Reporting Error in Aircraft Maintenance: are engineers reporting safety concerns?

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Kirsty Twyman

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Abstract

Aviation accidents seldom occur as the consequence of an isolated incident, but as the result of a series of contributing factors. The industry has focussed on detecting and predicting these casual factors to support accident prevention. However, the complexity of aircraft maintenance errors makes them somewhat harder to capture. One method adopted to support error identification is error-reporting systems.

The primary aim of study was to identify if reporting systems were being utilised by maintenance personnel. The secondary aim was to distinguish the factors that contribute to maintenance personnel rejecting reporting systems as a supportive tool. This was achieved through an online questionnaire. Due to a lack of research on error reporting and usability of reporting systems by aircraft maintenance personnel it proved difficult to use an existing survey, so survey questions were developed from an extensive literature review and a focus group made up of front-line personnel. Survey questions focussed on reporting system design, company attitude, error recognition and finally maintenance personnel personality patterns.

Results showed several issues affected reporting system usage including lack of company support, inadequate training, and lack of feedback. Perhaps the most significant discovery were engineers believing that they would report error, but were inadequately able to recognise error. Although regulatory authorities and organisations themselves are seeing the benefits of a positive reporting culture the current study showed there are still significant issues with current reporting systems, without these inhibiting factors being addressed the industry cannot solely rely on self-reporting to manage error.

Acknowledgements

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Table of Contents

Tables

Figures

Abbreviations

AMC	Acceptable Means of Compliance
AME	Aircraft Maintenance Engineer
AMM	Aircraft Maintenance Manual
ATSB	Australian Transport Safety Bureau
BFI	Big Five Inventory
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CAR	Civil Aviation Rule
CASA	Civil Aviation Safety Authority
CFR	Code of Federal Regulations
EASA	European Aviation Safety Agency
ED	European Decision
EU	European Union
EUROCONTROL	European Organisation for the Safety of Air Navigation
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organisation
LAME	Licensed Aircraft Maintenance Engineer
MBN	Maintenance Briefing Note
MRO	Maintenance and repair Organisation
NAA	National Aviation Authority
NTSB	National Transport Safety Bureau
NZ	New Zealand
SMM	Safety Management Manual
TSB	Transport Safety Board

Chapter One: Introduction

1.1 Reporting in Aviation

The aviation industry is trying to break away from the philosophy that safety is only achievable by the complete elimination of technical breakdowns and human errors (Amalberti, 2001). Past research (Hobbs, 2003; Fogarty, 2004; Hampson, Junor & Gregson, 2010) highlighted that an error free system was an impossible objective, since to err is human and the human element is difficult to predict or control. Human interaction in a highly technological advanced field always leaves room for error (Pidgeon & O'Leary, 1997). In the past the industry has endeavoured to design technology to counteract human error, but all this seem to achieve was to introduce a new set of safety concerns. For example, flight deck automation was designed so that irrespective of a pilot exceeding a certain parameter in the flight envelope the aircraft would protect and compensate, but this did not eliminate error on the flight deck; it just created a new set of safety concerns due to poor crew understanding of how the system worked (Amalberti, 2001). Aircraft design has evolved in an to attempt to create an error resistant environment, but it was an impossible goal to achieve; total elimination of error is impracticable, and now the industry experts and regulatory authorities are looking at methods to manage error rather than total eradication in order to achieve and maintain high standards of safety. Similarly, aircraft have evolved by building in error tolerant defences into the system; for example redundancy of systems and greater reliability monitoring programs, so that a system may remain functional even after a maintenance error (Amalberti, 2001).

It has taken a long time for it to be realised that human performance in maintenance has had a significant effect on safety in aviation. Fogarty (2004) noted that although it was recognised aircraft maintenance had a significant impact on industry safety and accident causation, past research into the nature of maintenance work and related human factors had been negligible. This realisation has brought greater focus to the maintenance environment in the hope of understanding and reducing maintenance error; however, a successful safety system requires the support and participation from engineers to sustain positive change.

Taylor (2000) reported that 39% of wide body aircraft accidents began with a problem in aircraft systems and maintenance, and although pilot error is often cited as the main cause of aviation accidents, pilot induced error came far later in the sequence of events, usually after something technical went wrong with the aircraft. Bringing the maintenance environment into focus and its contribution to accident causation has meant regulatory authorities have had to expand their efforts to incorporate maintenance safety into their policies and procedures (ICAO Safety Management Manual (SMM), 2013). This comprehension has commanded greater focus on the maintenance environment and introduced clearer regulations and guidelines from the authorities with the intention of reducing maintenance error.

In order to manage error the danger areas must first be identified. This can only be fully achieved with the support of front-line staff and their willingness to highlight the deficiencies in the system. However, insufficiencies are not all system related and can be human created; in this case the expectation is for front-line staff to self-report errors they may have been part of. Additionally, it is required that front-line staff go one step further and report colleagues, as often errors in maintenance are discovered during performing a different job after another person created the fault (Dekker, 2009; Gilbey, Tani & Tsui, 2015).

The industry provides many ways to self-report, several of which are discussed in Chapter 4, however an effective reporting system requires participation, and although there is a great deal written about their success, there is no solid evidence of how many reports are made compared to errors discovered. Patankar & Ma (2006) questioned how a reporting system could be considered as successful without knowing the extent to which safety concerns go unreported. A lack of evidence on how many safety lapses go unnoticed or unreported hinders the reporting system being deemed as effective. Patankar & Ma (2006) suggested that it should be the success of change that is assessed rather than the number of reports made to evaluate if a reporting system is functioning effectively.

One of the oldest founded reporting systems is the ASRS program. NASA reported that the success of ASRS program was apparent from the steady increase of reports made over the program's 37 years of operation (ASRS Program Briefing, 2013). Figure 1 is taken from the ASRS Program Briefing (2013) and shows the distribution of reports made over a 10-year period, with an estimated 80000 reports made in 2013. Figure 2 provides details on the top 20 events reported between 2008-2012.

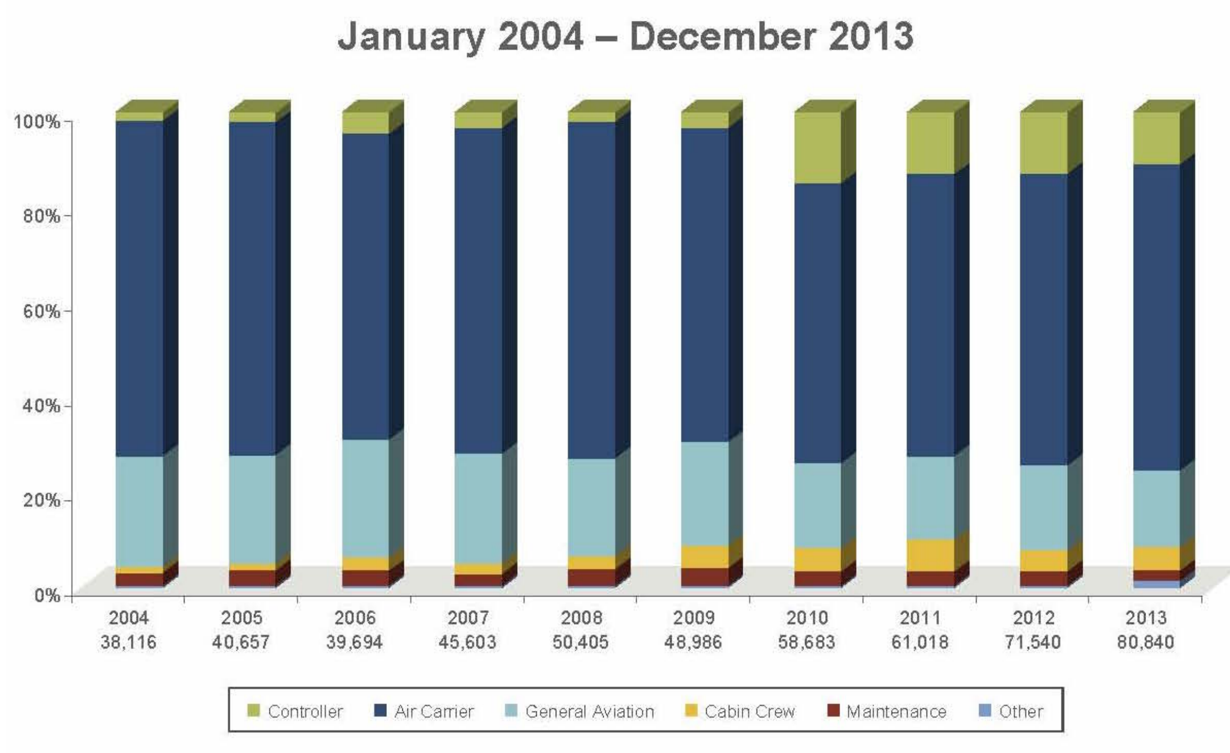

Figure 1: Percentage of Reports Total Intake (ASRS Program Briefing 2013)

A comparison of figure 1 and 2 shows that, whilst maintenance events are listed in several categories in the top 20 of most reported events, the maintenance department are the least likely to report an error when compared to other departments in aviation. At first glance this may indicate that if maintenance personnel were to report more frequently, maintenance events may significantly increase. However, as stated in the ASRS program briefing (2013), although reports were submitted by pilots or ground operations if they were assessed as being maintenance related they were included in this category, which brings us back to assuming that maintenance personnel may not be readily reporting their mishaps: these errors are often captured in the investigation of reports made by other operational departments and classified as maintenance error.

