Combining soft system methodology and Pareto analysis in the assessment of safety management performance: an aviation case

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Abstract: Although reengineering is strategically advantageous for organisations in order to keep functional and sustainable, safety must remain a priority and respective efforts need to be maintained. This paper suggests the combination of soft system methodology (SSM) and Pareto analysis on the scope of safety management performance evaluation, and presents the results of a survey, which was conducted in order to assess the effectiveness, efficacy and ethicality of the individual components of an organisation's safety program. The research employed quantitative and qualitative data and ensured a broad representation of functional managers and safety professionals, who collectively hold the responsibility for planning, implementing and monitoring safety practices. The results showed that SSM can support the assessment of safety management performance by revealing weaknesses of safety initiatives, and Pareto analysis can underwrite the prioritisation of the remedies required. The specific methodology might be adapted by any organisation that requires a deep evaluation of its safety management performance, seeks to uncover the mechanisms that affect such performance, and, under limited resources, needs to focus on the most influential deficiencies.

Keywords: safety management; evaluation; soft system methodology; SSM; Pareto analysis; performance; aviation.

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1 Introduction

Statistics published for civil aviation (e.g., ICAO, 2014; IATA, 2014; ATSB, 2014) indicate that accident rates, especially the ones of fatal events, do not significantly decline, although they have reached considerably low figures. Managing safety seems increasingly important and challenging as aviation organisations diversify in terms of aircraft types, operation requirements, flight sectors, cultures, etc. Safety management systems (SMS) espouse a quality management approach to the complex relationship between aviation safety and business. According to the International Civil Aviation Organization (ICAO, 2013) and the UK Civil Aviation Authority (CAA, 2002), SMS provides an organisational framework to manage safety effectively, serves as the very structure that generates positive safety culture within an organisation, and leads to enhanced safety performance by aiming at best practice and moving beyond mere compliance to regulatory requirements. In the same spirit, the Federal Aviation Administration (FAA, 2006) stated that SMS assist organisations in meeting their legal obligations along with their business benefits, the later deriving from a structured management and continuous improvement of operational processes.

According to ICAO (2013), an SMS holds three features: It is systematic because it emphasises in pre-planned and consistent procedures, proactive since it focuses in hazard identification and control, and explicit because it is fully documented and transparent. Goglia et al. (2008) defined SMS as: “A dynamic risk management system based on quality management system principles in a structured scaled appropriately to the operational risk, applied in a safety culture environment”, thus arguing, the direct relation amongst risk, safety and quality. Moreover, according to the FAA (2006), quality management techniques provide a structured process to ensure achievement and improvement of safety management programs. From a broad perspective, safety management is firmly connected to quality management (Karanikas, 2014).

Various authorities, institutes and authors (e.g., ILM, 2003a, 2003b; ASNZS, 2008; Bossink et al., 1992; Zhang, 2000; Gangemi, 1993; Priporas and Psychogios, 2007; DBIS, 2012; Knowles, 2011) adopted a ‘systems’ thinking’ approach to quality, and claimed that high level management plays a vital role in planning quality, the latter operationalised by middle-level managers and end-users. The individual must be respected, empowered, motivated and prompted to participate in organisational success and promotion (Garwood and Hallen, 1998). Lee and Quazi (2001) and Liu and Xu (2006) argued the need for effective and simplified quality performance assessment based on criteria awards (e.g., the Malcolm Baldrige National Quality Award and the European Quality Award), and prompted organisations to develop self-assessment questionnaires for measuring qualitative entities.

