

Learning from incidents in aircraft maintenance and continuing airworthiness: regulation, practice and gaps

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Abstract

Purpose – The ability to learn from previous events in support of preventing future similar events is a valuable attribute of aviation safety systems. A primary constituent of this mechanism is the reporting of incidents and its importance in support of developing learning material. Many regulatory requirements clearly define a structure for the use of learning material through organisational and procedural continuation training programmes. This paper aims to review aviation regulation and practice, highlighting the importance of learning as a key tenet of safety performance.

Design/methodology/approach – Applicable International Civil Aviation Organisation requirements and the European Union (EU) regulation in aircraft maintenance and continuing airworthiness management have been critically reviewed through content analysis.

Findings – This review has identified gaps in the European implementing rules that could be addressed in the future to support a more effective approach to the delivery of lessons in the aircraft maintenance and continuing airworthiness management sector. These include light-touch of learning and guidance requirements, lack of methodologies for the augmentation of safety culture assessment, absence of competence requirements for human factors trainers and lack of guidance on standardised root-cause analyses.

Practical implications – This paper offers aviation safety practitioners working within the European Aviation Safety Agency regulatory regime an insight into important matters affecting the ability to learn from incidents.

Originality/value – This paper evaluates critically and independently the regulation and practice that can affect the ability of EU regulated aircraft maintenance and continuing airworthiness management organisations to learn from incidents. The outputs from this research present a fresh and independent view of organisational practices that, if left unchecked, are capable of impeding the incident learning process.

Keywords Airworthiness, Aircraft, Accident investigation, Aircraft maintenance, Aviation safety

Paper type General review

Introduction

Throughout aviation history, learning from incidents has been considered to be one means of augmenting what Perrow (1999) terms “safety devices”. “Experience is the best teacher” according to Kleiner and Roth (1997) as they claim that the causes of the mistakes are often not fully accounted for and continue to be present in the absence of learning. In general terms, Nonaka (1991) suggests that creating new knowledge extends past a mechanistic approach and is strongly related to employees’ insights. An effective enabler of learning in this area is the collation of information on incidents. Details of the related processes, environment, procedures, competencies and implementing timely corrective actions all have a positive impact on learning and are generally intended to help prevent recurrence in the future.

Learning from incidents is mainly associated with post-incident learning. When we think of the word “incident”, it

conjugates up the notion of an action that may have grave consequences. Similarly, the word “accident” is often used in the context of an unplanned event or set of circumstances. In many industrial sectors and business domains, these descriptors are used with a degree of interchangeability when the words are applied to describe events. In aviation, there are clear high-level definitions for both event categories and these are based on the potential for harm. The International Civil Aviation Organisation (ICAO) defines (ICAO, 2010):

1 Accident, as “an occurrence associated with the operation of a plane that takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which:

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- A person is fatally or seriously injured.
- The aircraft sustains damage or structural failure.
- The aircraft is missing or is completely inaccessible”.

2 Incident, as “an occurrence, other than an accident, associated with the operation of an aircraft that affects or could affect the safety of operation”.

However, the presence of international legal obligations for maintaining safe aviation systems are intended to support individual state responsibilities when developing statutory safety requirements. In Europe, international standards and recommended practices (SARP) are transposed into national/European law, forming the basis of state oversight and operator obligations. Aviation regulations and the laws they are derived from are intended to establish standards and enable a benchmark for safe operations. Apart from setting out to support acceptable levels of safety within aviation segments, some references to learning are contained within the implementing regulatory framework.

This paper reviews the evolution of aviation regulation, with a focus on the aircraft maintenance and continuing airworthiness sector, examining the way in which regulations mandate learning from incidents. It also discusses how lessons are translated into best practice and what aspects of regulatory oversight affect the sector. The present work, using a systematic content analysis approach, offers a new and independent view on important matters that may have a negative impact on the incident learning process.

Material and methods

The paper features the concept of learning from incidents as grounded in enabling legislation. Within this area, operational activity capabilities are determined by very specific regulations and recommended practice. The static architecture of these domain requirements considered in the analysis thereby sets out the parameters of the documents qualifying for review.