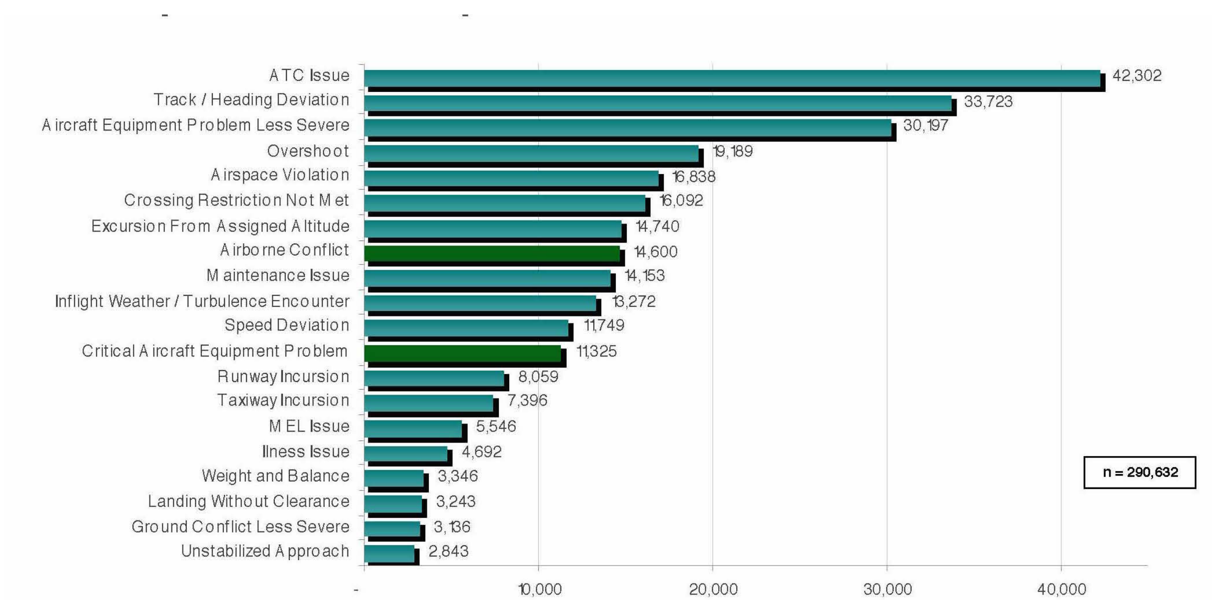

Figure 2: Top 20 Events Reported 2008-2012 (ASRS Program Briefing 2012)

1.2 The Current Study

Error reporting in aircraft maintenance is a topic that seems to be overlooked in aviation safety research. Perhaps it is believed there is no real concern with reporting system usage in aircraft maintenance, as indicated by the ASRS program briefing reports, there is an abundance of maintenance related reports submitted, but there is a real disquiet as to whether it is maintenance personnel submitting the safety related reports. It should also be of concern that if maintenance personnel are not reporting error, what are the underlying reasons for this?

The primary aim of this thesis was to explore the extent to which maintenance personnel self-report errors. The secondary aim was to explore the reasons why maintenance personnel may be resistive to reporting. Although there may be many potential reasons why someone chooses not report, from the literature review there were four recurring themes, reporting system design (accessibility, question types, relevance to job role, ease of use, quantity of information to be provided), attitude towards reporting (commitment, support, culture), lack of understanding of what is reportable (error identification) and deficiencies in the process behind (investigation, feedback, disciplinary action). Data was collected for the current study via an online questionnaire; the method chosen for its anonymity qualities in order to prompt participation from maintenance personnel who may not be so forthcoming if data collection was via their current organisation.

It was additionally considered that maintenance personnel reaction and response to neglecting to report error may not be an intentional disregard for safety, but related to the unique set of personal attributes they have been observed to share. McDonald et al., 2000; Thomas & Taylor, 2003; Hobbs, 2004; Hampson, 2010; described similarities LAMEs shared and the unique set of skills needed to work in aircraft maintenance, proposing maintenance personnel may share related personality traits. A short BFI-10 test (an abbreviated version of the BFI-44) was administered as part of the online questionnaire, developed to identify if participants presented any patterns with regards to the big five personality dimensions. Participants' trade, and current level were considered as the most relevant questions to analyse for group differences. Area of aviation, shift pattern, experience and department employed were not related to individual personality qualities, therefore they were not considered for group patterns and the big five personalities.

It was believed to be able to better understand why maintenance personnel may not utilise reporting systems several factors must be first considered including; the maintenance environment, the licensed aircraft maintenance engineer function, reporting regulations, and reporting methods available to personnel. Available aviation safety research did not appear to take into consideration the unique setting of aircraft maintenance or fully understand the role of maintenance personnel.

It was anticipated that by increasing understanding as to why engineers may not report, recommendations could be made to change the current view of self-reporting by front-line maintenance personnel. By considering engineers' views and thoughts on self-reporting the deficiencies in the current system can be better recognised. Understanding the system shortfalls allows for the opportunity to make change to the system and better tailor reporting methods to suit the unique requirements of aircraft maintenance.

Chapter Two: Literature Review

2.1 Error

ICAO SMM (2013) concluded that due to human activities and human built systems the aviation system could not be completely free of operational errors and their consequences. ICAO (2013) went on to emphasise that the industry should shift its efforts from achieving full eradication of error to accepting its inevitability and concentrate on learning to manage it in order to attain an acceptable level of safety within aviation. ICAO Annex I defines error as:

> *an action or inaction by an operational person that leads to deviations from organisational or the operational person's intentions or expectations.*
>
> (ICAO Annex I, 2006).

It has been understood for some time that accidents do not occur because of one action, but instead because of a series of events lining up at that exact moment to create an mishap, incident or finally an accident (Reason, 1997). Dekker (2004) viewed accidents as a drift into failure; a slow, incremental movement of the daily operation towards the edge of their safety envelope driven by pressures of external competition and internal influences that subtly influence the many decisions and trade-offs made daily by front-line personnel and managerial hierarchies. Dekker (2004) also noted the drift into failure is difficult to recognise because it happens in an apparently normal organisation by normal workers doing normal jobs. This means drift into failure can go undetected and many contributing factors can go unnoticed until an incident or accident occurs.

Figure 3 presents a version of Reason's Swiss cheese model illustrating how the organisation and individuals interlace to breach the barriers put in place to prevent accidents. Reason's (1997) research on safety distinguished between active failures (where the consequences of a human error are immediately felt) and a latent error, where the consequences may not be immediately apparent and can remain undetected for a period of time.

Reason (1997) described accident causation as beginning with latent failures, which originate from questionable decisions or incorrect actions. Front-line operators can become exposed to these latent failures, which may come to be uncovered or affect the performance of an unrelated task. A well-guarded system allows for latent and active failures to interact without defences being breached. When the defences remain in place the result would be an incident, however if all defences are breached it becomes an accident.

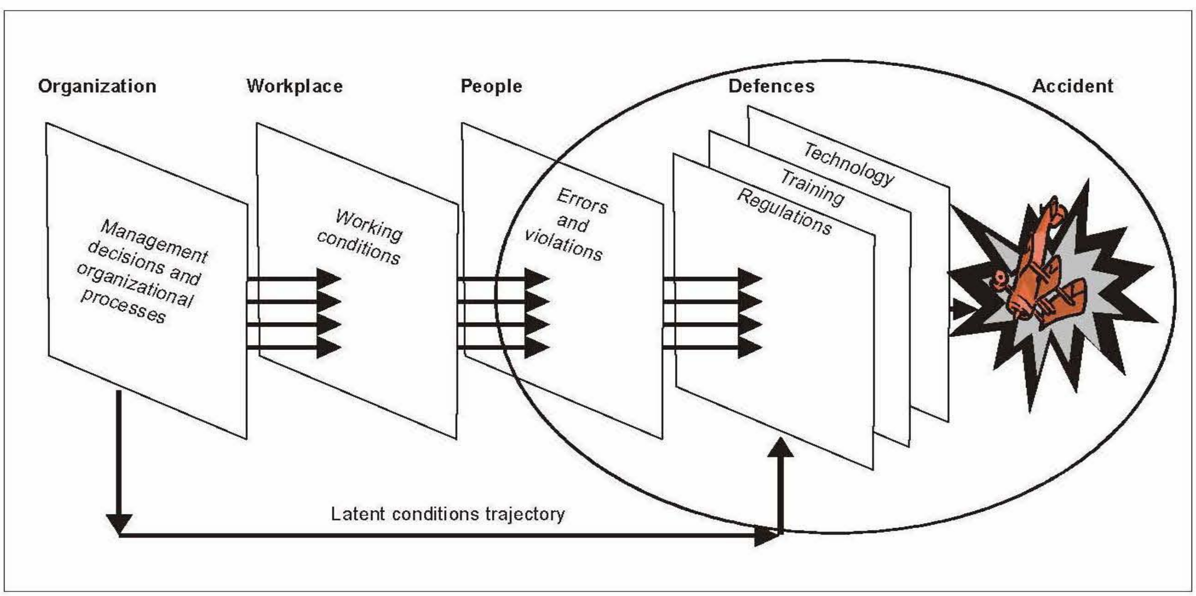

Figure 3: The Concept of Accident Causation (ICAO SMM, 2013)

Despite a greater focus on error and accident causation in maintenance, it remains a difficult task to analyse and understand in order to prevent similar instances. Hobbs & Williamson (2003) suggested one of the reasons for this is that maintenance error can remain latent for significant periods before an accident or incident occurs, making it difficult for investigators and perhaps too late for the industry to learn from in support of preventing reoccurrences.