Hoyle (2007) stated that measurement “….is a process of associating numbers with physical quantities and phenomena”; this also applies to intangible properties such as safety and quality. Coletti and Early (1998) defined measurement units as quantities of some quality features, accompanied by sensors, which comprise the measurement instruments. In particular, Coletti and Early (1998) set the characteristics of the ideal unit of measurement: understandable, providing an agreed basis for decision-making, conducive to uniform interpretation, economical to apply and compatible with the respective sensors; Kemp (2006) added the requirement for defined tolerances. According to the Institute of Leadership and Management (ILM, 2003a, 2003b) and the Australian/New Zealand Standardisation Authority (ASNZS, 2008), questionnaire surveys are the most common data collection method for measuring and monitoring customer satisfaction.

Soft system methodology (SSM) comprises a non-experimental strategy, whereby the researcher does not attempt to affect directly the situation, circumstances and experience of the organisation under study (Robson, 2002). SSM focuses on proposing models of 'soft' human activities, places emphasis on the understanding of the situation in which an intervention is required, and formulates the actions to be taken. Application and monitoring of the changes are not included in the SSM objectives (e.g., Attefalk and Langervik, 2001; Checkland, 2000; Lester, 2008). This specific methodology in the context of safety was applied by Adamides et al. (2012), who assessed the efficiency, efficacy and effectiveness of SMS components by following an almost exclusively qualitative approach, without integrating qualitative and quantitative data analysis.

Pareto analysis is a widely applied quality tool, according to which 20% of the defects are responsible for the 80% of the problems encountered; similarly, the management of this 20% of defects may result to an 80% increase of performance (e.g., Bass and Lawton, 2009). As Juran (1998) articulated, the major gains usually come from a vital few quality improvement projects, which usually demand involvement of multifunctional teams, in contrast with the majority of minor projects that individuals and small teams accomplish.

Taking into account the aforementioned concepts, the current research combined the principles of SSM and Pareto analysis into the assessment of safety management performance by analysing quantitative and qualitative data collected through a questionnaire. The scope of this paper is to propose an alternative method for organisations that require a deeper evaluation of their safety management performance, seek to uncover the mechanisms that affect such performance, and, under limited resources, need to focus on the most influential deficiencies.

2 Methodology

The research was conducted in a military aviation organisation (MAO) that is not obliged to operate an SMS, but has in place a safety program. The difference between an SMS and a simple safety program rests mainly on the accountabilities and responsibilities, which are clearly defined by an SMS, and a systemic approach to safety. The goal was to assess the performance of the MAO safety initiatives through a questionnaire survey, and based on the results, support the organisation to its smooth transition to an SMS scheme. After concluding how well the existing safety program is operated and what its strengths and weaknesses are, the MAO would proceed with introducing an SMS scheme.

The MAO's functional levels consist of the Headquarters, three major sections (MS), which report to the Headquarters, and numerous operations units (OU), each of them reporting to a MS. The MAO operates a wide range of aircraft types (e.g., interception, cargo, and training) and supports its flight operations with all relevant activities (e.g., maintenance, logistics, engineering, finance, and administration).

Since the MAO does not run a full SMS, a rigid safety culture program has not been introduced. The research focused on the following safety program elements, which the MAO includes in its internal regulations and procedures:

- *Dynamic accident prevention*: a long list of safety measures that the organisation issues over time and updates according to the results of safety investigations, audits and meetings, and international practices. The specific safety action requires from end-users and supervisors to monitor periodically the working environment and practices in order to identify deviations from safety standards and plan for local remedies (OU level).
- *Safety training*: the organisation introduces safety rules and concepts in its safety schools and seminars, and provides initial and recurrent training.
- *Safety meetings*: they are held periodically by the MAO headquarters, MSs and OUs.
- *Publications*: the MAO publishes a safety-focused magazine three to four times per year, and, occasionally, issues various posters with safety messages.
- *Information sharing*: safety information includes mandatory occurrence reports, safety investigation reports, minutes of safety meetings, safety audit reports and international standards.
- *Statistics*: the MAO publishes annually a safety statistics bulletin that includes accident rates over the past ten years in overall and per OUs and aircraft type. Each bulletin also contains short descriptions of accidents and incidents for the year of reference, along with their causes.
- *Medical services*: the contribution of medical services to MAO's occupational health and safety program.
- *Flight safety rewards*: a rewarding scheme for OUs with outstanding flight safety performance.
- *Road safety rewards*: rewards for drivers with excellent road safety performance.
- *Moral rewards*: these are presented to employees who have actively contributed to safety initiatives and successfully managed rare high-risk events.
- *Safety reporting*: the MAO runs a reporting system on a volunteer and anonymous basis in order to collect information about local and systemic hazards, whose mitigation exceeds the capacity of the OUs and requires intervention from the MSs and headquarters.
- *Local hazards reporting*: it regards communication of local hazards to other employees, in cases that mitigation measures cannot be applied immediately.
- *Foreign object debris*: the specific action aims to eliminate hazardous situations stemming from foreign object debris.
- *Safety investigations*: the MAO has published procedures for the reporting and investigation of accidents and incidents, publication of official accident reports, and monitoring of safety recommendations' implementation.
- *International standards*: international standards that are updated continuously and disseminated to the OUs.
- *Risk management*: policy and structured procedures for hazard identification, risk assessment, risk mitigation and risk acceptance.

2.1 Sample

The employees with active and official roles in safety program planning (safety professionals) and implementation (operation managers) were the sample population. The specific personnel have a high proximity to the MAO safety issues on a daily basis due to the nature of their tasks and responsibilities. The survey questionnaire (see below Section 2.2.) was administered as follows:

- OU level: managers who are responsible for delivering safety actions (OU commanders, deputy OU commanders, directors, operations managers, chief engineers, etc.), and safety officers, whose role is to advise managers. The researcher administered 199 questionnaires to a variety of flight, maintenance, ground support and administration personnel, who serve in 12 large representative OUs and implement all elements of the MAO's safety program.
- Management level: safety experts serving at the safety centre of the MAO headquarters and the three safety directorates, each one located in each MS. 20 questionnaires were administered to such staff.

In total 219 questionnaires were administered and 52 responses were received (23.7% response rate). Taking into account the target population and the specific response rate, the overall results were expected at a 90% confidence level and with a 10% error margin. These boundaries were considered as acceptable under the scope of this research.

2.2 Survey tool

In order to collect data regarding the MAO's safety program components, a questionnaire was administered to employees. A pilot survey and the feedback provided by three MAO's safety experts lead to refinement of the survey tool and enhanced its reliability and validity. The research tool, in addition to the informed consent form and instructions, included the following sections:

- Section 1: The participants were asked for their main role (manager/leader, safety officer or safety expert), the OU and/or the MS they report to, and the type of sector they serve (flight operations, maintenance or otherwise). This information comprised the independent variables for statistical analysis.
- Section 2: Each participant was asked to rate the dimensions of effectiveness, efficacy and ethicality of each MAO's safety program element and the safety program as a whole. A Likert scale from 1 to 5 was used, where 1 represented the lowest rate and 5 the highest possible score. The participants were instructed to avoid rating program elements that they had not been extensively involved in. Moreover, the participants were prompted to raise comments/recommendations for each program component (open-end question).

2.3 Questionnaire data analysis

The independent variables of MS and OU were coded in order to avoid identification of participants. The three MSs were assigned the codes F1, F2 and F3, and the OUs were coded as F*x*U*z*, where *z* represents the OU and *x* corresponds to the MS the OU reports to. The data collected through the survey tool were analysed as follows:

1. Quantitative analysis of the scores in total, per safety component and per dimension (effectiveness, efficacy and ethicality). Potential variances of scores were explored against the independent variables of:
   - participants' role (safety officers, safety experts and operation managers)
   - participants' specialty (aircrew, maintenance staff and other ground staff)
   - organisational level (i.e., OU or management level – including both the MSs and headquarters)
   - type of sector (flight operations, maintenance and other sector).
2. Content analysis of the suggestions that were formulated for each safety component and the MAO safety program as a whole. The analysis led to the development of codes – categories, which afterwards were subject to quantitative analysis (see Section 2.5. below). A variance analysis of the categories against the independent variables above was also performed.