To perform an efficient and effective review, a structured approach was required. Okoli and Schabram (2010) state that “a dedicated methodological approach is necessary in any kind of literature review”. In the editorial section of Weber (1990), the editor proffers, “content analysis classifies textual material, reducing it to more relevant manageable lots of data”. However, the author (Weber, 1990) later reveals the presence of an inherent issue with the method by suggesting that words, phrases or other units of text are assumed to have a similar meaning when classified in the same category. The issue being that such a distillation resulting from category-based reduction could semantically limit the inference arising from the analysis. As the primary function of aviation legislation is to support the achievement of acceptable levels of safety, it was established this constraint would not negatively impact the scope of the review.

At an international rule-making level, ICAO develops aviation safety, security and environmental protection requirements. The organisation also moderates SARP relating to the technical aspects of aviation, which form the basis of ICAO state signatory primary aviation legislation e.g. Chicago Convention (ICAO, 1944), Annex 19 (ICAO, 2013a). Additionally, as the paper relates to a European jurisdiction, it is also necessary to consider the requirements underpinning aircraft maintenance and continuing airworthiness management. Basic regulations such as European Union (EU)

Regulation 2018/1139 (EU, 2018), implementing EU Regulation 1321/2014 (EU, 2014b) were essential inclusions when analysing activity in the sector.

Inclusion/exclusion criteria

Stansfield and Thomas (2012) suggest a need to develop inclusion/exclusion criteria to support a thorough documentary review. Having a set of criteria helps to eliminate potential researcher bias during the review process. Inclusion and exclusion criteria were developed in concert with the objectives presented below and guidelines contained in Meline (2006):

- To review salient underpinning international aviation safety management requirements for the domain specific area.
- To review the appropriate European aircraft maintenance and continuing airworthiness safety management requirements.
- To identify regulatory gaps and potential enhancements capable of improving learning from incidents.

The inclusion and exclusion criteria used in this study are presented in Table 1.

Document review

Bowen (2009) relates the analysis of documents to giving voice and meaning around a topic under assessment. The subject documents supporting the review were selected as those mandated by the enabling requirements for the aviation domain activities. The review process took advantage of the following steps:

- Assemble the texts under review.
- Verify their applicability.
- Consider the presence of reviewer bias and mitigate.
- Ensure the process is supported by adequate domain knowledge.
- Consider any ethical issues that arise.
- Document the outcome of the review of each individual requirement with the scope of the analysis.

The following section presents the output from this process.

The regulatory framework

International civil aviation organisation

The ICAO member states and additional groups are involved in the rulemaking process. These stakeholders work together to reach a consensus in support of efficient, effective and sustainable aviation regulation. The related practices and policies are applied by member states within the parameters of their incumbent legal frameworks. Each member state in cooperation with its civil aviation authority transposes the requirements into national implementing regulations. For example, Ireland’s Air Navigation and Transport Act (1946) and subsequent amendments transposed the Chicago Convention (ICAO, 1944) elements into Irish law, comprising of Acts, Orders and Statutory Instruments. The regularising of a standard approach to aviation regulation in Ireland, which the Act enabled was an antecedent to the current body, the Irish Aviation Authority, which today discharges the State’s aviation oversight responsibilities in Ireland.

Table 1 Inclusion and exclusion criteria

Included	Excluded
ICAO Chicago Convention (ICAO, 1944)	Non-legislative domain publications relating to aircraft maintenance and continuing airworthiness management
ICAO Annex 13 (ICAO, 2010)	
ICAO Annex 19 (ICAO, 2013a)	
ICAO DOC 9859 (ICAO, 2013b)	
EU Regulation 2018/1139 (EU, 2018)	
EU Regulation 376/2014 (EU, 2014a)	
EU Regulation 1321/2014 (EU, 2014b)	
EU Regulation 996/2010 (EU, 2010)	

International civil aviation organisation Chicago convention – the basis for formalising structured aviation regulation

The work initiated by the Chicago Convention signatories (ICAO, 1944) was monumental in terms of the foundations it laid for regulations supporting a common global air transport system. The Convention enabled the establishment of ICAO, which has worked since its inception to support, foster and manage the international cooperation necessary to augment safe air transport. Its main remit is to “secure international cooperation and the highest possible degree of uniformity in regulations and standards, procedures and organisation regarding civil aviation matters” (ICAO, 1944). This has contributed to aviation continuously pursuing levels of safety that made it one of the safest forms of transport.