Other areas of aviation, for example flight operations or ATC, have been known to utilise the self-reporting system to a greater extent than in aircraft maintenance. Dekker (2009) reported this was largely down to the fact that other departments found themselves monitored by external bodies and reports were made by outsiders, suggesting the reporting system does not solely rely on self-reporting. Hobbs & Williamson (2003) went on to highlight, unlike pilots or air traffic controllers, maintenance personnel are not subject to data or voice recording; it can be solely down to self-regulating that an occurrence be reported at the time of it happening. This is also reliant on the maintenance engineer knowing that a reportable occurrence has taken place or that he (or she) has uncovered a latent error which may be classified as reportable. CAP 718 (UK CAA, 2002) highlighted that maintenance self-report programs have not progressed to the sophistication of those within the flight environment, meaning that maintenance error is discussed in terms of aircraft discrepancy rather than specific types of human or organisational error.

Hobbs (2004) discussed the effects concealed errors could have on an individual. Pilots or air traffic controllers could leave their shift at the end of the day knowing that a day's work was complete and any errors that were made during their shift would have an immediate impact or no impact at all; however, for maintenance personnel when they completed a day's work, they knew crew and passengers would rely on their work performed for months or years to come. The emotional burden on maintenance personnel goes largely unrecognised outside the maintenance world, with a lack of understanding the immense pressure and stress Aircraft Maintenance Engineers (AMEs) operate under.

There are many different types of error and not all lead to a catastrophic event. Reason (1997) categorised them as either latent or active and further broke them down into slips, lapses or mistakes. He also highlighted the difference between violations and error. In aircraft maintenance, regulations have made this an important distinction with regards to reporting non-compliances; the law provides protection under a non-punitive program of reporting, but only if the error is perceived as unintentional.

There are several studies emphasising the fact that accidents are not meaningless uncontrollable events (Reason, 1997; Hobbs & Williamson, 2003; McDonald, 2000; Dekker, 2009), but are made up of a combination of contributing factors, and if these factors were highlighted before the error manifests it may be able to prevent an accident. Boeing described a contributing factor as anything that affects how an AME performs the task that may lead to an error or violation. Figure 4 displays types of contributing factors that can be found in aircraft maintenance clearly showing anything that interacts with an AME may influence them in performing their job.

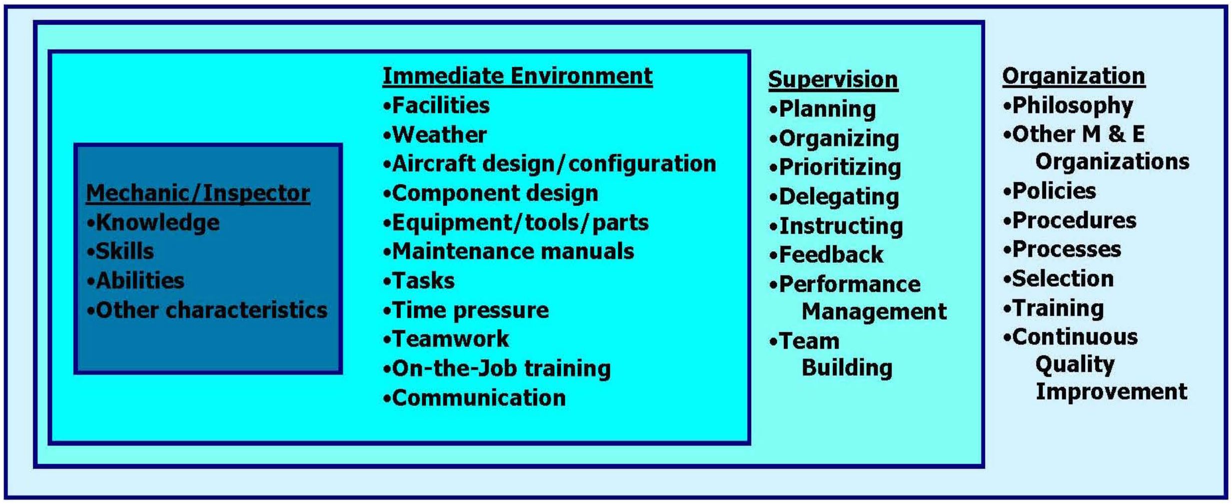

Figure 4: Contributing Factors Model (Etzold & Ma, 2014).

2.2 Violations

ICAO Annex 19 (2013) defined a violation as a deliberate act of wilful misconduct or omission resulting in a deviation from established regulations, company procedures and processes, standard practices or mandated guidance from the industry members. ICAO (2013) went on to state that the difference between errors and violations is the motivational factor. A person trying to do the best possible to accomplish a task, following the rules and procedures as per the training received, but failing to meet the objective of the task at hand, commits an error. A person who, while accomplishing a task, willingly deviates from rules, procedures or training received commits a violation (ICAO SMM, 2013), meaning the basic difference between errors and violation is intent. EASA (2014) confirmed this by stating error is unintentional, whilst a violation is a deliberate act or omission to deviate from established procedures, protocols, norms or practices. Whereas EASAs improved regulations supports a voluntary, confidential and non-punitive reporting system it provides no provisions of protection for persons reporting violations.

McDonald, Corrigan, Daly & Cromie (2000) found that of 286 aircraft mechanics surveyed, 34% acknowledged their most recent task had been performed in a manner that contravened the formal procedures during their normal job performance. By definition this is a violation and if voluntarily reported could be a punishable offence.

Although the regulations do not provide room for interpretation it is realised that violations cannot be so easily categorised nor can they all hold the penalty of punishment. The Global Aviation Safety Network (2004) which was a corporation made up of government, industry and labour aviation professionals, categorised violations increasing in severity to give a better understanding of the gravity of an individual's action. The first category was human error: the individual should have done other than what they did and through their unintentional actions caused (or could have caused) an undesirable outcome. The next category was negligent conduct: behaviour that falls below the standard required by the normal community. An individual fails to use a reasonable level of skill expected of that person in that particular activity, when compared to another person of the same level who would have chosen not to commit the same failure; the failure to recognise a risk that should have been recognised. The third category was reckless conduct: the risk was one that would have been obvious to a reasonable person. An individual taking an unjustifiable risk knowing that harm could result from the action would be an example of conscious disregard of an obvious risk. Lastly, wilful violation: a person knew or predicted the result of the action, but went ahead and did it anyway.

The Global Aviation Safety Network (2004) highlighted there was no one way to categorise unacceptable behaviour and assigning labels to incidents as either an error or a violation, as the governing regulations tended to do, was not a practical response to error. This method could not support an organisation's goal to highlight and manage risk. Dekker (2009) observed the majority of unsafe acts to which discipline should be enforced was neither appropriate nor beneficial to reporting error and that a border between acceptable and unacceptable behavior must be defined and the correct level of discipline should be applied.

By definition, violations are intentional acts, but they are not always acts of malevolent intent. Individuals may deviate from the procedures or norms knowingly, but with the certainty that the violation enables task completion without creating adverse consequences (ICAO SMM, 2013). Non-compliance becomes the automatic way to perform a task, and these violations involve a conscious decision of the individual to deviate or break the rules, although these acts are deliberate the possible bad consequence is not (Reason, 1997). Violations of this nature could be classified as oversights in judgement and may not warrant disciplinary actions depending on procedures and policy. ICAO (2013) categorised violations of this type as either situational violations: committed in response to factors experienced in a specific context, such as time pressure, high workload or inadequate support procedures, or routine violations: the normal way of doing business within a work group.

Such violations are committed in response to situations in which compliance with established procedures makes task completion difficult. For example, the first several pages of an AMM procedure are warnings, cautions, safety standard procedures and non-disclaimers by the manufacturer; the actual job starts a few pages in. It may be that the engineer followed the AMM to replace a component, but to follow all the safety and cautions may have hindered performing the actual task. When these safety steps are omitted routinely it eventually becomes the normal way of performing the job.

Organisationally induced violations are classified as an extension of routine violations, which tend to occur when an organisation attempts to meet increased output demands by ignoring or stretching its safety defences (ICAO SMM, 2013). In these cases the violation is enabled by the organisation. These categories of violations are extremely influential and may even become the norm as a side effect of doing what needs to be done to get the job finished. This is often not only individualistic behaviour, but apparent throughout the organisation. Highlighted in the research of Hampson, Junor & Gregson (2010) is that the studies available and aviation regulations failed to distinguish a violation from an innovation. They further suggest that deviation from working procedures and regulation should not be viewed as a violation, but as an on the spot change for the better decision to get the job done. The UK CAA (2009) supported this concept, they reported dual standards were widespread throughout the industry; engineers and technicians were trained to follow procedures on the one hand, and yet sometimes unofficially encouraged to violate procedures in order to get the job done. Hobbs (2004) conducted an aircraft maintenance safety survey, which yielded similar results to Hampson et al. (2010). Engineers were asked about what unsafe tasks they might have undertaken; not referring to the aircraft maintenance manual (AMM) or approved documentation, and procedural shortcuts on a familiar job were the most common responses. Sixty-nine percent of respondents believed it was sometimes necessary to 'bend the rules' to get the job done (Hobbs, 2004).

McDonald et al. (2000) conducted a study monitoring everyday tasks of AMEs and their findings showed that 34% of engineers recognised that when they carried out their most recent task they deviated from the procedure to complete the job. McDonald et al. (2000) reported a double standard existing in aircraft maintenance: AMEs had to complete tasks in accordance with the stringent procedures, but in a timely and efficient manner.

