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Developing a performance indicators lean-sigma framework for measuring aviation system's safety performance

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Abstract

The paper introduces a conceptual framework that could improve aviation safety performance and the safety performance measurement process. The framework provides guidance on how organisations could design, implement and use a proactive, performance-based measurement tool for assessing and measuring Acceptable Levels of Safety (ALoS) performance at sigma (σ) level, a statistical measurement unit. Nevertheless, the framework provides a holistic view on how organisations could set leading performance indicators and monitor metrics on the top of identified root-causes that affect system's safety performance or how to set lagging indicators and feedback metrics on the top of safety outcomes. In fact, the framework adapts and combines classical Quality Management tools, a leading indicators programme and Lean-Six Sigma methodology to formally and continuously improve a stable and in-control safety management process. Finally, the paper underlines the necessity of a new way of thinking for the development of a robust, proactive process for measuring aviation safety performance and system performance variability.

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Keywords: Aviation safety; Performance indicators; Lean Six-Sigma; System's performance

1. Introduction

According to the International Civil Aviation Organization (ICAO) Annex 19 (2013), '*safety is the state in which risks associated with aviation activities are reduced and controlled to an acceptable level*'. Since 2009, in an effort to improve Safety Performance (SP) and to achieve an Acceptable Level of Safety (ALoS) in civil aviation that would be met by all operators, the ICAO has launched Standard and Recommended Practices (SARPs) for the implementation of Safety Management Systems (SMS) in the Air Transport industry (ICAO, 2010a,b and 2009).

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In addition, in 2012, the European Aviation Safety Agency (EASA) released the first Implementing Rules (IRs) addressing safety management requirements for Authorities, Aircrews and Air Operators (EC, 2012a, 2012b). Indeed, EASA introduced an integrated approach to SMS implementation process since SMS should be fully integrated in the organisation's existing management system and safety management should include every facet of management that may impact aviation safety (Hamelijnck, 2012). Furthermore, on May 2013, the ICAO Safety Management Manual (SMM) Doc 9859/AN/474 introduced the concept of a Performance-Based (PB) approach to safety that complements the existing compliance-based approach and could achieve an ALoS performance (ICAO, 2013a). The PB approach should be capable of demonstrating SMS implementation and effectiveness in terms of measurable operational outcomes that are related to safety (Ulfvengren, 2014). Moreover, on 14 November 2013 the ICAO SARPs and management system requirements upgraded to a Standard and were published on ICAO (2013) Annex 19. According to this Annex, SP is defined as a State or a service provider's safety achievement as defined by its SP Targets (SPTs) and SP Indicators (SPIs) and an SMS should as a minimum include '*provision for continuous monitoring and regular assessment of the appropriateness and effectiveness of safety management activities* (ICAO, 2013). At European level a performance scheme has been made mandatory in Regulation (EU) No 1216/2011, but only for Air Traffic Management (ATM). The European Commission is getting ready to conduct a study to explore the possibility of extending the approach beyond ATM (EASA, 2014).

Moreover, in the aviation industry the development and measurement of proper indicators is not yet a straightforward process. Consequently, EASA has recently established the Network of Analysts (NoA) SPI Sub Group for considering the subject of SPIs (EASP, 2014). In addition, a Safety Management International Collaboration Group (SM-ICG) was created as a collaboration activity between key aviation authorities to encourage progress and harmonisation. Within SM-ICG a Metrics Working Group (WG) was established for developing and proposing a common understanding of the characteristics of the SP measurement systems and to develop a common methodology for setting expectations regarding SP (SM-ICG, 2013b). Also, SM-ICG has started to develop guidance material on how service providers could measure SP, and in July 2013 the first papers addressing performance measurement and providing guidelines to Service providers on the definition and implementation of a set of SPIs were published (SM-ICG, 2013a). Moreover, SM-ICG introduced the regulators' perspective and a system's approach for measuring different aspects of SP, a concept based on a three-tier SPI model, meaning regulator activities, service providers' behavior and final outcomes (SM-ICG, 2014). Besides, SM-ICG introduced the concept of Leading and Lagging indicators for measuring SP. Nevertheless, the SM-ICG guidelines are still confusing around the differences that exist between SPIs and metrics. To sum up, a process for developing and measuring SP through SPIs in the aviation industry is still in progress and the methodology for establishing proper indicators is not yet clear.

According to Neely, Gregory, and Platts, (1995), performance measurement is the process of quantifying the efficiency and effectiveness of actions within a business context. A Performance Measurement System (PMS) is the set of metrics used to quantify both the efficiency and effectiveness of a system in relation to organisational targets (Neely et al, 1996). An effective PMS should monitor past performance and help to plan future performance (Gutierrez, 2014). According to Muller, Wittmer and Drax (2014), one of the main SMS objectives is to measure system effectiveness, improving SP and therefore reducing exposure to the risk of having an accident or serious incident. Since most accidents have multiple precursors and cues that an accident is likely to happen, there is a common belief that even a small number of general "leading indicators" can identify increased risk of an imminent accident (Leveson, 2015). Besides, Leveson (2015) discusses how to identify and operationalise leading indicators as shaping and warning signals and through the Systems-Theoretic Accident Model (STAMP) proposes assumptions and their vulnerabilities as a proactive methodology for identifying leading indicators in an aviation system.

Furthermore, Podgorski (2015) suggests that new approaches are needed to ensure system effectiveness and he proposes a method for ranking and prioritising SPI related to Occupational Safety and Health management systems. In addition, Andriulo and Gnomi (2014) argue that near-miss events are accident precursors and propose a lean framework for measuring the effectiveness of a near-miss management system in the automotive industry. Also, Ulfvengren and Corrigan (2014) argue that Lean integrating quality management with existing management processes would achieve operational effectiveness and could demonstrate SP in compliance with new aviation safety regulations. Moreover, Rehman (2012) uses the Six-Sigma (SS) technique to reduce the occurrences of accidents at a manufacturing company and presents how the SS will help to evaluate the SP of organisations. Finally, Tenera and Pinto (2014) propose Define-Measure-Analyse-Improve-Control (DMAIC) as a cycle-based approach that adapts classical LSS tools to formally and continuously improve management process.