO proposes a four-step process for conducting safety risk assessments that involves: (i) the identification of hazards, and (ii) their consequences, (iii) the assessment of the consequences of hazards in terms of probability and severity (the product of probability and severity being the safety risk), and (iv) the mitigation of safety risks through the development of risk mitigation measures (ICAO, 2009).

Runway incursions are a consequence of hazards (i.e. conditions or objects with the potential to cause an incident (ICAO, 2009)) and current methods for assessing their safety risk focus on the determination of their probability based upon these hazards, using alternative techniques such as the European Organization for the Safety of Air Navigation's (EUROCONTROL) Integrated Risk Picture (IRP) and the Causal Model for Air Transport Safety (CATS) developed by the National Aerospace Laboratory (NLR) of the Netherlands. These studies violate the principle of a system-wide safety assessment by taking only pilot and air traffic control (ATC) factors into account and neglecting the influence of vehicle drivers/pedestrians (V/PD) or airport design factors (Ale et al., 2009; EUROCONTROL Experimental Centre, 2006). Therefore, a large amount of information relevant to runway incursions is not considered in each model, and hence, they are of limited relevance to stakeholders other than those for whom they were created. The consequence of this is that awareness for runway incursions is challenged towards specific scenarios (e.g. probability of ATC causing a runway incursion), discarding that others have the potential to result in a fatal accident. Although the current narrow approach is understandable given the different responsibilities and interests of the involved stakeholders, it is simply inadequate, since safety enhancement strategies that are developed through this piecemeal approach are inevitably biased. In addition, these models show methodological limitations. These include: missing or ambiguous definitions, insufficient specification of safety data, data quality concerns (e.g. data accuracy and completeness), and unspecified analysis methodologies. Overall, they focus on determining the probability of occurrence, although runway incursions are one of the most frequent incident types in aviation (EUROCONTROL, 2014; FAA, 2014a). Therefore, rather than predicting their probability, their causes and their relationship to severity should predominantly be addressed in order to avoid near-collisions.

An understanding of both the underlying causes of runway incursions and their relationship with severity following a robust methodology is much-needed. Although such severity assessments are essential for prioritising safety budgets and risk mitigation measures they have been neglected in the literature. Only Biernbaum and Hagemann (2012) have attempted to model runway incursion severity, but their analysis is limited to modelling the impact of contextual factors (i.e. conditions that were present at the time of occurrence, such as aircraft type and pilot demographics) on severity, whilst neglecting the actual causes of the incidents (e.g. human error, technical failure). In order to fully understand the risks associated with runway incursions, a robust analysis framework of runway incursion severity is required. The next section proposes such a new

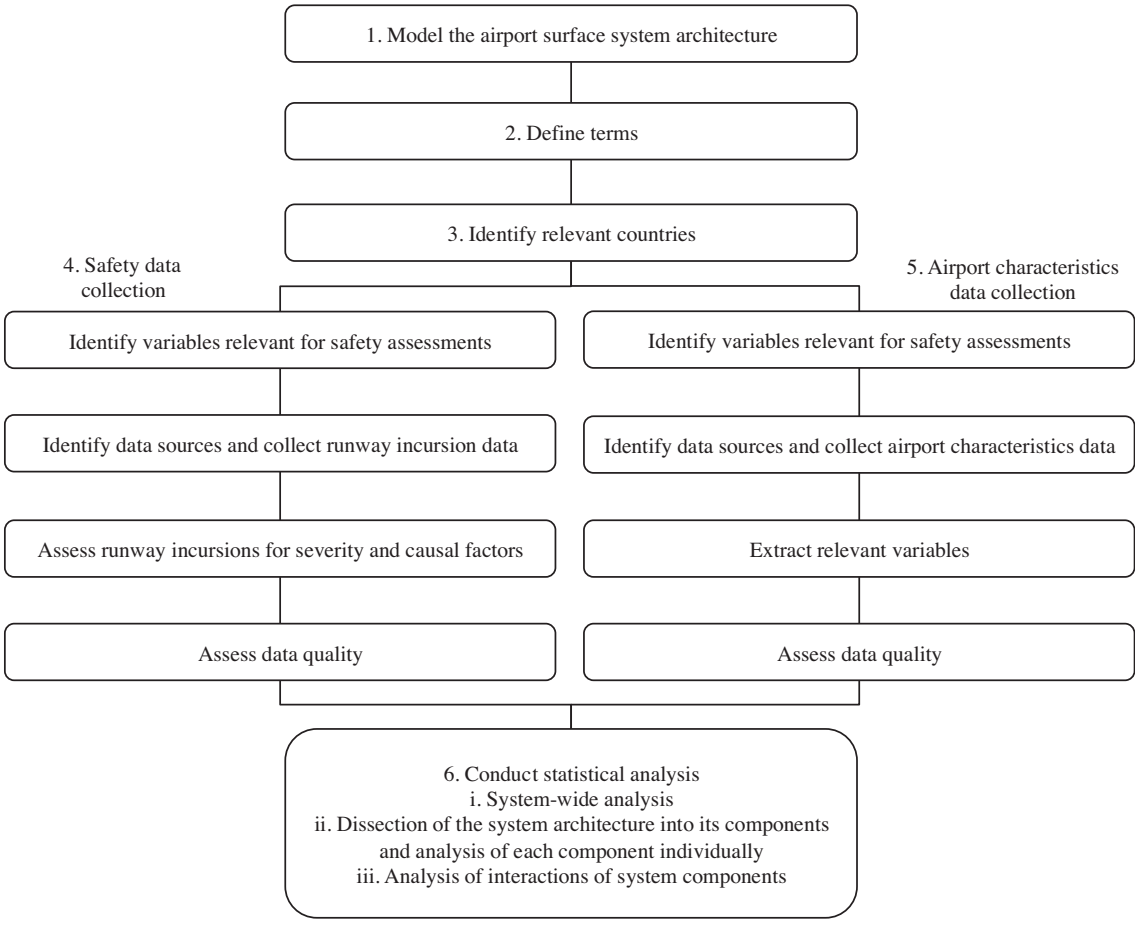

Fig. 1. Analysis framework.