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# The Intrinsic Quality of Aviation Safety Management Systems Indexed and Expressed Mathematically, Accurately Indicate Developmental Status, thus Facilitating Comparative Assessment and Trend Analysis

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**Abstract:**

A process has evolved to prove the viability of a mechanism that can be integrated with external audit processes and applied as a means to effectively index maturity levels of Safety Management within certificated - commercial aviation organisations; these findings are then cross-referenced to Quality Management as defined by ISO 9001:2000. Selected questions encompassing the regulatory and best industry practice components of a formal Safety Management System were formulated as an analytical tool and applied in a 'five point' grading system reduced to a percentage. Results indicated a definite relationship between the developmental level of the Safety Management System audited, and the degree of ISO 9001:2000 inclusion. Safety Management Systems although advanced in theoretical development, invariably fail because of a lack of understanding relating to practical application technique and associated measuring mechanisms. Quality Management and Aviation Safety Management processes co-exist within the ISO 9001:2000 Quality Management System. Safety as a 'Quality Resultant' is related to the level of success with the integration of these factors. The significance of this is enormous, as it means there is a tangible aspect that can be measured and compared. This standardised model applied nationally, internationally or within a military regime produces uniform results, allowing for accurate graded indexing. Indexed safety can benefit the Regulatory Authority, or by virtue of an announced 'grading', create competitive reaction that fosters continual improvement.

**Introduction:**

External audits carried out over an eight year period on 250 globally situated, Air Operating Companies, revealed varying degrees of national / international regulatory compliance; the most significant trend observed during this intensive process, was the level of safety awareness present within the safety management structure and related developmental maturity of the organisations quality management system.

Insight into similarities between aviation management structures and ISO quality management leads one to the startling realization that aviation management structures, conforming in varying degrees to the ideal ISO 9001:2000 quality management model, could gain maximum advantage by adopting ISO 9001:2000 quality management principles. The ISO 9001:2000 quality management model has universal acceptance as the leading quality management system. An aviation integrated ISO 9001:2000 quality management model would therefore be the most effective strategy to adopt; safety management as an integral part of this aviation ISO quality management model structure would thus yield the best safety result.

Currently, with no effective means available to index maturity levels of safety management systems within certificated, commercial aviation organisations - coupled with the awareness that ISO 9001:2000 quality management principles form the basis for a universally accepted ideal management process model, it became evident that an integrated, mathematically orientated, standardised model applied correctly would yield graded results, directly influencing safety outcomes and facilitating the implementation of remedial action requirements - improvement would of necessity follow in both safety and commercial functions.

An example of the value of the ISO process is demonstrated in Clause 8 of the ISO 9001:2000 Standard where reference is made to Measurement, Analysis and Improvement. This element is focused on identifying and measuring data and then linking them to organisational results. This element, if analysed in isolation from the ISO 9001:2000 Standard, is unique in that it if correctly implemented it will ensure that acceptable levels of safety are maintained continuously, and will not decline between audits, as is the present trend.

Generally, aviation safety management systems have been adequately defined, analysed and documented; for some years large corporations have insisted on their Service Providers implementing formal safety management plans as a prerequisite for effective aviation safety management control.

Safety management systems introduced have been constructed to afford a level of safety control. The significance of this safety control mechanism has only recently been recognised by Regulators, legislation governing the adherence of Air Operating Companies to these principles has been promulgated in many countries. In reality, usually only the documented / compliance requirement is addressed and the result is an inanimate library artifact. The executive control of safety management systems is generally ill-defined indicating varying levels of document compliance in the absence of real dynamic commitment.

The Operator / Aircraft Operator Certificate holder is primarily responsible for continuously monitoring and ensuring that licensed operations involving flight operations, maintenance functions and security is systemically safe and in compliance with Civil Aviation Regulations.

Aviation safety management expressed as a time-line progression, categorized into three events, displays factors with a common origin found in the 'Pre-Event'. Safety management and associated quality management principles become evident as integrated functions;

1. Pre-event Quality Management: Flight Operations and Maintenance functions
2. Event Accident or Incident
3. Post-event Accident / Incident investigation & statistical returns

The 'Pre-Event' is the subject of this standardised model; enhanced quality management has been identified as the necessary prerequisite to improved safety within Air Operating Companies.