2.4 Quantitative analysis

The data were entered in the PASW Statistics software and tested for normality in order to decide the appropriateness of parametric or non-parametric statistical tests. The Kolmogorov-Smirnov tests showed non-normality of data, hence, the following non-parametric statistics were applied:

- calculations of median values
- Mann-Whitney tests in the cases of two independent variables
- Kruskal-Wallis tests in the cases of three or more independent variables
- Friedman tests in cases of related samples.

In addition to the aforementioned tests, chi-square tests were used for the exploration of associations amongst nominal variables. The specific test requires at least five records per case in order to claim validity; thus, entries that did not fulfil this criterion were excluded from the calculations. If such entries were equal or more than half of the respective sample population, the chi-square test was not conducted.

Where allowed by the software package, in addition to the asymptotic significance, the exact statistics option was selected in order to strengthen the results. The confidence interval for hypotheses' testing was set at $\alpha = 0.05$.

2.5 Qualitative analysis

In order to develop principal categories, the researcher and a MAO's safety expert analysed and coded the comments, which the participants stated in response to the open-end question. A quantitative analysis of these categories in combination with the numerical data analysis (see Section 2.4 above) revealed the strong and weak components and dimensions of the MAO's safety program. An 'emergent coding' was followed (Stemler, 2001), consisting of the steps below:

- review of questionnaire comments by the researcher and the safety expert
- development of two individual checklists
- consolidation of the two preliminary checklists in one, ensuring mutually exclusive and exhaustive categories
- coding of the comments according to the new checklist
- check of the inter-rater reliability by applying the Fleiss kappa method (Fleiss, 1971) until a value of 0.75 was reached, which according to Koch and Landis (1977) is considered as 'substantial' agreement.

3 Results

3.1 Analysis of scores

The median values for the whole MAO safety program along the three dimensions were:

- effectiveness: 4
- efficacy: 3.5
- ethicality: 3.

The safety program's median score for all dimensions was 10 with a maximum value of 15 (i.e., five per dimension), corresponding to a 67% overall performance. The median values per safety component and dimension are presented in Table 1; both lowest scores of '2' were recorded for the effectiveness dimension of flight safety rewards and safety reporting components. Regarding the total scores per safety program component across all dimensions, Friedman tests showed a statistically significant difference (chi-square = 51.478, dF = 15, p = 0.000). The 20% best performed components were: moral rewards, information sharing and safety investigations. The lowest performed safety program elements were: flight safety rewards, road safety rewards and safety reporting.

Table 1 Scores of dimensions per safety program component at a descending order (median values)

Safety component	*Effectiveness*	*Ethicality*	*Efficacy*	*Total score*
Moral rewards	4	5	5	14
Information sharing	4	4	4	12
Safety investigations	4	4	4	12
Safety training	4	3.5	4	11.5
Statistics	4	3.5	4	11.5
Foreign object debris	4	3.5	4	11.5
Safety meetings	3	4	4	11
Publications	3	4	4	11
Local hazard reporting	3	4	4	11
International standards	4	3	4	11
Medical services	3	3.5	4	10.5
Dynamic accident prevention	3	3	4	10
Risk management	3	3	4	10
Safety reporting	2	4	3	9
Road safety rewards	3	3	3	9
Flight safety rewards	2	3	3	8

The Friedman tests revealed that each of the 16 safety components differed significantly regarding the dimensions of effectiveness and ethicality, as presented in Table 2, where the 20% of the best and worst performed components for these dimensions are shown.