The Convention is supported by 19 annexes that contain SARP's. The SARP's provide guidelines for all activities that relate to air operations, licensing, navigation, aircraft maintenance and safety management. While the Convention does not contain any technical requirements for learning from unwelcome events/incidents, Annex 13 (ICAO, 2010) (aircraft accident and incident investigation) and Annex 19 (ICAO, 2013a) (safety management) provide a framework to harvest information that can be applied to learning initiatives and prevent similar events.

International civil aviation organisation convention annex 13 – aircraft accident and incident investigation

ICAO Annex 13 (ICAO, 2010) assists states with the application of a consistent approach to investigations. The sole purpose of conducting an ICAO Annex 13 investigation is to use the outcome to prevent accidents and incidents through applying lessons learned and not apportion blame or liability. Causation and contributing factors must be established for aircraft accidents and serious incidents so that every effort can be applied to prevent recurrence. The establishment of causal factors is most efficacious when a standardised approach is applied for accident prevention.

The ICAO Annex 13 defines the responsibilities, obligations and entitlements of affected parties when safety events are investigated. It also contains a requirement to produce a final report that may contain safety recommendations. In effect, the state receiving a safety recommendation is obliged to implement procedures to monitor the progress of tasks required to address the issue. From an accident prevention perspective, states are obliged to establish and maintain an accident and incident database. This database is intended to facilitate the

analysis of event information and assist in revealing safety deficiencies. These outputs assist states to promulgate lessons to be learned in support of accident and incident prevention. In addition to the accident prevention capabilities of the ICAO Annex 13, further provisions for the collection, analysis and prompt exchange of safety information are contained in the ICAO Annex 19 Safety Management (ICAO, 2013a) and the ICAO Document 9859 Safety Management Manual (ICAO, 2013b).

International civil aviation organisation convention annex 19 – safety management

As the aviation industry's interactions and complexity continue to increase, safety management practices are evolving so that risk can be managed more strategically. Safety risks can be best addressed if managed proactively through adequate regulatory infrastructure and appropriate enabling elements. In 2010, ICAO recommended the development of a dedicated Annex to define state safety management responsibilities. This was achieved by consolidating safety management detail from six other Annexes into Annex 19. Each state's safety management responsibilities are represented in the form of pillars comprising of the following: a state safety programme (SSP), objectives and resources, risk management, safety assurance and promotion. The ICAO Annex 19 lays out detail to ensure the continued availability of safety data and information required to augment safety management (ICAO, 2013a). This standard requires states to establish a safety data collection system capable of capturing, storing, aggregating and analysing safety data. The purpose of collectively analysing safety data is to identify systemic hazards that may not be revealed through the lens of an individual entity analysis. ICAO Annex 19 also requires states to accord protection to data derived from reporting. A high degree of protection is considered necessary to foster an active reporting environment, in turn, supported by a just culture. Additionally, states are encouraged to take steps to promote a positive safety culture and encourage reporting. ICAO Annex 19 makes provisions to share safety information across states when mutual safety matters of interest are identified.

International civil aviation organisation document 9859 – safety management manual

The ICAO Document 9859 (safety management manual) provides guidance on the development and implementation of an SSP and it is applied in conjunction with ICAO Annex 19 (ICAO, 2013b). The manual's structure reaffirms the basics of

the effective application of safety management. SSPs and safety management systems (SMS) are considered in relation to their interaction with other annexes. A philosophy for implementing SMS by the aviation industry and a progressive approach for states implementing and maintaining SSP's is described. The productive role that ICAO state civil aviation authorities play in the implementation of SMS for industry is also emphasised.

ICAO Document 9859 (ICAO, 2013b) states, "culture is characterised by the beliefs, values, biases and the resulting behaviours that are shared by members of a society, group or organisation". An understanding of an organisation's cultural components and their importance to safety management is reaffirmed here. Improvements to the safety management process can be achieved when safety is instilled as a value within an organisation (ICAO, 2013b). Learning from incidents is an active output from a positive safety culture. Progressive state and industry stakeholders are actively directed to pursue improvement. ICAO Document 9859 (ICAO, 2013b) encourages stakeholders to leverage safety benefits from remaining vigilant to hazards by using safety data arising from reporting, data analysis and investigations. The document attributes the improvement in the civil aviation safety records to "a continuous learning process based on the development and free exchange of safety information".

