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The controllability classification of safety events and its application to aviation investigation reports

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ABSTRACT

This paper proposes an amendment of the classification of safety events based on their controllability and contemplates the potential of an event to escalate into higher severity classes. It considers (1) whether the end-user had the opportunity to intervene into the course of an event, (2) the level of end-user familiarity with the situation, and (3) the positive or negative effects of end-user intervention against expected outcomes. To examine its potential, we applied the refined classification to 296 aviation safety investigation reports. The results suggested that pilots controlled only three-quarters of the occurrences, more than three-thirds of the controlled cases regarded fairly unfamiliar situations, and the flight crews succeeded to mitigate the possible negative consequences of events in about 71% of the cases. Further statistical tests showed that the controllability-related characteristics of events had not significantly changed over time, and they varied across regions, aircraft, operational and event characteristics, as well as when fatigue had contributed to the occurrences. Overall, the findings demonstrated the value of using the controllability classification before considering the actual outcomes of events as means to support the identification of system resilience and successes. The classification can also be embedded in voluntary reporting systems to allow end-users to express the degree of each of the controllability characteristics so that management can monitor them over time and perform internal and external benchmarking. The mandatory reports concerned, the classification could function as a decision-making parameter for prioritising incident investigations.

1. Introduction

Despite the continuous increase in aviation safety levels over the past half-century (Boeing, 2017; Airbus, 2017), additional efforts are put to improve safety further by monitoring safety performance through respective indicators (Bellamy & Sol, 2012; Kjellén, 2009; Verstraeten et al., 2014). Regulations, standards and industry practice dictate the classification of safety events based on their actual severity. The use of event rates (e.g., number of accidents per unit of activity/exposure) prevails, thus suggesting a focus on recorded consequences to demonstrate safety performance (e.g., Airbus, 2017; Boeing, 2017; HSE, 2016; EASA, 2016a, ICAO, 2013a).

Amongst the various safety management activities that aim to improve safety by preventing reoccurrence of adverse events, States and organisations are required to conduct investigations of accidents and serious incidents (ICAO, 2010; EU, 2010). Despite the argument that near-misses might remain unreported and unrecorded unless their effects cannot be hidden (Bhagwati, 2006), the enforcement of mandatory reporting systems allows the recording of various characteristics of safety events. The collection of such data enables the industry and authorities to perform statistics, analyse associated factors and monitor trends. Although the conduction of investigations for incidents is non-obligatory, it is recognised that those also comprise opportunities for obtaining information that can lead to an increase of safety levels (ICAO, 1993; Wise et al., 2009). However, under the reality of limited resources, those are mostly devoted to the investigation of serious incidents and accidents (ICAO, 2015; Wise et al., 2009; Greenwell, 2003). Furthermore, risk levels are detected and prioritised using such an outcome-oriented approach (e.g., EASA, 2016b), which also prevails the threshold between voluntary and mandatory safety reporting. In general, current views on aviation safety and associated improvement initiatives concentrate principally on the severity of reported or anticipated events, which informs the decisions about focus areas and allocation of respective resources.

By considering the role of the human element in the development of events, Karanikas (2015) introduced a new classification scheme that incorporates the potential of an occurrence to escalate instead of counting only for its actual outcome(s). The author above contemplated

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that a sole emphasis on outcomes does not address the extent to which the system users control events. Karanikas (2015) showed that it is important to examine whether the outcome of an occurrence was associated with an attempt or opportunity to control an unfolding situation and consider the effectiveness of human interventions to alleviate the possible consequences of the safety event. The application of the suggested classification on a large aviation organisation concluded that (1) the specific classification scheme might function as an additional or alternative measurement of safety performance before focusing on the severity of eventualities, and (2) various factors were associated with the controllability of events, such as aircraft type and generation, and operating unit.

The primary goal of the study presented in this paper was to apply the classification of Karanikas (2015) to a sample of safety investigation reports published by various aviation authorities as a means to examine the value of the classification at a wider context and trigger the interest for its application by various industry sectors. Furthermore, this research aimed at evaluating the classification's potential to serve as a safety performance metric, as opposed to dominant severity-based metrics, and supplement the safety perspective of organisations and States by exploring associations of this classification with event characteristics and factors. Finally, based on the findings of this study, the authors reflected on the potential of the controllability classification to support the prioritisation of incident investigations and its connection with modern safety thinking and initiatives, such as system resilience and Safety-II.

The work presented in this paper is organised as follows. In Section 2, we present different types of safety event classifications and discuss various factors and characteristics of events discussed in studies and industry reports. Section 3 describes the reasons that led to the amendment of the controllability classification and is followed by the methods and materials used in its application and the analysis of data. The results of the research are presented in Section 4 of the paper and discussed in Section 5 against literature along with relevant limitations of the study. Finally, in the conclusions (Section 6), we present the value of the current study concerning various options for its application, the overall picture from the data analysis as well as recommendations for future research.