Table 2 Differences amongst dimensions of effectiveness and ethicality across safety program components

Dimension	*Effectiveness*	*Ethicality*
Chi-square value	43.582	54.797
Degrees of freedom (dF)	15	15
Significance (p)	0.000	0.000
20% best performed safety program components	Information sharing	Moral rewards
	Moral rewards	Safety investigations
	Foreign object debris	International standards
20% worst performed safety program components	Flight safety rewards	Flight safety rewards
	Safety reporting	Safety reporting
	Local hazard reporting	Local hazard reporting

The function of the respondents (i.e., safety expert, safety officer or operations manager) did not affect the ratings. The specialty (i.e., aircrew or maintenance staff) affected only the scores of the Information Sharing element; aircrew rated the specific component higher than the maintenance personnel did ($p = 0.019$). There was only one record for the category of ‘other ground staff’, thus, this category was excluded from the calculations.

Kruskal-Wallis tests revealed that the total scores for the statistics, moral rewards, local hazard reporting and safety investigation components differed amongst the headquarters and the three MSs, as reported in Table 3.

Table 3 Differences in scores of components amongst the headquarters and the MSs

Safety program component	*Statistics*	*Moral rewards*	*Local hazard reporting*	*Investigations*
Chi-square value	9.010	8.070	12.464	9.059
Degrees of freedom (dF)	3	3	3	3
Significance (p)	0.029	0.045	0.006	0.029

The OU variable was associated with the total scores of publications, medical services, safety reporting and local hazard reporting (Table 4); two out of 12 OUs were excluded from the calculations due to limited records.

Table 4 Differences in scores of specific components amongst the OUs

Safety program component	*Publications*	*Medical services*	*Safety reporting*	*Local hazard reporting*
Chi-square	19.287	18.846	17.577	18.570
Degrees of freedom (dF)	9	9	9	9
Significance (p)	0.023	0.027	0.025	0.029
20% of the OUs with the highest scores	F1U2, F1U4	F2U1, F1U4	F1U4, F3U1	F1U4, F3U1
20% of the OUs with the lowest scores	F1U3, F2U2	F1U1, F2U2	F1U3, F2U2	F1B5, F2U2

The Mann-Whitney test revealed significant differences between the organisational levels (i.e., OU and management levels) regarding the elements of information sharing (p = 0.023), statistics (p = 0.022) and medical services (p = 0.036). The participants who served in management levels (i.e., the headquarters and the MSs) rated the aforementioned components lower than the employees who served in OUs.

The participants' position as operational (i.e., implementing the safety program) or managing (i.e., planning and monitoring of the safety program) affected only the Information Sharing component (p = 0.003); operational personnel rated the specific element significantly lower than managers did.

3.2 Analysis of comments

In total, 356 comments were recorded; Table 5 reports in an ascending order the frequencies of comments made per element and about the safety program as a whole. The most commented components were the dynamic accident prevention, safety training and safety investigations. The elements of safety meetings, statistics, foreign object debris and international standards gathered the fewest comments.

Table 5 Number of comments per safety program element

Safety program component	*Number of comments*	*Percentage of total comments (%)*
International standards	9	2.5
Safety meetings	10	2.8
Foreign object debris	13	3.7
Statistics	13	3.7
Moral rewards	16	4.5
Road safety rewards	16	4.5
Publications	17	4.8
Total safety program	19	5.3
Information sharing	20	5.6
Risk management	21	5.9
Medical services	22	6.2
Flight safety rewards	23	6.5
Local hazards reporting	24	6.7
Safety reporting	27	7.6
Dynamic accident prevention	32	9.0
Safety investigation	37	10.4
Safety training	37	10.4

The content analysis of the comments resulted to the coding of Table 6, where the frequency for each of the 20 developed categories is ranked in an ascending order. Most of the comments referred to the 'substantial implementation of the safety program', 'safety training customisation and extension', 'motivation for participation' and 'increase of communication effectiveness'.