One area in the ICAO Document 9859 (ICAO, 2013b) where reporting, analysis of data and learning make an effectual contribution to safety is when entities collectively consider deviations (operational and otherwise) from an organisation's baseline safety performance. The resulting "chasm" is often termed "practical drift" (Snook, 2000). Experience gleaned from reporting informs us that this condition can occur for various reasons, i.e. technology not operating as intended, procedural deviations due to environmental conditions, change and interaction with other systems. The document reaffirms the importance of capturing deviations or drift as early as possible. The predictive value of this information cannot be overstated when early intervention to restore a satisfactory condition can be made without delay. Additionally, the resulting lessons learned can be applied to system, procedural and structural improvements to prevent event recurrence.

European Union regulations

Member states of the EU are obliged to comply with regulatory outputs from the European Aviation Safety Agency (EASA). EASA, amongst other functions, supports the European Commission (EC) in the technical development and compliance oversight of aviation regulations and monitors and approves organisations involved in the maintenance of aviation products, with the desired outcome of safe operations. Moreover, a major aspect of EASA's work is to analyse safety and research data.

European Union regulation 2018/1139 – common rules in civil aviation in the European Union

EU Regulation 2018/1139 (EU, 2018) aims to establish and maintain a high level of safety in the EU aviation. This regulation covers the design, production, maintenance and operation of aircraft and their parts. It also affects aircraft operating in and out of the EU and defines the role of EASA.

Amongst EASA's administrative functions is its responsibility to perform safety oversight of aircraft maintenance and management organisation activities, managing these responsibilities through implementing regulations. Similar to the ICAO requirements, EU Regulations 376/2014 (EU, 2014a) and 1321/2014 (EU, 2014b) facilitate the exchange of safety information amongst EASA and the national civil aviation authorities. Therefore, this regulation enables EASA to moderate a structure that collects, exchanges and analyses safety-related information (EU, 2018). It also mandates that there are provisions ensuring the collected information and data is securely stored and protected. An electronic database is recommended, as an efficacious repository to manage and exchange data in support of preventing recurrence of events.

European Union regulation 376/2014 – reporting, analysis and follow-up of occurrences in civil aviation

The EU, in recognition of its duty of care to the travelling public, acknowledges that it must continue to improve aviation safety performance. Based on the imminent increase in aviation activity, significant challenges loom if the EU is to only preserve current levels of safety. Thus, to remain abreast of the future challenges, the EU is transitioning towards a proactive aviation risk-based safety system (EC, 2015). The desired outcome is that member states and industry will work together to collect data for early identification of hazards and implementation of mitigating actions. This enables focussing oversight efforts where they can be most effective for safety management purposes. The EU Regulation 376/2014 (European Union [EU], 2014a) was developed to enable the collection, analysis and follow up of occurrences for a performance-based safety oversight system. This regulation recognises that "while the ability to learn from an accident is crucial, purely reactive systems have been found to be of limited use in continuing to bring forward improvements" (European Union [EU], 2014a). However, it suggests that these reactive systems should be bolstered by "proactive systems, which use other types of safety information to make effective improvements in aviation safety" (EU, 2014a). This is largely left up to each organisation to develop their own "proactive system" in conjunction with the ICAO Annex 19 on SMS. One collective element addressed by this regulation is the reporting of incidents and accidents.

A main tenet of the reporting system is the ability of an individual to report any hazard or potential hazard in a "free and frank" manner. This element of a safety culture's philosophy is to be supported by "just culture", where the outcome for the individual is not based on punitive measures or being inappropriately punished for reporting or co-operating with occurrence investigations. This regulation has provisions for mandatory and voluntary occurrence reports. There are discriminating conditions that must be met to determine when to report a hazard. Organisations are required to have a process to implement a timely follow-up and notification of their analysis to the aviation authority. Reporting entities are encouraged to submit reports to a portal moderated by EASA. Aviation authorities have access to the portal and the incidents and accidents are categorised in accordance with a standard accident/incident data reporting programme (ADREP) taxonomy and uploaded to a European coordination for

accident and incident reporting systems database. This database assembles (multi-modal) transport safety data.