As discussed previously, reported violations were difficult to categorise as a punishable act. Ward et al. (2010) discussed several projects funded by the European Union (EU) organised to analyse organisational systems, which showed that in over 40% of tasks surveyed, the AME involved had not carried out their work in accordance with approved procedures or manuals. The study exposed the system as unsupportive in aircraft maintenance by forcing AMEs to adapt and optimise maintenance performance through carrying out intentional violations. Ward et al. (2010) wanted to investigate how could these errors be defined as violations when personnel were doing them to make the system work? Regulations did not define a bad violation in contrast to a good one, and he believed where a bad system existed violations should be recategorised. Ward et al. (2010) was attempting to point out that the term violation could not be used for all instances, especially in cases where people were committing such violations to make the system work. Error theories do not provide criteria to distinguish between good and bad procedures, or good system and bad systems; they take the value of the existing system for granted and because of this, and despite of itself, it places the blame at the doorstep of the individual.

2.3 Culture

Reason (1997) believed five elements were essential for maintaining a supportive and positive safety culture: knowledge, flexibility, learning, reporting and a no-blame policy (see fig. 5). Understanding a company's culture and the relationship between each of the factors is vital in safety management. It is expected that all organisations strive for a positive culture, but with so many unknown variables it is a difficult task.

Atak & Kingma (2010) noted that organisations may put safety first, but what this means in practice may be contingent on the technology at hand, the kind of organisation and the changing market conditions under which these organisations operate. Gheradhi, Nicolini & Odella (1998) supported this reasoning: they described safety as not being an objectively given condition, but rather a socially constructed and relative organisational property dependent upon organisational values, meanings and safety practices. It was believed that organisations could not learn a safety culture; the company in fact learned safe working practices and these defined the company's safety culture (Gheradhi et al. 1998).

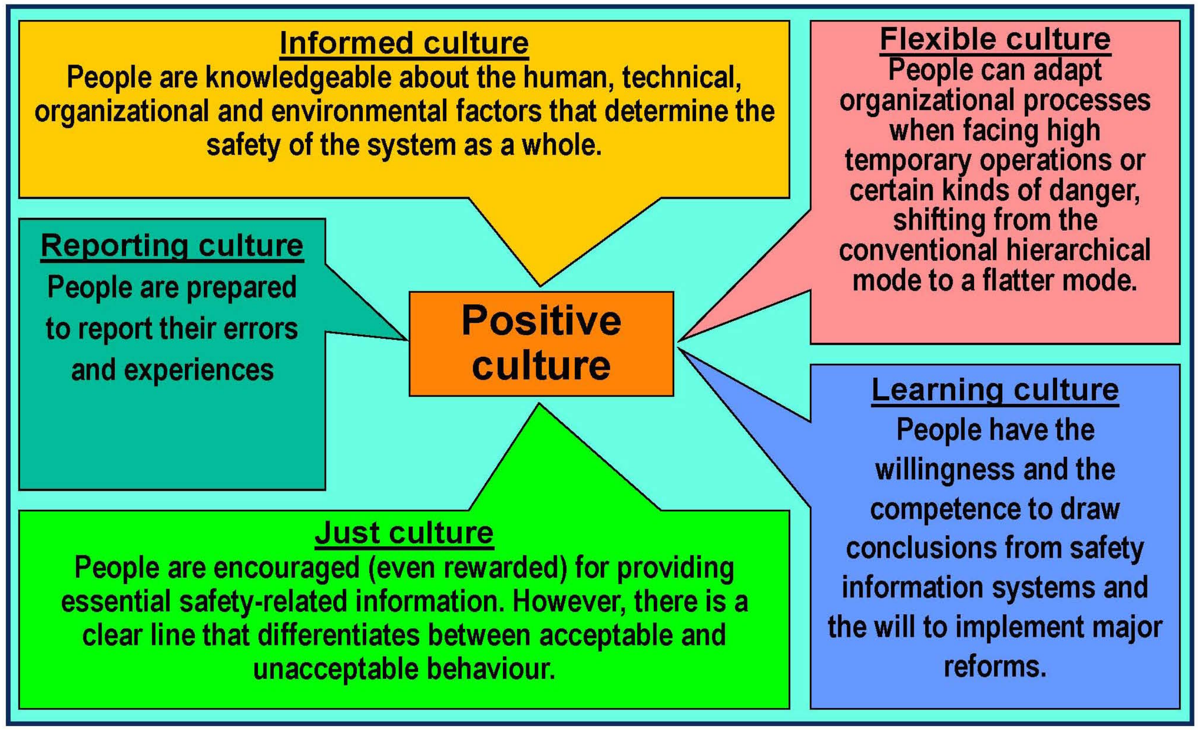

Figure 5: Positive Culture (Etzold & Ma, 2014, based on Reason 1997, Components of Safety Culture)

2.3.1 Safety Culture

Safety culture is "the set of beliefs, norms, attitudes, roles, and social and technical practices within an organization which are concerned with minimizing the exposure of individuals, both within and outside an organization, to conditions considered to be dangerous" (quoted in Garland, Wise & Hopkin, 1999, p82).

Aviation is one of the high-risk operation industries and there are certain cultural aspects that relate to safety (Garland et al., 1999), and as such requires a strict and clear discipline towards all aspects related to safety. To achieve this it requires attention to all matters, including effective communication between management and personnel, and a clear and firm leadership which sets the standard and expectations through their actions. Information flow is one of the main characteristics that organisational culture is dependent upon to protect safety (Garland et al., 1999) and should cross all borders within an organisation: hierarchy, departmental, and cross-trades. The inquisitive nature of a culture can lead to solving problems even before they become apparent (Garland et al., 1999), but it requires all members of the group aiming for the same goals to be successful.

Reason (1997) described culture thus: "like a state of grace, a safety culture is something that is striven for but rarely attained" (p. 220). He proposed that although an organisation may promote their exceptional safety culture as being the foundations of their company, without having all the key requirements functioning positively it is impossible to achieve. ICAO promotes and defines a healthy safety culture, which relies on a high degree of trust and respect between personnel and management, and must therefore be created and supported at the senior management level (ICAO, 2013).

As defined in CAP 718 (UK CAA, 2002) a good safety culture would include support from the top, a formal safety policy, awareness and adherence of the safety policy, practical support to enable the workforce to do their jobs safely (for example training, planning, resources and workable procedures), a just culture and open reporting, a learning culture and willingness to change when necessary, and corporate and personal integrity in supporting the safety policy principles in the face or potentially conflicting commercial demands.

A resilient safety culture requires a strong reporting culture throughout the whole organisation (ICAO SMM, 2013). This is developed from personal beliefs about, and attitudes toward, the benefits and potential detriments associated with reporting systems, and the ultimate effect on the users acceptance or utilisation of such systems (ICAO, 2013). A successful reporting system requires a continuous stream of information from front-line personnel. It would also be dependant upon a clear and published disciplinary policy differentiating between acts of deliberate misconduct and inadvertent errors, and an open and honest policy affirming the actions that would be taken depending on the type of error. Declaring a total no blame policy so that personnel feel more comfortable to report is impossible to achieve, since deliberate acts of misconduct against the safety system are punishable by the regulations that aviation are bound by.

2.3.2 Professional Culture

Many subcultures exist in an aviation organisation. Usually subcultures are shaped by the tasks by which they perform. In the aviation system, there are different and complex responsibilities, and job positions create subcultures; for example corporate management, pilots, mechanics, flight attendants, security personnel and ground handling are all classified as subcultures (Garland et al., 1999). The assumptions each subculture holds about the other can lead to factors that can separate the group as a whole, for example, how a pilot and aircraft maintenance engineer view each other’s role in operating the aircraft, or how a line maintenance engineer perceives the role of an engineer based in the hangar. The history of each group influences their attitudes about each other, Garland et al. (1999) observed a noticeable physical separation of the group's crew stations according to their jobs that led to their lack of awareness regarding other groups' duties and responsibilities. A psychological separation in each group was observed that led to personality differences, misunderstanding of motivations and other things that did not unify them as a team (Garland et al., 1999). Differences in training, administrative segregation and regulations, created group differences and led to confusion in terms of sterile cockpit procedure and licensing requirements (Garland et al., 1999).

These assumptions can be found within the maintenance environment where numerous subcultures exist. In many companies distinct subunits can be observed between departments: base maintenance and line maintenance, quality and maintenance, engineering and maintenance, engineering and quality. Subunits will also be observed between job types: mechanical and avionics, engineering and AMEs, quality and everyone else. Subcultures can upset the equilibrium of a harmonious working environment where working together can be problematic, where a strong sense of protection of job area is apparent and where a distrust of a different trade or qualification is present.

McDonald et al. (2000) conducted a safety climate survey amongst aircraft maintenance engineers where they received 622 responses from four different organisations. Considerable differences in safety climate were found between different occupational groups. McDonald et al. (2000) provided evidence that a strong professional subculture existed in all four organisations, additionally there was indication that the subculture was independent of the organisation.

Patankar (2003) conducted a similar study, but within one organisation over different occupational types in the industry (flight operations, maintenance and other personnel). Again, significant differences were noted between flight operations, maintenance, and other personnel with regard to several factors including pride in company, safety opinions, and supervisor trust. All departments had a high commitment to safety, but differences existed within one company under the same safety culture, which Patanker (2003) attributed to professional culture.

2.3.3 Blame Culture

Reason (1997) attempted to give some insight into why blame rather than acceptance is a natural reaction to a mistake, shown in figure 6. He believed anyone was susceptible to error; even individuals with the best intentions could make the worst errors. It was also believed that blame was a natural reaction to error because of human behaviour constraints.