2. Literature review

2.1. Classification of safety events

Safety events, irrespective of industry sector, are commonly classified according to the magnitude of their actual impacts on the environment, infrastructure and equipment, and infliction of injuries or casualties. In general, regulatory bodies utilise their classifications of safety occurrences to depict safety performance through accident frequencies and rates (e.g., EMSA, 2016; ICAO, 2017b; EASA, 2016a, 2016b) and decide whether they will launch a safety investigation. Each classification indicates the threshold above which safety investigations are obligatory or to be conducted in the interest of the respective national investigation body. Investigation agencies shall perform safety investigations for accidents, serious accidents, and very serious casualties. Despite being more abundant, less severe occurrences are investigated in cases of retrievable data and their potential to lead to safety improvements (e.g., EU, 2009; EU, 2010; IMO, 1997; EUAR, 2016).

The classification categories of safety events vary across industry sectors. For example, events in the railway domain are categorised as serious accidents, accidents and incidents (EU, 2016). In the maritime industry, an event can be named as a marine casualty, serious casualty, very serious casualty or marine incident (IMO, 1997). The classification of occurrences in the aviation industry emphasises the potential of the event to develop into an accident with severe consequences. A serious incident is an occurrence that had a high potential to escalate into an accident (ICAO, 2010; EU, 2010), and its classification depends on the analyst's interpretation (Greenwell, 2003). The indicative examples given above apart from the different category names regard also diverse thresholds between the categories. The aviation sector concerned, Kaspers et al. (2016) discussed that the ambiguity in standards regarding the threshold between serious incidents and incidents might lead to diverse interpretations and, therefore, render rates or frequencies of events other than accidents as an unreliable safety performance metric. Overall, apart from the definitions of accidents that in all industry domains include the case of fatal injuries and almost catastrophic implications on other assets, the existence of various severity classifications across the industry does not allow a reliable comparison between them regarding rates of events other than accidents. Consequently, accident rates remain the principal indicator used for benchmarking amongst organisations and industry sectors.

The impact-based classification of events is also used in risk management, where analysts rank safety occurrences according to the level of their expected consequences and probability. The former parameter is estimated qualitatively according to the actual severity of similar past events and is complemented with expert judgment. Probabilities can be derived with either quantitative methods when adequate and reliable data are available or a qualitative approach based on the frequency of similar events in the past; in such evaluations, the engagement of experts remains as an option. The two parameters mentioned above are crossed in a respective matrix, and the risk level of an event is determined with the scope to inform decision-making for allocating resources to control risks of higher rank (e.g., ICAO, 2013a; IMO, 2015; EC, 1996; Stamatelatos and Dezfuli,011). However, the lack of standardisation of matrices across and within industry sectors, the inherent ambiguities in the categories of severity and likelihood, and the cognitive biases affecting expert judgment threaten the validity and reliability of such an approach (Hubbard & Evans, 2010; Duijm, 2015; Karanikas and Kaspers, 2016).

In the Air Traffic Management (ATM) domain, for instance, Eurocontrol (2009a) has mandated its member States to comply with the "European Safety Regulatory Requirements" (ESARRs). ESARR details the assessment and reporting of events based on a defined list of ATM-related occurrences, divided into accidents and incidents, which, as a minimum, each State report and evaluate. Also, ESARR define the safety data to be communicated with Eurocontrol to identify key risk areas to improve overall operational safety in the ATM system (e.g., rates of occurrences or flight deviations). Having realised that standard metrics of safety rates and traffic volume alone do not sufficiently represent the overall system-wide performance, Eurocontrol (2009b) introduced the Aerospace Performance Factor (APF). The particular metric aggregates various factors related to operational safety risks retrieved from reported incidents and uses a time-variant value that demonstrates the overall risk and performance trend over time as a means to foster safety proactively. To inform decision-making, safety performance is measured through the APF based on a substantive set of safety metrics, risk assessments from experts and its normalisation against overall traffic volumes. The methodology described above focusses mainly on actual or possible deviations from expected performance that can lead to more severe events. Thus it constitutes an outcome-based assessment of potential harm which informs organisational decisions (Di Gravio et al., 2015).

In his work, Karanikas (2015) highlighted the outcome bias that prevails the industry in safety performance metrics which do not consider an event's potential to escalate or the efforts of involved personnel to alleviate the anticipated event's consequences. A new classification was therefore suggested based on the controllability of safety occurrences with the intent to differentiate between events with and without user's intervention and indicate the effectiveness of actions of involved personnel to mitigate the ultimate outcomes (Table 1). It is noted that the author used the term 'accident' to refer to safety occurrences of all severity levels used by the particular organisation. According to