Table 6 Results of questionnaire comments' coding in an ascending frequency order

Code	*Description*	*Frequency*	*Percentage (%)*
Adequate time for implementing measures	More time must be allowed for implementation of preventive measures	1	0.3
Detailed statistics	There is a need for more detailed statistics	3	0.8
Adequate monitoring	More monitoring of safety initiatives' implementation is required	5	1.4
Meetings' frequency and representation	Safety meetings must be scheduled at a lower frequency, depending on the agenda. Operation managers must participate in MS level safety meetings	5	1.4
Increase of interest	A variety of safety information, accident photos and videos, etc., will increase employees' interest in safety activities	9	2.5

Table 6 Results of questionnaire comments' coding in an ascending frequency order (continued)

Code	*Description*	*Frequency*	*Percentage (%)*
Avocation of exclusive staff	There is a need for appointing exclusive personnel to perform safety activities (e.g., safety investigations, prevention of foreign object damages)	10	2.8
Connection to operations	Safety must be closely connected to operational objectives	10	2.8
Simplicity	Safety rules and procedures must be simplified and adapted for the average employee	11	3.1
Fairness	Safety rewards must be extended to all specialities and roles, beyond pilots and vehicle drivers as means to foster fairness.	12	3.4
Restructure of safety administration	Safety administration needs to be reorganised and staffed by personnel with specific and relevant criteria	15	4.2
Meritocracy	The MAO must publish meritocratic criteria for increasing the objectivity of safety rewards, safety roles appointments, etc.	15	4.2
Confidence amongst organisational levels	Practical demonstration of commitment to safety by managers and supervisors will increase confidence amongst users and managers at various organisational levels	19	5.3
Adaption and enrichment	International standards must be customised to the MAO's context. Continuous communication with international agencies and users will support the improvement of the safety program	20	5.6
Reduction of bureaucracy	Reduction of bureaucracy might be achieved by introducing new technology	21	5.9
Increase of resources	There is a need for devoting more resources for managing the safety program	22	6.2
Reformation of the safety program	The existing safety program needs evaluation in order to proceed to an extensive reformation and innovation, and development of safety culture	24	6.7
Increase of communication effectiveness	Periodical and frequent communication at all organisational levels is required. Electronic means can facilitate communication of safety information.	30	8.4
Motivation for participation	Personnel need more motivation in order to actively participate in safety initiatives	34	9.6
Customisation and extension of safety training	There is a need for both organisation-wide and local safety training, along with special training for safety personnel	39	11.0
Substantial implementation	The substantial implementation of safety program components must be fostered, and frequent waivers must be avoided	51	14.3

4 Discussion

According to the overall results, MAO's safety program seems to be effective but underperforming into the dimensions of efficacy and ethicality. This indicates an area of special attention when introducing new safety initiatives or amending the existing ones since their suitability to the MAO context and the devotion of adequate resources need to be considered. Moreover, the MAO scored 67% across all dimensions; such result comprises a trigger for further enhancement of its safety management performance. Firstly, the MAO must focus on sharing positive management practices regarding the components, which acquired the highest scores (i.e., moral rewards, information sharing and safety investigations). Secondly, the organisation must reconsider its program elements that presented the lowest rates:

- flight and road safety rewards components might require reformation in order to increase their impact on safety promotion
- the safety reporting element needs to be assessed for its usability and user friendliness
- actions for increasing the effectiveness and ethicality of the local hazard reporting component must follow.

Differences in rates amongst employees with various specialties (aircrew or maintenance staff) and tasks (operations or management) were observed only for the safety information sharing component; it seems that the value of this initiative must be adequately communicated to maintenance personnel and staff with operational roles. The fact that the scores for the rest of the safety program elements were not influenced by the aforementioned variables indicates that common perceptions are shared across the MAO principal job and task specialisations.