European Union regulation 996/2010 – investigation and prevention of accidents and incidents in civil aviation

The EU Regulation 996/2010 (EU, 2010) supports safety by enabling efficient and effective investigations. It also requires the provision of certain information to state investigating authorities (SIAs) in a timely manner in relation to all persons and dangerous goods carried on board an accident aircraft. This regulation applies to the investigation of accidents and serious incidents as specified in the ICAO Annex 13 (ICAO, 2010). The following are some of the accidents and incidents where this regulation applies (EU, 2010):

- Accidents occurring in EU member states.
- Accidents occurring outside of EU member states but involving an EU registered aircraft or being operated by an EU operator, where EU member states are entitled to appoint an accredited representative or have a special interest, such as where EU citizens are involved in an accident or serious incident.

This regulation stipulates that SIAs are independent from oversight or other state safety aviation roles, such as aviation authorities. SIAs must be functionally independent and capable of conducting a full safety investigation while being adequately resourced.

Effectively, SIAs investigate accidents and serious incidents so that lessons can be learned, and recommendations can be made to help prevent the occurrence of similar events. SIA's release several different publications that contain this information. These reports fall into the following categories, namely, interim and final reports, accident and serious incident reports, safety bulletins and foreign accident reports. For example, under Irish law, investigations enabled by EU Regulation 996/2010 and ICAO Annex 13 are required to be independent of judicial proceedings and are in no way intended to apportion blame or liability (Air Navigation Regulation, 2009).

European Union regulation 1321/2014 – continuing airworthiness and approval of organisations and personnel

The EU Regulation 1321/2014 (EU, 2014b) specifies the compliance requirements necessary for persons and organisations involved in continuing airworthiness activities. The regulation comprises of specific requirements for:

- Maintenance organisations (Part 145).
- Continuing airworthiness management organisations (CAMOs) (Part M).
- Maintenance personnel (Part 66).
- Maintenance training organisations (Part 147).

Collectively addressing these requirements theoretically means the associated processes supporting airworthiness ensure an aircraft is fit for safe flight.

Organisations operating under EU regulations must formally engage a CAMO to support the maintenance management function. The purpose of CAMO is to ensure that all mandatory requirements are addressed, and the aircraft continues to be maintained in an airworthy condition. The

CAMO manages and forecasts maintenance and through formalised agreements, ensures the necessary maintenance inputs are performed by an aircraft maintenance organisation (AMO), on time and to the correct standard.

Aircraft maintenance and continuing airworthiness activities are affected by regulations mandating the reporting of issues that could affect safety. These mandatory occurrence reporting responsibilities also extend to individuals who hold privileges within organisations, under this regulation (EU, 2014b). The individual requirements that enable the EASA Part 145 and Part M code activities require the reporting obligations and responsibilities to be stated in procedural form in the companies' expositions. This is to support the organisation's mandatory occurrence reporting system, which collects, analyses and evaluates reports. The organisation must identify adverse trends and implement timely corrective actions. Both EASA Part 145 and Part M requirements encourage the distribution of internal occurrence reporting outputs to staff. Learning material is used to raise awareness of reported issues, and therefore, assist with preventing a recurrence of the event or similar events.

The importance of occurrence reporting cannot be overstated when attempting to identify contributing factors and the potential emergent lessons. This regulation recognises the positive impact a functional just culture has as it encourages "free and frank" reporting. Reporting is further augmented when staff are aware that those who report will not be inappropriately punished for doing so or for co-operating with ensuing investigations. This psychological contract is further reinforced by the presence of a closed-loop process that requires the reporter to receive feedback on their report.

Figure 1 offers an illustration of the overall ICAO and EU regulatory landscape described in the previous section, where the interactions and relations of the requirements and regulations are shown.