**Equations / Methods:**

The formulation of a standardised safety assessment model integrated and applied with external audit processes was seen as a logical step following initial audit processes where the need to establish a validated measuring tool designed to assess and grade an Air Operating Companies safety management performance was demonstrated.

This was done through the application of a 'Five Point' grading system. The auditors doing the evaluation had the discretion to award marks accordingly. The idea of awarding marks out of a possible five was to obtain a more even mark - as opposed to the right / wrong of existing compliance orientated audit systems. 5 relates to low risk. 1 relates to high risk. A score of 1 or 2 indicates a problem requiring immediate attention. 'X' in Table 3 (Section 4, Tables and Figures) – indicates that the ISO process has not been implemented.

The three tables (Table 1, 2 and 3) as described, and depicted in Section 4, Tables and Figures have been extracted from a comprehensive model designed to accurately index and express mathematically the safety management - developmental status of the applicable Air Operating Company. Additional opportunities recognised within this process were comparative assessment between organisations and trend analysis.

Table 1. Compliance Audit (adapted to national regulations)

Table 1 is designed to assess within the audit process, the level of compliance that the Air Operating Company has with national regulations. Normally this is the audit level applied by the national civil aviation regulatory authority. The mathematical result is obtained by scoring 1 – 5 as described above; alternatively there is the option to define the result as 'NA' with a zero score rating. The number of questions on the checklist scored is divided into the total e.g. if 40 questions were asked with a resultant score of 120. The percentage result would be 120 out of a possible 200 (40 x 5 = 200) i.e.

$$\frac{120}{200} \times 100 = 60\% \qquad (1)$$

Table 2. Sample Extract of Best Industry Practice Audit

Table 2 has similar scoring to Table 1.

Table 3. Sample Extract of ISO 9001:2000 Gap Analysis Audit

Table 3 requires an in depth knowledge of both aviation and ISO 9001:2000 principles to effectively derive the scored result. The option 'X' in Table 3 (Section 4, Tables and Figures) – indicates that the ISO process has not been implemented. This would equate to 'NA' in the other tables but the option is left open as it might apply to ISO 9001:2000 but not directly to aviation safety specific functions within the organisation.

An average is then taken from the three scored results.

Figure 1. Process-based ISO 9001:2000 aviation quality management system model

Figure 1 describes the links between the elements within the context of an ideal quality management system. The element requirements are the components of the system, the components are essential, but how they relate to one another, or how they link, defines the success of the aviation safety management system and associated quality / business management system.

Figure 2. Aviation - Enhanced PDCA Methodology

Figure 2 describes the Plan – Do – Check – Act, ISO 9001:2000, quality management process construction and analysis model.

**Tables and Figures**

Table 1. Sample Extract of Compliance Audit (adapted to national regulations)

