Journal of Air Transport Management 44-45 (2015) 65–69

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

Note

Overall safety performance of the air traffic management system: Indicators and analysis

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

[a] Department of Mechanical and Aerospace Engineering, University of Rome "La Sapienza", Italy
[b] ENAV S.p.A, Italy

ARTICLE INFO

Article history:
Received 27 May 2014
Received in revised form
7 January 2015
Accepted 15 February 2015
Available online 28 February 2015

Keywords:
Air transport safety
Overall safety performance
ESARR
Aerospace performance factor
Analytic hierarchy process

ABSTRACT

Defining means to assess safety performance and delve into their causes is one of the current and future challenges of the ATM sector. Following the experiences of the Aerospace Performance Factor by FAA and EUROCONTROL, this research aims to apply the Analytic Hierarchy Process (AHP) in order to build synthetic and user-friendly safety-related indicators. Through the analysis and combination of the safety events over time (accidents, incidents and issues), this model will pinpoint critical situations and will address the interventions of the decision makers.

1. Introduction

According to ICAO's Global Air Navigation Plan (ICAO, 2013a), each Member State should look at air safety as the highest priority. Strategic regulatory and infrastructure development has the role of proactively address current and emerging safety risk in order to manage and support air traffic development. For this reason, Air Navigation Service Providers (ANSPs) are incessantly seeking for improvements on their operations and performances. The EUROCONTROL Performance Review Commission (PRC) and the US Federal Aviation Administration (FAA) identified (EUROCONTROL and FAA, 2012) common information and performance indicators to use for monitoring safety in each region.

In Europe, EUROCONTROL encourages its Members States (and non-Member States too) to implement standard occurrence reporting and assessment schemes. It aims to define means to assess safety performances and their trends over time, to delve into the causes of all types of safety occurrences and to take corrective measures.

EUROCONTROL describes also the ATM-related occurrences, which as a minimum, shall be reported and assessed to set-up a safety events database, as prescribed (EUROCONTROL, 2009a) in EUROCONTROL SAfety Regulatory Requirement 2 (ESARR 2).

2. Safety database

Referring to Reason's Swiss cheese model (ICAO, 2013b), an incident or any other less serious occurrence could be interpreted as an accident, except that not all the holes in the defense layers lined up. With this interpretation, it is clear how the frequency of accidents is not sufficient to describe safety performances. The Performance Review Commission NLR (2006) used the metaphor of an iceberg to picture that accidents constitute a small but visible subset of occurrences, while incidents and less serious events constitute a larger, often invisible, subset of the iceberg. Therefore, reporting also less serious events gains a primary role in safety analysis.

According to the nature of the human reporting, which is the most common source of data gathering, the information per occurrence increase with severity. However, statistics on less serious events have more potential because of their higher frequency and their easier reporting. ESARR 2 Appendix A (and B) provides the minimum contextual/factual ATM related (and no-ATM related) events to record for each occurrence, as in Fig. 1, classified according to their flight phase, i.e. Airport related events (APT) and En-Route related events (ENR). Then, for each category, they follow the structure of Fig. 1.

* Corresponding author. Via Eudossiana 18 – 00184, Rome, Italy.
E-mail address: francesco.costantino@uniroma1.it (F. Costantino).