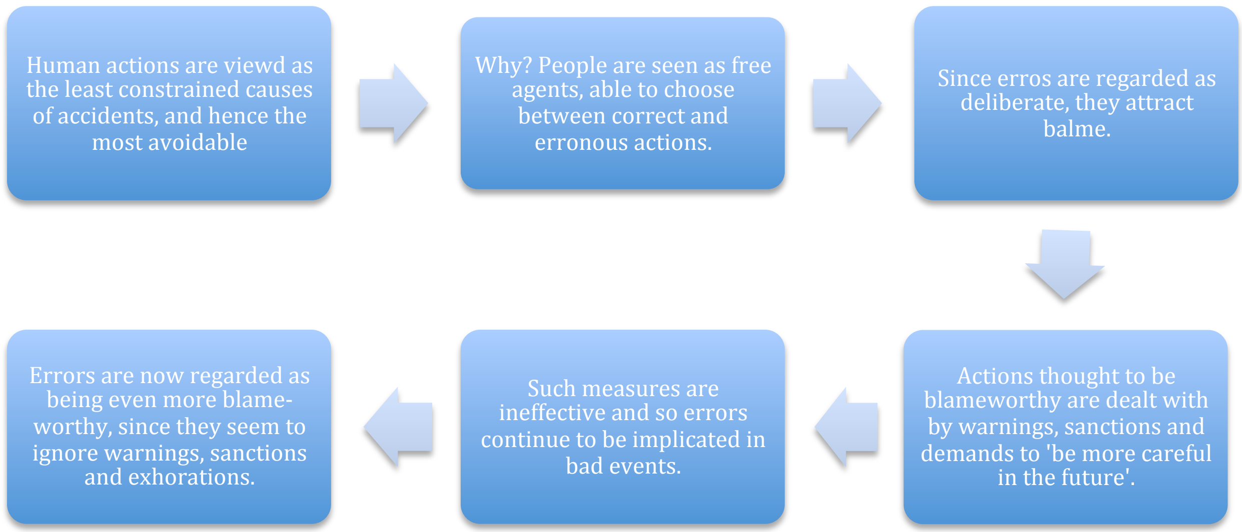

Figure 6: Elements of the blame cycle (based on model Reason, 1997)

Hobbs (2004) remarked it was a blame culture which prevented communication about maintenance incidents, and without this communication a successful safety culture could not exist. He went on to say that it was the industry norm to focus the blame on one individual so that there can be an instant fix by disciplinary action or dismissal, making the problem disappear, although this was usually only temporarily. Hobbs (2004) survey of Australian maintenance personnel showed that over 60% reported having corrected an error made by another engineer rather than report it, it was found that the fear of disciplinary action for the reporter or the original offender was one of the main reasons for not highlighting the finding.

Ward et al. (2010) reported how aircraft maintenance had dealt with error in the past was unsupportive and uncooperative, mainly because little was known about how the maintenance system functioned and nobody really understood the concept of contributing factors in the maintenance environment. As the human element became more of a focus in error causation the current methods of dealing with incidents did not evolve in step. Dealing with human error became centered on information campaigns highlighting the accident and telling people not to commit the error again (Ward et al. 2010). Individuals involved in the incident were either singled out and punished, or if the organisation had evolved slightly, the chosen candidate to take the blame was usually sent for training and the organisation's 'no blame' policy became known as the 'blame and train' policy (Ward 2005).

Aircraft maintenance has been known in the past to support a punitive blame culture, where most of the investigation process was focused on finding the one culpable individual and close out the incident without analysing the root causes and providing preventative actions. There was no support or understanding for reporting, investigation, finding the root cause and preventing the incident from happening again (Patankar & Driscoll, 2004). The blame culture, which prevailed in aircraft maintenance, discouraged personnel from officially reporting incidents (ATSB, 2001), the blame culture was one in which the reporting of errors was effectively dissuaded by disciplinary procedures, a fear of the consequences deterred any cooperation between maintenance personnel and the reporting system.

Hobbs (2004) reported that over 60% of AMEs had corrected an error made by another engineer without documenting their action. This was during a time when a strong blame culture existed and AMEs were dissuaded from communicating about maintenance incidents knowing that management response would have been punitive. If accidents were reviewed as an individual being the cause, then the findings and recommendations only produced solutions that counteracted the conditions caused by that individual. This of course, would not prevent the accident from happening again, as accidents are a series of preconditions coming together and lining up, waiting for an individual to make an error and set off a chain of events. If the preconditions go undetected, they can lie in wait for the next chain of events, therefore the company must take responsibility for identifying latent failures in the company's system; they must be aware of where potential threats lie and work towards neutralising their effects before incidents or accidents happen.

2.3.4 Just Culture

Dekker (2009) described how threats of prosecution did not prevent individuals from making error, but rather from reporting them. He defined a just culture as the sustainability of learning from failure through the reporting of errors, adverse events and incidents. Dekker (2009) highlighted the importance of a culture where there was no fear of reprisal, but where a clearly defined disciplinary policy was essential. A total no blame culture was neither realistic nor appropriate, without clear boundaries then an 'anything goes' attitude could adopted: if there is no defined line of what is acceptable or unacceptable behaviour, why would an individual report anything, as everything is classified as tolerable behaviour (Dekker, 2009). However, drawing the disciplinary line of what can be classified as acceptable error is a challenging task: the intent is to ensure individuals feel confident to openly share their experiences and working norms, but much of what is reportable is defined as violations.

Dekker (2009) also discussed accountability and how it was often synonymous with blame, he defined it as being responsible for one's own action and mistakes. He went on to compare forward and rearward looking accountability; forward accountability would have individuals taking responsibility for seeking and using information to avoid errors, and when they occur, being upfront and reporting them to safe-guard continuous improvement of the system. Rearward looking accountability would focus on blame and punishments for undesired outcomes, which could encourage hiding information, shifting blame and avoiding responsibility.

Recently EASA (2014) mandated a "just culture" in organisations. They state that member states shall adopt internal rules describing how just culture principals are guaranteed and maintained. EASA (2014) defined a just culture as:

> *a culture in which front-line operators or other persons are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but in which gross negligence, wilful violations and destructive acts are not tolerated* (EC 376/2014).

This definition provides a sense of security to those who report a deviation from the procedures and polices that are mandated and must be adhered to even when impractical, but provides a clear statement that not all behaviour will be tolerated, however ambiguity in the regulation of what a violation incorporates could leave opportunity for interpretation issues.

The ICAO SMM (2013) defined the principles a just culture should be founded on. It is assumed Aircraft Maintenance Engineers (AMEs) are highly trained, motivated and responsible employees who make errors. By accepting that human error is inevitable a culture can be defined to learn as much as possible and adapt the current system. A just culture puts emphasis on identification and correction of the safety insufficiencies, rather than focusing on appointing blame and punishment. A just culture encourages AMEs to report safety deficiencies without apprehension about punishment, but does not tolerate reckless behaviour and deliberate wilful acts, company policies should define what is acceptable and unacceptable behaviour and clearly state what individuals are accountable for if they knowingly violate. A just culture can lead to increased event reporting, based on the philosophy that lack of reporting does not indicate a safe system; it is accepted that error exists and the known is safer than the unknown. Increased reporting can highlight safety concerns before system failure. A company can successfully monitor the safety of its system through cooperation with front-line staff and a supportive reporting system.

2.3.5 Reporting Culture

Reason (1997) emphasised the importance of a strong reporting culture in order to sustain a resilient and supportive safety culture. Several key elements were highlighted by Reason (1997) as being essential to the success of a positive reporting culture:

- A just culture
- Motivation for reporting
- User-friendly and job relevant reporting system
- Training and instructions on reporting
- Feedback structure

- Oversight from management ensuring the reporting system remains effective and making changes as required to ensure it continued value.
- Confidentiality or de-identification
- Separation; the segregation from the departments (or authorities) collecting and analysing from those bodies with the authority to administer disciplinary actions.

To maintain a strong reporting culture a feeling of trust must be established and maintained. O'Leary and Chappell (1996) stated trust is the central element for a reporting system to be effective in uncovering failures. The organisation should not only be concerned about system usage, but that the content of the report contains detailed facts and useful information, which may mean the reporter is expected to provide detailed information of their failure. This can only be achieved if a sense of trust exists between the employee and the company (O'Leary and Chappell, 1996).

Hudson (2001) emphasised the requirement for information flow and trust for a system to be successful. He developed a model to show the relationship between information and trust, as employees became increasingly informed the level of trust grew within an organisation. Hudson (2001) provided four development stages: pathological; where company attitude throughout was who cares as long as long as no one finds out, in this phase violations were not only excused, but were encouraged. The reactive principal only put emphasis on safety once an accident had happened, before this point safety was rarely a consideration. The calculative phase suggested there was a system in place to manage hazards, but the next steps had not yet been taken to utilise the tools available. The proactive stage included working on the problems that have been identified using available tools such as safety audits, surveys and voluntary reporting systems and was starting to attempt to manage error. Lastly, the predictive stage where safety was the number one objective of the organisation using forecasting tools and modelling techniques to identify potential system vulnerabilities before they developed into hazards.

Gill & Shergill (2004) conducted a safety survey analysing an organisation's commitment to safety and their safety management system. They discussed the importance of a shared commitment to safety in all levels of the organisation. They went on to show that this shared commitment was vital to establishing an informed culture where employees readily report their errors and near misses as part of the company's strong reporting culture, but employees must feel confident that they will be treated fairly and not punished in order to sustain a non-punitive culture (Reason, 1997). Without this commitment there could be a lack of motivation to use the system and a sense of fear preventing trust in the system. Gill & Shergill (2004) provided evidence that to have a successful reporting and safety culture a company would have several requirements to meet: the company would need to take action on reports made, enforce safety policies and procedures, take disciplinary action on those in violation of the policies, support the staff making the reports and praise those who were willing to raise issues, and lastly the company must consider itself responsible for the success of the reporting system and be willing to change if there were apparent deficiencies.