| COMPLIANCE ASSESSMENT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FLIGHT OPERATIONS AUDIT<br>Organisation / Management | | | | | | | | |
| **Organisation / Management** | | **Result** | | | | | | **Reference** |
| 1 | Chief Executive Officer (CEO) | 5 | 4 | 3 | 2 | 1 | NA | CA Act 28 |
| 2 | Head of flying operations | 5 | 4 | 3 | 2 | 1 | NA | |
| 3 | Head of training and checking organisation | 5 | 4 | 3 | 2 | 1 | NA | |
| 4 | Head of aircraft maintenance | 5 | 4 | 3 | 2 | 1 | NA | |
| 5 | Aviation Safety Officer | 5 | 4 | 3 | 2 | 1 | NA | |
| **Organisational Structure 28(1)(b)(i)** | | | | | | | | |
| 6 | Organisation suitable with regard to the size and scope of the proposed operation | 5 | 4 | 3 | 2 | 1 | NA | |
| 7 | Chain of command appropriate to ensure safety of operations | 5 | 4 | 3 | 2 | 1 | NA | CA Act 28(1)(b)(ii) |
| 8 | Numbers of management positions not excessive | 5 | 4 | 3 | 2 | 1 | NA | |
| 9 | Flying/administration tasks balanced for Flight Crew Managers | 5 | 4 | 3 | 2 | 1 | NA | |
| **Organisation has sufficient number of suitably qualified and competent employees 28(1)(b)(iii)** | | | | | | | | |
| 10 | Flight crew | 5 | 4 | 3 | 2 | 1 | NA | |
| 11 | Cabin crew | 5 | 4 | 3 | 2 | 1 | NA | |
| 12 | Crew training and checking | 5 | 4 | 3 | 2 | 1 | NA | |
| 13 | Other technical trainers | 5 | 4 | 3 | 2 | 1 | NA | |
| 14 | Operations planning | 5 | 4 | 3 | 2 | 1 | NA | |
| 15 | Operations control | 5 | 4 | 3 | 2 | 1 | NA | |
| 16 | Crew scheduling | 5 | 4 | 3 | 2 | 1 | NA | |
| 17 | Load control | 5 | 4 | 3 | 2 | 1 | NA | |
| 18 | Passenger handling | 5 | 4 | 3 | 2 | 1 | NA | |
| 19 | Administrative support | 5 | 4 | 3 | 2 | 1 | NA | |
| 20 | Overall Organisation (including Board of Directors, if any), Chief Executive Officer | 5 | 4 | 3 | 2 | 1 | NA | |
| 21 | Head of Flying Operations<br>(See Approval of Chief Pilot) | 5 | 4 | 3 | 2 | 1 | NA | |
| 22 | Head of Training and Checking<br>(See Approval of Chief Pilot) | 5 | 4 | 3 | 2 | 1 | NA | |
| 23 | Flying Operations Organisation and Staffing<br>(See Form 127 Checklist – Flying Operations Organisational Structure and Staffing) | 5 | 4 | 3 | 2 | 1 | NA | |
| 24 | Maintenance Organisation and Staffing<br>(See Form 128 - Checklist – Maintenance Organisational Structure and Staffing) | 5 | 4 | 3 | 2 | 1 | NA | |

Table 2. Sample Extract of Best Industry Practice Audit

| BEST INDUSTRY PRACTICE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **FLIGHT OPERATIONS AUDIT**<br>**Organisation / Management** | | | | | | | | |
| 1 | Has the CEO published a written policy statement on safety? | | 5 | 4 | 3 | 2 | 1 | NA |
| 2 | Does the CEO express the principles or philosophies of management? | | 5 | 4 | 3 | 2 | 1 | NA |
| 3 | Is the CEO advised of deficiencies that could produce serious accident potentials? | | 5 | 4 | 3 | 2 | 1 | NA |
| 4 | Is there an annual safety program objective plan? | | 5 | 4 | 3 | 2 | 1 | NA |
| 5 | Does the CEO brief the ASO on the results of audit evaluations? | | 5 | 4 | 3 | 2 | 1 | NA |
| 6 | Does the CEO conduct internal staff/employee visits as part of his management style? | | 5 | 4 | 3 | 2 | 1 | NA |
| 7 | Is the Aviation Safety Program / Accident Prevention Program planning, specific and controlled? | | 5 | 4 | 3 | 2 | 1 | NA |
| 8 | Do established procedures assure prompt and accurate reporting of all reportable hazards, mishaps, incidents and accidents? | | 5 | 4 | 3 | 2 | 1 | NA |
| 9 | Are sufficient aircrew flying training hours available to provide the quantity and quality of training required to maintain the desired level of proficiency? | | 5 | 4 | 3 | 2 | 1 | NA |
| 10 | Are monthly surplus flying hours fully utilized for continuation training (where applicable) to enhance a desired level of proficiency for aircrew? | | 5 | 4 | 3 | 2 | 1 | NA |
| 11 | Do aircrew feel that present levels of continuation training are sufficient? | | 5 | 4 | 3 | 2 | 1 | NA |
| 12 | Has a systematic plan been scheduled and correctly followed to complete all aircrew flight training requirements six monthly / annually (proficiency)? | | 5 | 4 | 3 | 2 | 1 | NA |

