Research in Transportation Business & Management xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Research in Transportation Business & Management

Overall safety performance of the Air Traffic Management system: The Italian ANSP's experience on APF

Giulio Di Gravio [a], Riccardo Patriarca [a], Maurizio Mancini [b], Francesco Costantino [a,*]

[a] *Department of Mechanical and Aerospace Engineering, Sapienza University of Rome, Via Eudossiana, 18-00184 Rome, Italy*
[b] *Operations Directorate, ENAV S.p.A., Via Salaria, 716-00138 Rome, Italy*

ARTICLE INFO

Article history:
Received 8 July 2015
Received in revised form 18 February 2016
Accepted 2 March 2016
Available online xxxx

Keywords:
Safety events
Safety analysis
Risk assessment
AHP

ABSTRACT

Air Traffic Management (ATM) system needs to be continuously monitored to evaluate safety performance of operational activities, in order to maintain and improve safety levels. However, standard metrics of counting events (incidents, accident and near misses) are not able to give usable information to decision makers in supporting their strategies. As safety events are generally rare, traditional statistical analysis generally fails to represent the overall system performance.

This paper discusses the development of the Aerospace Performance Factor (APF) methodology in a real case implementation. The research presents to ATM safety managers and researchers the main framework and the roadmap to develop a specific system-wide assessment, giving them guidelines based on lessons learned. Starting from international regulations and describing the European APF context, this paper offers a detailed description of the APF implementation to the Italian Air Navigation Service Provider ENAV s.p.a., one of the first ANSPs to adopt, customize and implement the methodology.

For acronym definitions refer to EUROCONTROL ESARR 2 (EUROCONTROL, 2006b).

1. Introduction

According to ICAO's Global Air Navigation Plan, each EU Member State should look at air safety as one of its top priorities (ICAO, 2013a). On this path, EU Regulation 376/2014 (EU, 2014) states that every effort should be made to reduce the number of accidents and incidents to reinforce public confidence in aviation transport. To this purpose, Air Navigation Service Providers (ANSPs) must plan a rugged and proactive process of addressing current and emerging safety risks, according to international and national regulations. This process plays a fundamental role to ensure that air traffic development is carefully supported by strategic regulatory and infrastructure evolutions.

Historically, ANSPs used single metrics as traffic counts, accidents, incidents etc. to gauge safety performance, without proposing a system-wide performance information. In addition, the lack of a harmonization in reporting, analysis and assessment of safety occurrences, motivates, in October 2009, the EUROCONTROL Performance Review Commission (PRC) and the US Federal Aviation Administration (FAA) to identify common framework (EUROCONTROL and FAA, 2012). These scheme will lead to a more systematic visibility of safety occurrences and their causes, allowing identification of appropriate corrective actions and sharing knowledge among third parties.

With the contribution of EUROCONTROL, FAA, US Naval Safety Center, easyJet Airline and the Imperial College of London (EUROCONTROL, 2006a), the Aerospace Performance Factor (APF) helps to give an overall view of safety performance. The APF is a methodology to combine multiple indicators, weighted by expert judgments and normalized against system operations, to globally evaluate the performance of a system. The APF offers synthetic, holistic and user-friendly indicators of safety levels for specific airspaces, airways, airports, etc.

In accordance with the European Safety Regulatory Requirements (ESARRs), this paper aims to in-depth analyze the APF building process, with particular attention to the analytic aspects of the APF Safety Indexes.

List of acronyms: ACD, Accident; AIS, AIS occurrence; ASP, ATM specific; ATO, Aborted take-off; BS, Bird strike; CAO, Collision between aircraft and other; CFIT, Collision flight into terrain; CGA, Collision on the ground between aircraft; CGG, Collision on the ground between aircraft and other; COM, Communication; CSC, Call sign confusion; DACD, Damagin accident; DATC, Deviations from ATC clearance; DATS, Deviations from ATC procedure; EME, Emergency; EXT, External; INCD, Incident; INS, Inadequate separation; ISS, Issues; LBS, Level bust; LSR, Laser; MA, Missed approach; MAC, Midair collision; MET, Radar met occurrence; NCFIT, Near collision flight into terrain; NCO, Near collision; OTH, Other; PCNC, Potential for collision or near collision; PLCC, Prolonged loss of communication; PRI, Priority request; PRO, Procedural; PSMI, Potential separation minima infringement; REX, Runway excursion; RIN-AAY, Runway incursion — avoiding action necessary; RIN-AAN, Runway incursion — no avoiding action necessary; SCS, Similar call sign; SMI, Separation minima infringement; SYF, System failure; TRA, TCAS resolution false; TWY-AAY, Taxiway incursion — avoiding action necessary; TWY-AAN, Taxiway incursion — no avoiding action necessary; WS, Wind shear; (A), Event with ATM contribution.

* Corresponding author.
E-mail address: francesco.costantino@uniroma1.it (F. Costantino).

http://dx.doi.org/10.1016/j.rtbm.2016.03.001
2210-5395/

In the first part, it presents a description of the standard methodologies commonly adopted by ANSPs to report and address air transport risks. Then, it describes a walkthrough of the APF building process, focusing on the Analytic Hierarchy Process and its features. Lastly, it describes the APF implementation for ENAV (the Italian ANSP) focusing on the importance of the outcomes that arises from an on-field application. The conclusions analyze the possibilities for further research, evolving the APF to obtain a real-time or even forecasting tactical tool for safety performance monitoring.