2.3.6 Command Climate

The aviation coast guard has long since established a working and successful safety culture though their command climate initiatives and many principals can be compared to civil aviation, which appears to be several steps behind in successful implementation and maintaining. Stolzer, Halford & Goglia (2014) observed a culture deep rooted in the everyday duties of the aviation coast guard, which seemed to have an affirmative influence on many factors including high promotion and retention rates, overall job satisfaction, excellent human relations, freedom from harassment and an overall positive safety culture.

Stolzer et al. (2014) acknowledged the need for a top down approach to safety and reporting, stating that it was the responsibility of an organisation's management to provide a cohesive and effective environment, achieved through cultivating the command climate (or safety culture). Effective aviation safety requires continuous command emphasis, managers must lead by example and have the following attributes as defined by Stolzer (2014):

- Have a clear vision and establish attainable goals
- Allow subordinates freedom to exercise imitative
- Establish accountability
- Show confidence in subordinates
- Encourage and reward where appropriate
- Achieve high performance through positive motivation
- Listen to subordinates and seek ideas

- Demonstrate concern about the welfare of subordinates
- Establish and model high ethical standards

Stolzer (2014) recognised a positive safety culture came from the authority of management. When management demonstrated high integrity, increased reporting, communication, trust and confidence throughout the organisation was evident.
Stolzer et al. (2014) also specified what commitment would be needed from subordinates to secure the success of the system; use a mature and professional judgement at all times, eliminate unacceptable risk by never using downgraded equipment or work in conditions that exceed the limits of the team, have a proactive attitude to hazards and error, understand the importance of incident reporting to prevent reoccurrence of mishaps, do not allow the tempo of operations to dictate how the job is performed or violate to get the job done, and openly discuss close calls or mishaps knowing that all will benefit from learning from each other.

Chapter Three: Aircraft Maintenance

Several researchers (Reason, 2003; Hobbs, 2004; Dekker, 2009; Hampson et al., 2012) have highlighted how maintenance plays a significant part in accident causation, but it has not been until recently that experts and researchers have turned their interest towards consideration of aircraft maintenance and how error can be better managed to prevent incidents and accidents. Before making an assessment or forming an opinion about the maintenance role in accident causation it is first important to appreciate the nature of the work and the environment in which aircraft maintenance is conducted. Weick, Sutcliffe & Obstfeld (1999) observed that maintenance personnel come into direct contact with the largest number of failures, at earlier stages of development, and have a continuing appreciation of the vulnerabilities in the technology, disorder in the operations, inaccuracies in the procedures, and sequences by which one error triggers another.

The unique environment and persons involved in maintenance must be deliberated; it is unlike any other area in aviation and requires its own set of considerations when evaluating how to manage safety and error (Hampson, 2010). Also to be considered are the challenges faced in the maintenance environment and the professionals who are responsible for the aircraft who are tasked with maintaining a high standard of safety under a unique set of conditions. Ward et al. (2010) provided four key areas, which must be considered in aircraft maintenance performance. Firstly, the regulations that the aviation industry is controlled by: aircraft maintenance is a highly regulated industry where maintenance organisations are recurrently subjected to audits and approvals by aviation authorities covering compliance and operational requirements to ensure continuous conformity without deviation. Secondly, external bodies including manufacturers, customers, vendors and airlines, also play a key role in influencing compliance and operational matters, (for example aircraft design, system access and maintainability, in-service aircraft modification, all which have an effect on aircraft maintenance performance). Thirdly, internal functions affecting maintenance, which includes a number of key functions that continually support the pre-check aspects of aircraft maintenance (for example, contract negotiation, personnel capacity, personnel capability, slot availability, and so on). The final key area highlighted by Ward (2010) was the maintenance production system: this is where the work is actually carried out, either base or line maintenance, scheduled or unscheduled maintenance, all of which is continually supported by engineering, planning, operational and quality departments.

3.1 Environment

Aircraft maintenance is a complex activity in which individuals perform diverse tasks in an environment with time pressures, minimal feedback, and in difficult ambient conditions (Dhillon & Liu, 2006). Maintenance personnel are constrained by a set of rigorous regulations that are inconsistent between countries, regions and authorities, wherein aviation is a global activity. Maintenance personnel must deal with organisational culture, their own individualistic nature, environmental conditions and the pressure of their role in the larger matrix of safely operating aircraft. Included in the blend is pressure from the organisation to save time, to save money, and to minimally affect the operational schedule of the aircraft. At the same time engineers must consistently maintain a high level of integrity, being under pressure to make judgments without hesitation, and to carry the responsibility of being the last line of defence when it comes to serviceability of an aircraft.

Human performance limitations in the maintenance environment must also be considered: shift work, day and night operation, weather conditions, equipment and tooling availability, and accessibility of the aircraft and its systems. Hobbs & Williamson (2003) noted that aircraft maintenance was performed in an environment that contained many potential error-producing conditions. Some of these conditions included inadequately designed or insufficient documentation, lack of or inadequate tooling, time pressures, shift work and environmental extremes. Combined with non-technical issues such as poor communication, inadequate supervision and a breakdown in inter-departmental support all of the above can create a highly unstable situation often managed by one individual.

Hobbs & Williamson (2003) provided the following interpretation of the prevailing aircraft maintenance system:

> *If some evil genius were given the job of creating an activity guaranteed to produce an abundance of errors, he or she would probably have come up with something that involved the frequent removal and replacement of large numbers of varied components, often carried out in cramped and poorly lit spaces with less-than-adequate tools, usually under severe time pressure. There could also be some additional refinements. Thus, it could be arranged that the people who wrote the manuals and procedures rarely if ever carried out the activity under real-life conditions. It could also be decreed that those who started a job need not*

> *necessarily be the ones required to finish it. A further twist might be that a number of different groups work on the same item of equipment either simultaneously or sequentially, or both together.*

Hobbs & Williamson's (2003) definition of the maintenance environment incorporated many the factors discussed by others who have carried out studies of aircraft maintenance environment and safety concerns (McDonald, 2000; Hobbs, 2004; Dekker, 2009; Hampson, 2012). They all highlight the unique role of the maintenance engineer in a demanding environment under diverse conditions.

3.2 Licensed Aircraft Maintenance Engineers (LAME)

The public's focus regarding flying is directed towards the pilot as the core hero (or anti-hero) and the belief that he (or she) is solely responsible for the successful operation of the aircraft. Realistically, many individuals are required and they are all responsible for safety, but it is the LAME alone who declares the serviceability status of the aircraft, defining it as airworthy and fit for flight. The basic difference between an aircraft engineer and a licensed aircraft engineer is qualifications. Yadav (2010) described the purpose of licensing as to ensure accountability of a professional in a section. ICAO Annex 1 (2006) defined licensing as a method used to authorise a person to perform specific activities that, unless performed properly, could endanger aviation safety. The difference between an AME and LAME is not just qualifications, but also experience, responsibility, accountability, integrity and the ability to make stand alone decisions.

A flight cannot take place without Licensed Engineers; they provide the final reassurance that an aircraft is fit for flight, therefore playing a critical role in aviation safety. Aircraft are made up of a series of complex and inter-related systems, which LAMEs are expected to learn, retain the knowledge of and recall when required, whilst functioning under strict regulations and harsh environmental conditions.

The FAA provide the following description on their website for the role of Licensed Aircraft Maintenance Engineer;

> *An aircraft maintenance engineer is responsible for ensuring an aircraft operates properly and safely. A maintenance engineer may make repairs, troubleshoot problems, conduct inspections and make upgrades to aircrafts. Daily duties may include authority inspections, scheduled maintenance, AOG maintenance, repairs and recordkeeping of all maintenance activities (FAA Website, 2015).*

Hobbs (2004) described the unique set of conditions which LAMEs work under, highlighting that maintenance personnel work in a more hazardous environment than most other labour intensive jobs, and noted how each day can bring a different set of challenges to the previous one. He goes on to highlight that the work carried out by LAMEs may be performed at heights, in confined spaces, in extreme cold or scorching heat. The work can be physically energetic, but also requires clerical skills and attention to detail.

Maintenance engineers typically spend more time preparing for a task than actually carrying it out. Dealing with documentation is a key activity, and maintenance engineers commonly spend nearly as much time wielding a pen as they do holding a screwdriver. The work requires good communication and coordination, yet verbal communication can be difficult due to excessive noise levels and the use of protective hearing devices. The work frequently involves fault diagnosis and problem solving in the presence of time pressures, particularly at the final stages before departure.

Hampson et al. (2010) analysis of LAMEs and their responsibilities found that a number of interpersonal and other skills, in addition to technical skills, are required in the LAME labour process. As they explained, LAMEs are not just trained monkeys who follow a set of procedures or working instructions, but are called upon frequently to fill gaps in documentation, and to make high level and rapid safety critical judgements often making decisions that are fully compliant with procedure and policy. However, these are often conflicting with aircraft operation and impacting schedules.

3.3 Professional Culture

Although it may be human fallibility to make mistakes, it also is human nature to create solutions, identify alternatives, and meet future challenges (Dunn, 2003). LAMEs can be classified as a sub-culture within an organisation and have a special set of attributes unique to the maintenance environment, which are important to understand to partly explain why error may go unreported.

Taylor & Thomas (2003) described LAMEs as professionals who take responsibility for their own behaviour, who make judgments based on reliable data, and who assertively encourage this responsibility in others involved in flight safety. McDonald et al. (2000) supported this theory by explaining that LAMEs have a strong sense of responsibility for the overall safety of the system, going beyond simply performing a technical task to a set standard. They go on to describe how LAMEs adapt to the deficiencies in the system, which includes dealing with the system's inability to provide routinely the basic requirements for task performance and the lack of monitoring of what is actually happening. Engineers achieve this by having a strong professional commitment to safety and teamwork, and having the confidence in their own abilities to solve problems.