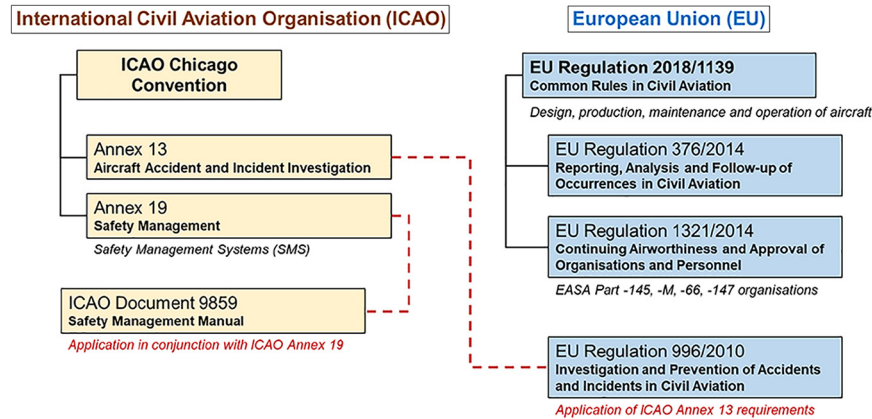
Implementation of regulations

Framework and compliance

The EU Regulations 376/2014 (EU, 2014a) and 1321/2014 (EU, 2014b) require the operation of a SSP, similarly to ICAO Annex 19 requirements (ICAO 2013b). The aim of SSP is to proactively discover and manage factors that may contribute to incidents and accidents and to fortify the maintenance and operational systems against errors. For AMOs (EASA Part 145) and CAMOs (EASA Part M), the associated responsibilities must be reflected within procedural form for each code. Details of these procedures are prescribed in the EU Regulation 1321/2014 (EU, 2014b). This detail covers basic training and competence requirements for staff and managers, reporting requirements, initial and recurring human factors (HF) and training in procedures for managing reporting systems.

When organisations apply to civil aviation authorities for the privileges that relate to aircraft maintenance and continuing airworthiness management, compliance audits are performed by the authorities to ensure the applicant can perform the necessary tasks. Each approval has a two-year cycle and authorities must perform continuous oversight to ensure that organisations remain in compliance. Each EASA Part 145 and

Figure 1 The ICAO and EU regulatory framework surrounding safety management; focussed on aircraft maintenance and continuing airworthiness management



Part M organisation must perform annually a complete programme of internal audits by their independent quality assurance system. Aviation authorities and regulated organisations apply the regulatory detail in a similar manner when measuring compliance with each code. For both maintenance and continuing airworthiness management reporting, the occurrence reporting system and responsibilities are a subset of the overall audit programme.

Reporting

Lessons from events and incidents are derived from several sources within the aviation system. ICAO Annex 13 accidents and serious incidents are supported with the publication of thorough and independent non-biased reports. Often based on causal or contributing factors, safety recommendations may feature elements that affect the maintenance or management function or both. Depending on who the investigating authority directs the safety recommendation to, affects how the lesson is promulgated to industry stakeholders.

Internal and external reports

Internal company occurrence reporting systems that underpin the identification of issues relating to flight safety or the release of a safe product are valuable sources of data for learning within EASA Part 145 and Part M organisations. According to the EU Regulation 1321/2014, organisations are required to have a system to collect, analyse, develop interventions as required and promulgate lessons to prevent reoccurrences. When organisations deliver initial and continuation HF training they must feature a cross-section of lessons arising from internal occurrence reporting and operating experience. Organisations also have to look outside their own specific areas and introduce lessons from other areas of the industry.

Occasionally, incidents that arise through internal occurrence (voluntary and mandatory) reporting are required to be reported to external bodies such as aviation authorities, aircraft manufacturers or SIAs. These entities will review the incident and decide if further information or intervention is required to terminate their request. All incidents reported to aviation authorities are collated and published on an annual basis. These reports are made available and operators, approval

holders and individuals are encouraged to review and assimilate, as necessary. These reports are often used in support of EU Regulation 1321/2014 (EU, 2014b) continuation training syllabi. Moreover, in a case where it is found that aviation regulation was a contributing factor to an event, a safety recommendation may be directed to EASA. If accepted by the recipient, it can be a catalyst for regulatory amendment. The amended regulation is then brought to the attention of staff through an internal training mechanism mandated by EU 1321/2014 (EU, 2014b). In the case of accidents and serious incidents arising from factors relating to aircraft design or maintenance error, lessons may be learned through the conduit of mandatory communications, the Airworthiness Directives (ADs). ADs require immediate recognition and recipients are legally obligated to comply within defined timeframes.

Databases and reporting standards

Databases containing details of events with known potential and latent ancillary contributors can be monitored with the assistance of continuous analysis. For example, in the United States (US), a combined effort by various industry stakeholders, known as the aviation safety reporting system (ASRS), collects voluntary reports. The outputs from ASRS set out to identify system deficiencies and corresponds directly with individuals in positions that can affect improvements and corrective actions. These reports are often of interest to organisations operating aviation products that have originated in the US.