http://dx.doi.org/10.1016/j.jairtraman.2015.02.005
0969-6997/

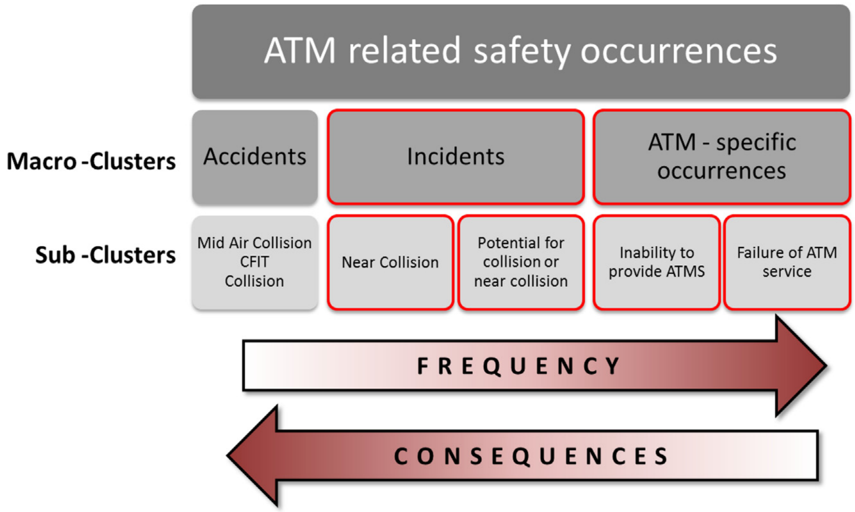

Fig. 1. ATM related safety occurrences (database structure).

3. Safety indicators' building process

Historically, ANSPs used basic metrics as traffic counts, number of accidents and incidents to gauge safety performances. Anyway, these standard indicators fail to represent effectively the overall safety perspective and do not represent a system-wide performance measurement tool. Time series of events can help to evaluate specific criticalities, in particular when observed at an operational level (Careddu et al., 2008), but they need an assessment methodology to combine different evidences, according to the dimensions of the iceberg of safety (Reason et al., 2006).

Firstly, FAA and US Naval Safety Center (Futron Corporation, 2010) understood that new ways to measure and improve safety performance would be necessary, therefore they developed the Aerospace Performance Factor (APF) in order to fit this gap.

The APF (EUROCONTROL, 2009b) aims to aggregate multiple operational safety risks, expressed as the weighted sum of incidents into one single value capable of showing macro changes in performance trends. Although this unique value gives the overall risk, according to the methodology, it can be broken down into its components to analyze specific causal factors.

The Safety Index building process relies on the Analytic Hierarchy Process (AHP), a multi-criteria decision making tool developed by Saaty in the early 1970s (Saaty, 2008). Once obtained the AHP weights, it is possible to evaluate the Safety Indexes, considering the linear combination of the weighted events, normalized by the traffic count (see Eqs. (1)–(2)):

$$Event_i\ APF\ Safety\ Index = \frac{Event_i annual\ count}{TOTAL\ traffic\ count} Event_i\ AHP\ weight \quad (1)$$

$$APF\ Safety\ Index_j = \sum_i^n Event_i\ APF\ Safety\ Index \quad (2)$$

The normalization allows comparisons of results that do not depend on the specific monthly movements but are gradable in a general context.

Through AHP, it is so possible to integrate tangible events (data and quantitative measures) with intangibles (general indications, experiences, estimations, qualitative evaluations of experts) to create an effective safety monitoring system that could take into account both perceptions and events (Lintner et al., 2009).

4. Case study: the Italian ATM system

ENAV s.p.a. (the Italian national authority for flight assistance) is one of the first ANSPs that implemented and applies Safety Indexes as a performance monitor and decision support system tool. In particular, the aim of the project was to consider the aggregation and comparison of ESARR 2 reporting, as for traditional analysis of safety (e.g. separation minima infringement or runway incursions), with different event that could partially be referred to ATM services but contribute to the reduction of safety (e.g. requests of priority or emergency, missed approaches, aborted take offs, etc.). The significance of these last issues, in particular, can contribute to reduce the safety performance of the traffic control system, increasing its level of uncertainty when complex scenarios arise.

ENAV s.p.a. structures a safety control process defining a two-dimension scorecard that reflects the structure of its database of events. The first classification replicates the ESARR 2 requirement of differentiating the flight phase (APT and ENR). For each group, the second dimension provides a further partition, according to the ATM's role in the event (ATM contribution and no ATM contribution). Table 1 shows the main clusters' weights of the Index that collect all the events regardless the contribution of ATM, i.e. Safety Index 1 ENR (the same for APT and ENR). The second level of indexes, Safety Indexes 2 APT and ENR, reduce the set of the events only to the ones that could present an ATM contribution.

5. The Safety Indexes' benefits

Considering this approach, safety performances can use the same principles of quality control analysis, following standard sequence Juran's framework (Fig. 2):

- choose the control subject (air transport safety performance);
- choose a unit of measure (weighted and normalized number of occurrences);
- set a goal for the control subject (EUROCONTROL's regulations);