McDonald et al. (2000) defined the common set of values that LAMEs tend to share, including their understanding of the importance of safety, teamwork and cooperation. They have the self-confidence of being able to manage oneself, coping with error and problem solving. LAMEs often call upon "skills of experience" in a highly regulated environment in order to meet the demands of the organisation. There is a belief in professional judgment based on experience, knowledge and skill in carrying out work that can be called up and used rather than blindly following a set of procedures. However, McDonald et al. (2000) also noted that the ability and the need to take charge was not always shared, and on occasion there was a lack of assertiveness among operational personnel about decisions that had to been taken. Patankar & Taylor (2008) discussed the individualistic attributes that LAMEs display and how it affects their interpersonal skills and their position within the company. Both McDonald (2000) and Patankar & Taylor (2008) suggested that the individualistic nature of LAMEs had on occasion prevented them questioning the decisions of management personnel even when they did not agree.

Hampson et al. (2010) noted that a LAME's professional nature was defined by their responsibilities:

- They must sign off the release to service before an aircraft is allowed to fly declaring it as serviceable and airworthy, where many individuals performing different tasks have undertaken work. The LAME must take accountability for the work performed by others when confirming the airworthiness status of the aircraft.
- Use uncodified "skills of experience" to judge that the work of others is done to the necessary standard in accordance with all the correct procedures and policies without deviation (or violation).
- Work to standard operating procedures specified in manuals and constrained by heavy regulation.
- Possess skills that are both technical and interpersonal.
- Accurate task performance and aviation safety is significantly dependant upon LAMEs' skills, the accredited training they receive, and on good company relations that allow LAMEs the flexibility to recall their skills of experience without compromise by cost and time pressures.

By ensuring all maintenance personnel are fully trained and regulated that aviation industry aims to maintain the safety of aircraft. However, often the rules and regulations put in place to protect the safety of individuals introduces a new set of risks and unwarranted behaviors in order to achieve the task.

Chapter Four: Reporting

Carroll (1998) categorised reporting as part of the learning cycle and classified four processes required to take place within and across individuals, groups, departments, organisations, and institutions:

- Observing; noticing, attending, heeding, and tracking - (reporting)
- Reflecting; analysing, interpreting, and diagnosing - (investigation)
- Creating; imagining, designing, planning, and deciding – (change)
- Acting; implementing, doing, and testing – (feedback)

The first phase of the cycle for error management is reporting, without this essential step the process for change cannot be initiated. Stolzer et al. (2014) noted a successful safety system relied upon consistent decision-making which in turn required the acquisition and use of sound information. This means the organisation must constantly inform itself through any and all methods including reliance on self-reporting. Front-line personnel still provide the greatest amount of real time information regarding hazards, mishaps, mistakes and the usability of the safety system.

4.1 Types of reporting

CAP 382 (UK CAA, 2011) defined a reportable occurrence as any incident which has the potential to endanger, or if not corrected could endanger, the aircraft, its occupants or any other person.

4.1.1 Mandatory Reporting

Kohn, Corrigan, & Donaldson (2000) described mandatory reporting as a type reporting system where the main purpose is to hold providers accountable. They went on to say that most mandatory reporting systems were operated by state regulatory programs which had the authority to investigate specific cases and issue penalties or fines for wrong-doing and that these systems served three purposes. First, they provided the public with a minimum level of protection by assuring the most serious errors were reported and investigated and appropriate follow-up action was taken. Second, they provided an incentive to organisations to improve safety in order to avoid the potential penalties and public exposure, and finally, they required all organisations to make some level of investment in safety.

The European Aviation Safety Agency (EASA) affirm occurrences which may represent a significant risk to aviation safety shall be reported and provide a mandatory list of reportable events and state the persons who must report. However, they do not share the same definition of a mandatory system as Kohn et al. (2000), but take a more liberal approach in order to promote safety. EASA (2014) specified that without prejudice to applicable national criminal law, Member States shall refrain from instituting proceedings in respect of unpremeditated or inadvertent infringements of the law which come to their attention, excluding those occasions where there is evidence of wilful misconduct.

The Australian Transport Safety Board (ATSB) were more in support of the definition made by Kohn et al. (2000); not only did they mandate occurrence reporting, but they defined a clear policy and provided well-defined provisions when it was a punishable offence not to report, and provided immunity only for persons that could show they had not carried out any wrongdoing in accordance with the Transport Act 2003, yet promoted a just culture and endorsed a non-punitive approach to blame.

What is defined as mandatory reporting depends on the law of the state, and although ICAO and its 191 members should have a standardised approach to what is reportable and what protection reporters should have, it is down to the National Authority to provide the regulations and guidance. EASA provides an important example of standardisation, where it is expected that the 32 member countries be equally governed by the EU regulations in place, but in reality practices continue to deviate among the different member states (Groenleer, Versluis, & Kaeding, 2008). EASA performs regular standardisation inspections to ensure that all regulations have been correctly and consistently applied. They are tasked with monitoring whether EU rules are applied at the national level, by auditing and carrying out standardisation inspections of the national authorities and auditing the organisations under the oversight of the national authorities (Groenleer et al., 2008). However, EASAs ambiguous regulations allow for different interpretations of the rules across member states making standardisation difficult to achieve.

4.1.2 Non-Mandatory (Voluntary Reporting)

Groenleer et al. (2008) classified voluntary reporting systems as a method to concentrate on safety improvement. The focus of voluntary systems is usually on errors that resulted in no harm (sometimes referred to as near misses). Reports are usually submitted in confidence by anyone who was involved or has observed an error. Voluntary systems focus on the analysis of near misses with the aim to identify and remedy vulnerabilities in systems before the occurrence of harm (Groenleer et al., 2008).

ICAO SMM (2013) defined voluntary reporting systems as a system that allows the submission of information related to observed hazards or inadvertent errors without an associated legal or administrative requirement to do so. Defining voluntary as the person and not the report type, means a voluntary reporting system may include mandatory and non-mandatory report, but the person making the report is not mandated to do so.

EASA recently amended the regulation (376/2014) mandating voluntary occurrence reporting. EASA's guidance is that voluntary reporting systems should be designed to complement the mandatory reporting systems, and both should allow individuals to report details of aviation safety-related occurrences. The voluntary reporting system is open to all individuals so that each person in an organisation has the opportunity to report safety concerns or actual error.

4.1.3 Anonymous Vs. Confidential Reporting

All mandatory reporting systems reviewed were confidential and not anonymous; from the literature review an anonymous reporting system was not apparent in aviation, although several were available in the medical industry (Holden & Karsh, 2007). Non-mandatory reporting and voluntary reporting systems tend to be confidential, requiring that any identifying information about the reporter is known only to the persons in charge of the system, in order to allow for follow-up action. Holden & Karsh (2007) stated that anonymous reporting blocked access to further information; this opinion was reinforced by UK CAA (2003) and ICAO (2009) who stated that anonymity was not a realistic possibility; to ensure validity of the report and to allow further access to the reporter if additional details were required could only be achieved by being able to return to the original reporter.

O'Leary and Chappell (1996) determined that the main difficulties with total anonymity were investigators would not be able to contact the reporter for further information or resolve questions, or management may have the possibility to dismiss anonymous reporters as disgruntled troublemakers. They believed the best process to maintain confidentiality was de-identification of reports, removing the reporter's name and any identifying details within the report after receipt once it was established no further details would be required to support the report.

Anonymous reporting was perceived as an effective method of collecting data by the aviation coast guard (Stolzer et al., 2014). It was believed that some people felt more comfortable reporting hazards on their own time and in their own way, as a result suggestion boxes could be found around the workplace where personnel could report observations or findings without providing personal data. However, as reported by Stolzer (2014) anonymous reports often included contact details and this could have been used as an important indicator of a confident safety environment; if reporters were willing to give personal information (when there was no requirement) to allow follow up this could be indication of the level of trust within the safety culture.

All reporting systems are governed by the laws supporting confidentiality and are considered to provide the reporter with a sense of security. Protection from discovery and punishment, reinforced by the organisation, is essential to the success of a reporting system; if there is no trust in the company that reporters have the protection of the organisation, it will be difficult to overcome the barrier of fear (Holden & Karsh, 2007).

4.1.4 Reactive Safety System

A reactive system waits for an accident or incident before carrying out an investigation and an individual being held accountable and punished normally concludes the investigation. Etzold & Ma (2014) described a reactive safety system as having the following characteristics:

- Reliant on accident and serious incident investigation
- Judicial inquiry
- Does not have need of a just culture, supports a punitive culture
- Requires minimal employee cooperation
- Has been the long term solution in aviation for decades
- Produces minimal contributing factors and / or findings

It is the intention of the maintenance industry to move away from old style reactive reporting (Dekker, 2009; Hampson et al., 2010; ICAO, 2013) and encourage a proactive or predictive safety system with a just culture approach to allow the free flow of information without fear of punishment or retribution.

4.1.5 Proactive Safety System

With a proactive system an event happens, and the investigative process tries to find out what, why and how it happened, and with one step further, to try and find ways to prevent it from happening again. Etzold & Ma (2014) provided the key characteristics of a proactive safety system:

- Reliant on mandatory and voluntary reporting systems
- Based upon the belief that identifying safety risks within a system before it fails
- Can minimize system failures and taking steps to reduce the risks before the system fails
- Non-punitive reporting systems – requires a clear disciplinary policy
- Requires company-wide support to be successful.