SARP that define an ICAO state obligations have been developed as a result of the collective efforts of participating states, i.e. ICAO Annex 13 (ICAO, 2010) defines the standards requiring the reporting of accidents involving aircraft with a maximum take-off weight (MTOW) of 2,250 kg and above. The same document contains details of reportable incidents deemed important for accident prevention for 5,700 kg MTOW aircraft. An accident/incident data reporting system (ADREP) is operated and managed by ICAO, with safety data from the member states received, verified and retained in ADREP. This global repository reflects the aggregate of state-reported occurrences/incidents/accidents. The following outputs are available from ADREP:

- Annual statistical presentation of broad categories of information broken into headings, such as event types and operational phases.
- Report summaries delivered on a bimonthly basis illustrating a global view of “significant” reported events.
- Feedback to ICAO states in response to requests for ADREP information.

The ICAO Accident/Incident Reporting Manual (ICAO, 2014) defines the report content, its composition and means of transmittal to ICAO. A taxonomy is used to standardise the inputs for reporting. One of the difficulties faced by the ADREP system administration is that some of the state reporting systems do not strictly apply this taxonomy. However, to improve harmonisation and exchange of information, regulated entities affected by EU Regulation 2018/1139, have already migrated to the ICAO common ADREP taxonomy. The ADREP software platform currently in use by ICAO was developed by the EC and was made available for implementation in the middle of the 2010s. While some ICAO states process reports manually, the basic software is available free of charge and it is expected most national reporting systems will be capable of transferring data by electronic means. The outputs from the ADREP system are useful for HF training programmes and offer a solid data set to compare national against global event rates.

Results and discussion

Regulations empower aviation authorities to affect a certain degree of oversight to reporting and learning systems. However, in aircraft maintenance and continuing airworthiness, there are a few areas where legislation does not support learning from incidents within organisations. Without a standardised approach to learning from incidents, it is questionable if the benefits can be fully realised from current efforts. Organisational and regulatory oversight does not have the mandated scope to decipher if the incident learning content of HF training is being delivered effectively. Oversight and quality assurance audits merely verify that a company is delivering HF training and because the regulations do not articulate the need to go any further, and the quality and impact of the training material are left to the organisation. This issue is often compounded by the struggle for compliance, specifically “minimum compliance”, which many organisations demonstrate and could be considered a by-product of regulatory gaps.

The following subsections present and discuss the results from the review of the EU codes for aircraft maintenance and continuing airworthiness management.

Light-touch learning and guidance requirements

Safety requirements are scoped to support the achievement of an acceptable level of aviation safety. At the same time, affected industry segments will often lobby rule makers in an attempt to decrease the effect of an impending regulation. Therefore, the larger industry segments have a strong degree of influence over the final drafts of regulatory requirements. These are common challenges for the EC in the relation to rulemaking. In the case of EU 1321/2014 (EU, 2014b) and EU 2018/1139 (EU,

2018), these must be generic enough to support the industry segments but also satisfy stakeholders other than aviation regulatory entities. The aviation industry is continuing to demand more efficiency, sometimes under the veil of corporate social responsibility but often without additional tangible safety outcomes.

The expanding regulatory oversight burden that comes with an increase in aviation activity is not sustainable if the paradigm of light-touch learning and guidance requirements continues to prevail. The EU “aviation strategy” (EU, 2015) commits to a shift from the current regulatory model to a risk-based oversight system. This will direct resources at areas of risk in the industry. Effectively, this should lessen financial outlay for member states while it will preserve and further develop acceptable levels of safety if supporting regulatory frameworks evolve. Regardless, implementing rules must be amended to address a means of defining a simple life-cycle approach to learning from incidents and how learning can be measured and improved where necessary.