Table 3. Sample Extract of ISO 9001:2000 Gap Analysis Audit

| ISO 9001:2000 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **GAP ANALYSIS**<br>**Quality Management System** | | | | | | | | | | |
| **Topic: "Top management provided evidence of its commitment to the development and implementation of the QMS and continually improving its effectiveness".** *(ISO 9001 cl.5.1)* | | | | | | | | | | |
| | **Checklist analysis** | **ISO ref.** | **QAS ref.** | **Result** | | | | | | |
| 1 | The importance of meeting customer as well as statutory and regulatory requirements relating to safety management (output of processes) is communicated to all relevant parties – internal. | *(ISO 9001 cl.5.1A)*<br>*(ISO 9001 cl.1.1)* | | 5 | 4 | 3 | 2 | 1 | X |
| 2 | The Quality Policy has been established. | *(ISO 9001 cl.5.1b)* | | 5 | 4 | 3 | 2 | 1 | X |
| 3 | The Quality Policy:<br>✈ Is appropriate to the profile of the organisation.<br>✈ Addresses commitment to comply with requirements and continually improve the effectiveness of the QMS.<br>✈ Provides a framework for setting objectives. | *(ISO 9001 cl.5.3)* | | 5 | 4 | 3 | 2 | 1 | X |
| **Topic: "Quality objectives are established".** *(ISO 9001 cl.5.4.1)* | | | | | | | | | | |
| 5 | A framework for establishing and reviewing objectives at relevant levels and functions in the organisation has been established. | *(ISO 9001 cl.5.3 (c)* | | 5 | 4 | 3 | 2 | 1 | X |
| 6 | Objectives are consistent with Quality Policy. | *(ISO 9001 cl.5.4.1)* | | 5 | 4 | 3 | 2 | 1 | X |
| 7 | Measurable objectives have been established and are relevant to process outputs. | *(ISO 9001 cl.5.4.1)* | | 5 | 4 | 3 | 2 | 1 | X |
| **Topic: "Top management has effectively communicated its message to the organisation".** *(ISO 9001 cl.5.1 & 5.3)* | | | | | | | | | | |
| 9 | Effective communication processes between top management and the rest of the organisation are established. | | | 5 | 4 | 3 | 2 | 1 | X |
| 10 | Members of the organisation are aware of, and understand the following:<br>✈ Quality Policy.<br>✈ Responsibilities, authorities & relationship to others.<br>✈ Statutory and regulatory requirements for the position held.<br>✈ The results of reviews of the effectiveness of the QMS.<br>✈ The organisations improvement requirements for the QMS including those with respect to meeting customer requirements, feedback and perceptions. | | | 5 | 4 | 3 | 2 | 1 | X |