However, the research identified the following:

- Four out of the 16 elements (i.e., statistics, moral rewards, local hazard reporting and safety investigation) showed dissimilar rates amongst the four high- and middle-management functions (i.e., the headquarters and the three MSs);
- Three out of the 16 components (i.e., information sharing, statistics and medical services) were rated differently by each organisational level (i.e., OU and management levels), the lowest scores given by OUs employees;
- Staff of different OUs rated differently four safety program elements (i.e., publications, medical services, safety reporting and local hazard reporting). It is of high interest that participants positioned in the OU 'F1U4' rated all these four components higher than employees of other OUs, and the staff serving in the OU 'F2U2' rated all aforementioned safety initiatives lower than personnel working at other OUs.

These observations suggest that:

- The lack of common perceptions amongst the management functions must be addressed in order to achieve an alignment of safety initiatives' planning.
- There is a need to bridge the gap between management and operations, and thus, promote a common approach to safety management.
- Local conditions across the various OUs might have played an important role in the development of perceptions of their employees regarding the MAO's safety program. This implies that the MO must adapt a tailored approach when introducing and implementing safety actions across its OUs.

It is remarkable that the participants commented less on the 'worst performed' components compared to the frequency of their statements about the rest of the safety program elements. In contradiction to expectations, although safety training, safety investigations and dynamic accident prevention components collected the best scores, these also gathered most of the recommendations for improvement. This implies some inconsistency, and probably indicates an immature organisational culture under which personnel formulate deficiencies but do not proportionally participate in suggesting improvements.

Eventually, taking into account the content of the most frequent comments, the MAO must consider mainly the following issues during the planning of its interventions:

- allocation of adequate resources
- enhancement of effective communication in order to ensure its safety program acceptance and substantial implementation
- provision of further induction and recurrent safety training to its workforce in order to support its safety program realisation
- increase of employees' motivation by introducing fair and innovative physical and moral rewards.

5 Conclusions

The methodology followed in this study revealed various weaknesses of the MAO's safety program. The analysis of the quantitative data regarding the effectiveness, ethicality and efficiency dimensions per safety program component, along with the comments made by the participants, allowed a holistic approach to the evaluation of the MAO's safety program. Moreover, the participation in the research of a variety of professional roles, functions and specialties ensured the collection of diverse perceptions. However, a larger sample would increase the statistical confidence and reduce error margins in future studies

The employment of independent variables (e.g., management or operational levels and types of participants' role and tasks) explored their potential influence on scores and indicated areas of special concern. Furthermore, the analysis of the comments unveiled the strategy that the MAO needs to employ during the reformation of its safety program elements, starting from the ones with the lowest scores. Investment on resources will ensure the maintenance of performance regarding the elements that excelled, and enhance the dimensions of the weakest components.

Certainly, end-user attitudes towards safety activities are important for an overall safety performance assessment. However, such broad views might be measured through the widely established safety culture and climate assessment tools, (e.g., Simon, 2005; Gibbons and Thaden, 2008). As Adebiyi et al. (2007) argued, participation of end-users in the assessment of specific safety actions might be of low credibility due to factors such as lack of accurate information, negative preconceptions due to end-users' involvement in accidents, local working environment factors, etc. Moreover, managers and safety professionals have already acted as end-users, and they are still obliged to apply safety rules and procedures; hence, their inclusion in safety surveys guarantees by definition a wide viewpoint. Therefore, at a first step towards the assessment of the safety initiatives, end-users might not be surveyed, but their perspectives could be considered in future research regarding local issues.

The specific methodology is not limited to simple safety programs, such as the one the current study considered. It can be followed also for evaluating a complete SMS, which by default includes a range of different activities and initiatives (e.g., policy, risk management, training, safety investigations and safety promotion). Therefore, this methodology might be adapted and applied by any industry sector that requires assessment of its whole safety management performance or evaluation of individual safety activities. It is crucial that such assessment must collect views of every management and operation level and represent perceptions of personnel who collectively plan, apply and monitor safety actions. Any organisational change based on this approach is expected to be highly endorsed by the employees.

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