Absence of minimum competence requirement for human factor trainers

The review of EU 1321/2014 (EU, 2014b) highlights the absence of competence and qualification requirements for staff delivering HF initial and recurrent training. Additionally, there is no defined or accepted practice specified for assessing the depth of student learning or the assimilation of learning outcomes. HF training feedback is required to be used by the custodians of the training programmes. The intent is that the information received from students will strengthen future training programmes. In the programmes developed and delivered, the learner’s ability and style are not required to be considered. Redeveloping and expanding guidance on regulatory feedback is one mechanism capable to support an improved design template that could be used in support of learning from incidents. Even though compliance with HF training syllabi requirements are verified, the current requirements do not extend far enough to support the need for increased measurable learning effectiveness to underpin risk-based oversight. If the current regulatory requirements for the delivery of lessons learned are not redrafted to reflect a standard for the preparation of initial and recurrent HF training, assessment and competence requirements for trainers, the improvements anticipated from the risk-based methodologies shall not materialise in full.

Methodologies to augment assessment of safety culture

Regulations require staff to receive continuation training at least every two years. The advent of EU requirements has stood the industry in good stead and has contributed greatly to achieving acceptable levels of safe operations. To achieve the maximum impact from training (especially material featuring lessons learned), it would assist to periodically assess the prevailing cultural conditions within an organisation. Currently, there is no regulatory requirement that supports such an assessment. The EU Regulation 2018/1139 (European Union [EU], 2018) refers to the “promotion of a culture of

safety” as it relates to reporting of incidents. The term “just-culture” is also referred to in EU Regulation 1321/2014 (EU, 2014b). However, the absence of any guidelines on how to establish the strength of a just culture or details of how to assess its presence are duly absent from the requirements. An embedded regulatory approach applying an ethnographic methodology in support of safety culture assessment could qualitatively verify the effectiveness of HF training in addition to formally gauging an organisation’s culture. This would need to examine issues around communication and trust within AMOs, as both HF are important for the establishment and sustainment of a healthy safety culture within organisations (Chatzi *et al.*, 2019; Chatzi, 2019).

Lack of guidance on a standard approach to root-cause analysis

Many regulations support the notion that more reporting is necessary. Reporting can be impeded for many reasons, such as cultural, environmental and production pressures. There are pros and cons associated with increased reporting, if, however, the root causes are not correctly established, any additional effort by individuals may be futile. In cases where root cause analysis is inadequate, there is often a missed opportunity for learning. The EU Regulation 1321/2014 (EU, 2014b) does not stipulate guidance for an acceptable model to augment or propagate this element of learning.

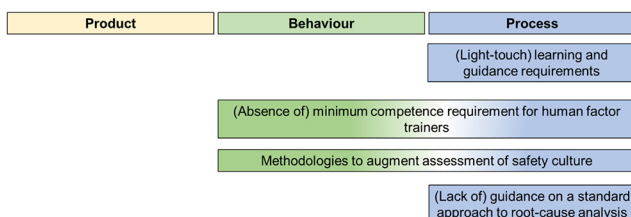
It is interesting to map these four findings against the product-behaviour-process (PBP) model (Purton *et al.*, 2014), examining specifically looking at the regulatory interventions. The output of this exercise is illustrated in Figure 2. The first observation is that the product segment of the PBP model, namely, any changes on the design and certification of aircraft and products, would not be affected. However, the behaviour and process segments are indeed segments where regulatory changes would be introduced. Greater emphasis is on behaviour aspects, as the two of the four findings are of mixed nature (related to both behaviour and process).

Conclusions

The review of aviation safety regulations has revealed the following:

- A solid architecture of regulatory requirements is used by states to base their aviation regulatory frameworks.
- States have developed regulations, standards and practices in support of a common approach to aviation safety oversight. These enable organisations to develop a

Figure 2 Mapping of the findings against the PBP model (Purton *et al.*, 2014) in relation to regulatory interventions



procedural approach to regulatory compliance in concert with safe operations.

- Regulatory stakeholders are aware of the tasks to be pursued so that current levels of safety are sustained and improved.
- Using safety intelligence derived from an efficient occurrence reporting system is an efficacious means of proactively identifying latent hazards and risks in potentially under-performing areas. A mechanism to be applied in Europe in support of achieving satisfactory safety levels is performance-based oversight, allowing better safety oversight upon aviation segments not performing well.
- Regulations encourage the proactive use of information in respect of lessons available from various sources. In addition to published accident and incident reports, internal data from reporting support mandatory continuation training for staff within AMOs and CAMOs.
- Examination of the primary enabling legislative requirements highlights underperforming areas within the enabling regulatory content. This could be used as input to EASA regulatory rule-making development groups tasked with the improvement of EU Regulation 1321/2014 learning capability.

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