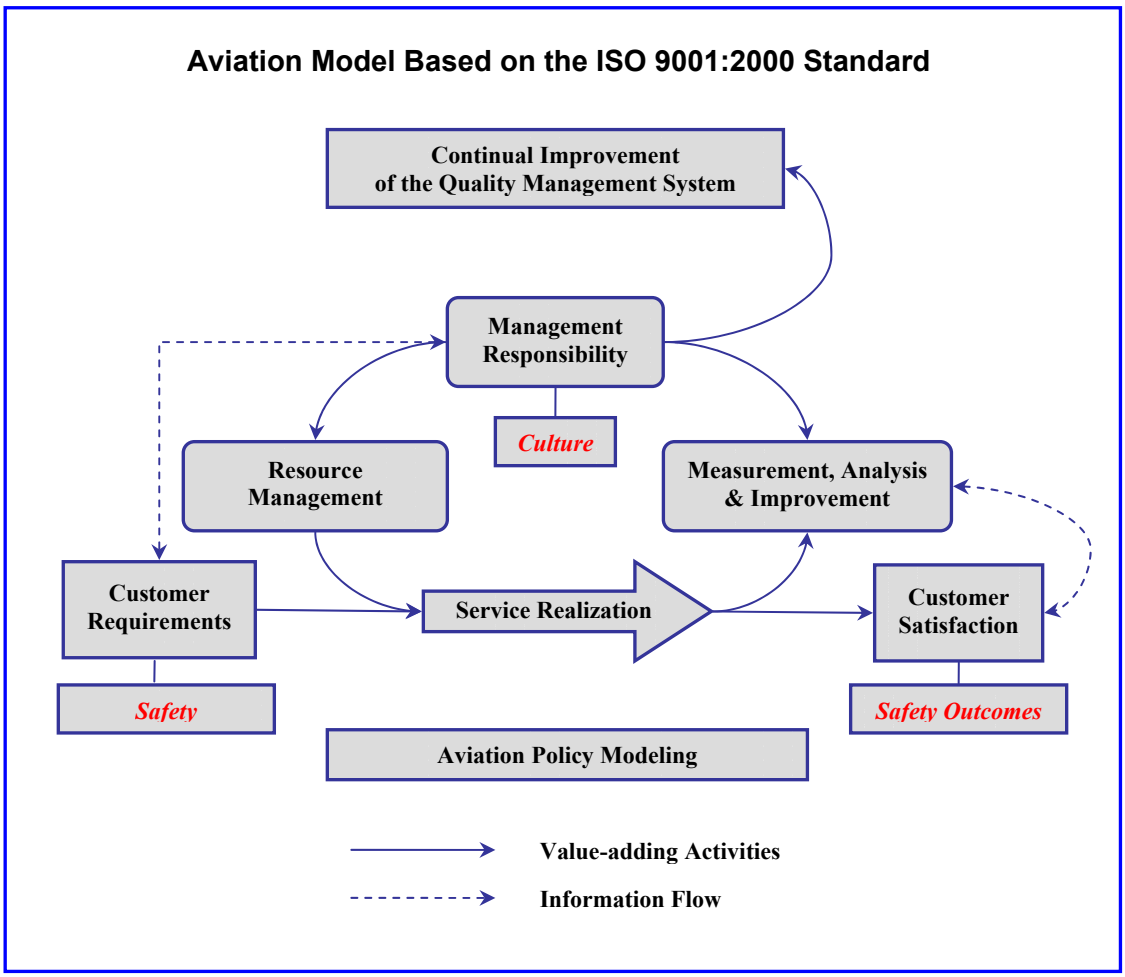


Figure 1. Process-based Aviation Quality Management System

ISO 9001:2000 based on a process approach requires a clear understanding of all processes implemented within the Air Operating Company. Requirements for these processes shown in figure 1 above are stated in the following clauses of ISO 9001:2000:

- Clause 4 – Quality management system.
- Clause 5 – Management responsibility.
- Clause 6 – Resource management.
- Clause 7 – Product realisation.
- Clause 8 – Measurement, analysis and improvement.

The implementation of the ISO 9001:2000 process-based aviation quality management system involves the identification and evaluation of the processes relevant to the quality management system and its application throughout the Air Operating Company. Each process is then individually mapped and recorded into a matrix that links the total networked interacting processes within the Company.

This approach is simply illustrated in the following 'Enhanced PDCA Diagram – Figure 2.