2. Problem: monitoring global safety

Under the sign of the Chicago Convention (ICAO, 2006), states have the responsibility to ensure and maintain acceptable levels of safety. At both national and organizational level, Standards and Recommended Practices (SARPs) established by the ICAO (2009) clarify that safety performance measurement is a non-stop activity, involving continuous monitoring. In this context, ANSPs have to address actual service levels and counter any negative impacts on performance, strengthening the system infrastructure. In recent years, according to aviation constant growth (ICAO, 2013b), these tasks become even more crucial. For this reason, ANSPs are incessantly seeking for improvements of their features.

The ways in which ANSPs monitor safety performance is determined partly by international agreement, and partly at the discretion of each state. Nevertheless, it is not possible to establish a corrective action without a flawless and detailed measurement tool. ICAO Annex 13 (ICAO, 2001) contains the mandatory safety program and accident prevention measures that each state has to develop. More specifically, in Europe, EU Directive 2003/42/EC (European Parliament and European Council, 2003) contributes to air safety by ensuring that relevant information on safety is reported, collected, stored, protected and disseminated.

Subsequently, EUROCONTROL Performance Review Commissions (PRC) and the US FAA produced a thorough report (EUROCONTROL, 2010) on safety performance, based on operational data from several relevant facilities. This report inspired in 2012 a new important research (EUROCONTROL and FAA, 2012) that shows the importance of using common information and common performance indicators for safety monitoring in each region. On this line, ESARR 2 Appendix A (EUROCONTROL, 2009b) contains the list of ATM-related occurrences, which as a minimum shall be reported and assessed. Appendix B contains minimum information to be included in the summary and reported to EUROCONTROL.

Assessing safety according to the number of undesirable events, (e.g.) accidents and incidents, is a well-consolidated process (Hollnagel, 2013). These statistics give some signals to providers, regulators and recipients but they fail to represent the global performance.

For this purpose, it is important to highlight the core concept of Reason Swiss Cheese Model (RSCM) (Reason, 1990). This model considers an incident (or any other less serious occurrence) as an accident, except that not all the holes in the defense layers lined up. With this interpretation, it is clear that the accidents count is not sufficient to describe overall safety performance. It is therefore necessary to take in consideration the contribution of any safety related event, especially of all the multiple events with smaller consequences. These latter are usually more frequent and the statistics of their occurrences have more potential than the ones on accidents.

RSCM leads (Reason, Hollnagel, & Paries, 2006) to the metaphor of an iceberg where the most serious occurrences — accidents and serious incidents — constitute a small but visible subset of events, while the “non-serious” incidents and other safety events constitute a large subset of the iceberg, which however largely remain invisible. Both ESARR 2 (EUROCONTROL, 2009b) and EU Directive 2003/42/EC (European Parliament and European Council, 2003) recognize the relevance of such occurrences but the main problem consists in pave the way to a measurement tool capable of considering them critically.

The standard collection of information on safety occurrences never really evolved past the ‘sophistication’ of the ratios (Futron Corporation, 2010), never being fully integrated in a system-wide performance. FAA and US Naval Safety Center understood that new ways to measure and improve safety performance would be necessary. In early 2006, with the contribution of easyJet (Lintner, Smith & Smurthwaite, 2009a), they start developing the APF, basing on Analytical Hierarchy Process (AHP), a multi-criteria decision making technique adopted in several different contexts (De Felice & Petrillo, 2014).

3. Method: the APF methodology

The APF enables synthetic and holistic analyses of safety performance, filling the gap of account reporting systems. It helps in aggregating a weighted sum of events into one single value to represent an overall safety performance and its trends.

3.1. The APF's main steps

The APF methodology follows five steps (Licu, Cioponea, Stewart, Majumdar, & Dupuy, 2009):

- Determine the organizational factors that influence performance. This is accomplished by convening a panel of experts from different divisions within the organization (senior management, flight operations, dispatch, training, maintenance, flight crew, safety team), including also people with fresh eyes and no bias toward one or more particular sources of information.
- Determine the information available on those factors. The input for developing the APF must derive from data sources that have been in place for a reasonable period, in order to track performance over time. Available data has two benefits that may enhance the use of the APF: they are already familiar to decision makers and their usage minimizes any additional effort on the employees. Note that in case the panel of experts determines the need to measure a specific performance, it is necessary to consider the additional resources (costs, time and additional workload) required to gather the new data.
- Organize the influencing factors. Once the experts have determined the organizational factors to use as inputs to the APF, the next phase consists in organizing them into categories to develop the APF Mind Map. The APF Mind Map is a graphical depiction of the relationships among data. It highlights the hierarchy and shows more in depth the interdependencies of the processes.
- Determine the relative importance or weighting of the factors. The innovation of the APF methodology relies in defining the contribution of each element to the overall safety performance. To this extent, the APF methodology suggests the Analytical Hierarchy Process (AHP) to weight data. This process involves a second panel of experts, SMEs (Subject Matter Experts) to express the judgments, to normalize against the volume of system operations.
- Display information for decision makers. Information has to provide a comprehensive and intuitive picture of organizational safety performance, graphically displaying the weighted Mind Map values and its changes over time. The Safety Index is the time series of the reported events, weighted and summed up in a global index, to represent in a synthetic view the safety performance of the ATM system.

3.2. Analytic Hierarchy Process' main steps

The AHP is a multi-criteria decision making tool developed by Saaty in the early 1970s. Its fundamental steps (Saaty, 2008) are as follows:

- Define the problem and determine the kind of knowledge sought, in particular determine what organizational factors have an influence on safety performance. In this paper, the analysis of ESARRs accomplishes the target.