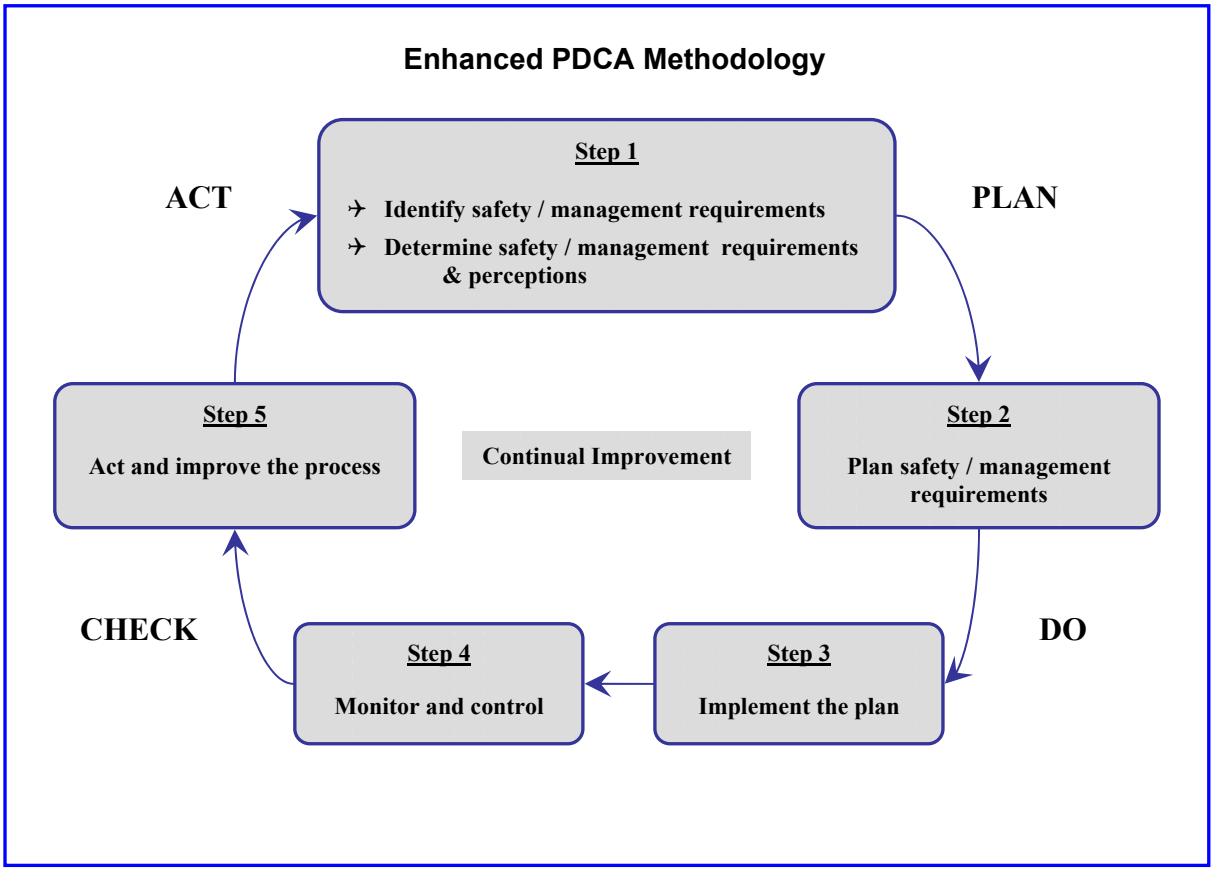


Figure 2. Aviation - Enhanced PDCA Methodology

The Plan – Do – Check – Act, ISO 9001:2000, quality management process construction and analysis model is the tool that is used to individually map and record interacting processes into a documented system.

The mapping and recording of individual and interactive processes is important because it maps out on a time-line basis all the functions within the company. This documented process is then integrated into the quality / operations manual and is available for reference as a work instruction if required.

**Conclusions and Recommendations**

The application of the standardised safety assessment model as described within certificated - commercial aviation organisations has shown that management of safety is usually applied in random fashion with no set objectives and no means of identifying and measuring data or linking them to organisational results. Scored results obtained indicate very low levels of effective safety management and related developmental maturity of associated quality management systems.

It was apparent after only a few applications of the model, that the original hypothesis relating to the value of involving quality management principles in enhancing aviation safety was valid.

Advantages in applying an integrated and systematic approach as defined by ISO 9001:2000 relates directly to the safety assessment findings.

The application of the safety assessment model effectively demonstrating weaknesses within the system had the advantage of communicating priorities, monitoring performance and thus through heightened awareness provided a clear basis for improving results. The following were some of the benefits observed:

- ✈ Measurement data obtained could be integrated into continual improvement processes.
- ✈ Measurement, analysis and improvement of services and processes dictated the establishment of priorities.
- ✈ Benchmarking could be utilised (internally and externally) to improve efficiency.
- ✈ Levels of communication improved.
- ✈ Self-assessment, through internal audit processes associated with the application of the safety assessment model could be utilized to monitor performance and identify opportunities for performance improvement.

The application of the safety assessment model within the audit process having revealed the need for enhanced quality management initiated the integrated, mathematically orientated, standardised model concept. It was immediately apparent that a successful outcome was dependent on the model being created from intricately merged aviation and ISO 9001:2000 content structures.

The integration of the model into existing external audit processes, realizing the planned objectives of indexing and assessing, exposed failings within the most critical functions of Air Operating Companies. Initially attempts to provide the most appropriate corrective and preventative actions were only partially successful in terms of an interim solution.

Further research revealed that ideal solutions are multi-faceted and require tremendous energy to implement. It was realized that supplemental processes would facilitate successful outcomes. Some of the supplemental processes introduced include the use of electronic communication methods to implement, upgrade and monitor the safety / quality management systems described. This remotely monitored oversight function can be network or internet based and has the advantage of raising safety awareness within the company safety management structures to levels previously unachievable through conventional in-house monitoring means.

**Acknowledgments**

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