4.1.6 Predictive Safety System

This method attempts to learn from the setting, the environment, or a situation, before an event happens through hazard identification and risk analysis. The system requires a supportive reporting culture relying on front-line staff actively participating in voluntary reporting to be successful. Holden & Karsh (2007) stated that because hazard identification did not require incidents or accidents to actually happen, that it was the most constructive form of reporting; however, hazards continued to be the least likely to be reported. They went on to maintain that hazards are much more numerous and frequent and can be used, if reported, to analyse and put changes in place before an incident occurs. However it relies heavily on reports being made; without these there is no data to analyse. Holden & Karsh (2007) also noted that because hazards and incidents are not as emotionally charged as accidents and they tend not to be associated with blame and cover-ups, employees may be more willing to share experiences and observations, and can provide un-biased information. Holden & Karsh (2007) observed that a shortcoming of reporting potential hazardous conditions in some companies was the reporter's lack of understanding of what is reportable. This could either clog up the current system through over-reporting; overwhelming system administrators, with the potential for actual hazardous conditions not being investigated correctly, or the lack of understanding could prevent employees from reporting anything and without reports there would be no data to analyse.

ICAO published guidance through the Safety Management Manual (2013) which encouraged organisations to promote a culture that established safe working practices and encouraged the process of active and effective safety reporting. ICAO introduced requirements for states to ensure their aviation service providers implemented a safety management system which supported a predictive safety system. A predictive system aims to give a real time continuous picture of a safety system. ICAO is promoting the safety management system (SMS) and regulatory authorities are mandating it for aviation related organisations. SMS has been a mandatory requirement for flight operations since October 2014 (965/2012) and will be mandated for Part 145 organisations from 2017. As defined by ICAO (ICAO SMM, 2013) a SMS is made up of:

- Senior management commitment
- A risk management system
- A non-punitive environment

- A reporting system capable of collecting, analysing and sharing safety information
- A method of sharing with the industry lessons learned

4.2 Regulations

ICAO provides standards and recommended practices (SARPs) for the implementation of a safety management system which incorporates a suitable reportable system. Although ICAO makes recommendations only, it is understood that if you meet the requirements of ICAO the context of hard law will be achieved. ICAO annexes 6, 11, 14, 19 and the ICAO Safety Management Manual details all standards and practices related to safety and reporting (Muller, Wittmer & Drax, 2014).

4.2.1 International Regulations (ICAO)

It is an ICAO standard for all organisations involved in the design, production, operations and maintenance of aircraft to have an occurrence reporting system. ICAO Annex 13 (2001) puts requirements on States to establish and operate a mandatory incident reporting system to collect information about actual or potential safety hazards. In addition, States are encouraged to implement a voluntary incident reporting system to facilitate the collection of information that could not be captured by the mandatory incident reporting system.

ICAO Annex 13 (2001) provides the following guidance:

- Each State shall establish a mandatory incident reporting system to facilitate collection of information on actual or potential safety deficiencies.

- Each State shall establish a voluntary incident reporting system to facilitate collection of information on actual or potential safety deficiencies that may not be captured by the mandatory incident reporting system.
- Mandatory occurrence reporting requirements for aviation service providers and operating personnel are set by the State regulatory and investigation authorities in compliance with ICAO provisions. Such national regulatory reporting requirements and related means of compliance may vary widely throughout the States.

4.2.2 European Union (EU) (EASA)

EASA, the governing Agency of the European Union, divide regulations into mandatory minimum standards (hard law), established by the EU Commission, and recommendations (soft law), which incorporate acceptable means of compliance (AMC), guidance material (GM) and certification specifications (Muller, Wittmer & Drax, 2014). EASA establish the soft law themselves and although it is only recommended, if an organisation implements the AMC material in full they are guaranteed to be in compliance with the hard law.

EASA specify the following regulations and guidance for reporting;
EU Regulation No. 376/2014 (EASA, 2014) on the reporting, analysis and follow-up of occurrences in civil aviation: Mandatory Reporting - Occurrences which may represent a significant risk to aviation safety and which fall into the categories as listed in the regulation shall be reported by the persons listed in regulation through the mandatory occurrence reporting systems.

The regulation also provides provisions for voluntary reporting, mandating such reporting:

1. Each organisation established in a Member State shall establish a voluntary reporting system to facilitate the collection of;

(a) details of occurrences that may not be captured by the mandatory reporting system;

(b) other safety-related information, which is perceived by the reporter as an actual or potential hazard to aviation safety.

EU Regulation No. 2015/1018 (EASA, 2015) providing a list of what is considered as mandatory occurrences in civil aviation to be must be reported according to Regulation (EU) No 376/2014 of the European Parliament and of the Council. *Annex II Occurrences Related to the Technical Conditions, Maintenance and Repair of the Aircraft*, provides a list and classification for each mandated reportable occurrence, the list has been provided in the appendices, Annex B.

Both regulations became effective 16th November 2015, at which time all applicable organisations must be compliant. To date 376/2014 and 2015/1018 provide the most extensive details of what is expected from a reporting system and what shall be reported.

EU Regulation No. 1321/2014 (EASA, 2014) on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks.

Annex II - Part 145.A.60: Occurrence Reporting of the regulation gives details on mandatory reporting;

Part-145.A.60 requires all Part-145 approved organisations to report occurrences meeting certain criteria to the competent authority, state of registry and organisation responsible for the design of the aircraft. Whilst this requirement is primarily intended for technical problems affecting aircraft, it also extends to errors where these have resulted in "any condition of the aircraft or component....that has resulted, or may result, in an unsafe condition that hazards seriously the flight safety" (Part-145.A.60 (a)).

Agency Decision 2003/012/RM (EASA, 2003) on the general acceptable means of compliance for airworthiness of products, parts and appliances.

Acceptable Means of Compliance (AMC) 20-8 Occurrence Reporting provides guidance in order to determine which occurrences should be reported to the Agency (EASA), national aviation authorities (NAA) and to other organisations. The AMC provides a definition of the objective of occurrence reporting:

- *The objective of the occurrence reporting, collection, investigation and analysis systems described in the operating rules, and the airworthiness rules is to use the reported information to contribute to the improvement of aviation safety, and not to attribute blame, impose fines or take other enforcement actions.*
- *The detailed objectives of the occurrence reporting systems are; to enable an assessment of the safety implications of each occurrence to be made, including previous similar occurrences, so that any necessary action can be initiated. This includes determining what and why it had occurred and what might prevent a*

similar occurrence in the future. To ensure that knowledge of occurrences is disseminated so that other persons and organisations may learn from them.

- *The occurrence reporting system is complementary to the normal day-to-day procedures and 'control' systems and is not intended to duplicate or supersede any of them. The occurrence reporting system is a tool to identify those occasions where routine procedures have failed.*
- *Occurrences should remain in the database when judged reportable by the person submitting the report as the significance of such reports may only become obvious at a later date.*

(EASA AMC 20-8, 2003)

4.2.3 United States (FAA)

The operator of any civil aircraft, or any public aircraft not operated by the Armed Forces or an intelligence agency of the United States, or any foreign aircraft shall immediately, and by the most expeditious means available, notify the nearest National Transportation Safety Board (NTSB) office.

The FAA stipulate that a confidential reporting system in which employees can report hazards, issues, concerns, occurrences, incidents, as well as propose solutions and safety improvements, must be developed and maintained (FAA AC120-92, 2015). Voluntary reporting of safety issues and events observed by any employee is encouraged through the ASAP, but is not a mandatory requirement. The FAA provides extensive guidance of the ASAP via Advisory Circular 120-66. The Voluntary Disclosure Reporting Program

(VDRP) is another method of reporting, allowing for organisations to identify, report and correct instances of regulatory non-compliance. The FAAs role is to review, accept and oversee corrective actions and conduct follow up surveillance (FAA AC120-92, 2015).

4.2.4 Australia (CASA/ATSB)

Transport Safety Investigation Act 2003 Act No. 18 of 2003 as amended:

the Act provides the following regulation on compulsory (mandatory) reporting; if a responsible person has knowledge of an immediately reportable matter, then that person must report it to a nominated official as soon as is reasonably practicable, by the means prescribed by the regulations and including those of the particulars prescribed by the regulations that are known to the responsible person.

The Act also states that if something is not reported which is deemed mandatory the responsible person can face up to imprisonment for 12 months, which may be initiated at any time within 6 years after the commission of the offence. CASA provide guidance for voluntary reporting systems stating that the regulations may establish a scheme for the voluntary and confidential reporting of issues that affect, or might affect, transport safety to the ATSB.

4.2.5 New Zealand (NZ CAA)

Civil Aviation Rule Part 12 stipulates;

each pilot-in-command of an aircraft that is involved in an accident or, if that person is fatally or seriously injured, or if the aircraft is missing, the operator shall notify the

Authority of the accident as soon as practicable. A person who is involved in an incident that is a serious incident or an immediate hazard to the safety of an aircraft operation must notify the Authority of the incident as soon as practicable.

There was no guidance available for voluntary reporting provided by the NZ CAA.

4.2.6 Canada (TSB)

Canadian Transportation Accident Investigation and Safety Board Act, *SOR / 2014-37.* The act provides the following regulation for mandatory reporting;
the owner, operator, pilot-in command, any crew member of the aircraft and any person providing air traffic services that have direct knowledge of an occurrence must make a report.

The TSB also provides guidance on voluntary reporting declaring any person having knowledge of a transportation occurrence, other than those persons required to report the occurrence to the Board, may voluntarily report to the Board any information that they believe to be relevant.

4.3 Regulatory Guidance on what to Report

Guidance and regulatory notification differs greatly between countries, although as a minimum, all follow the standards as provided by ICAO. A review of the different countries regulations showed the intent of the ICAO SARPs was established, but the degree of detail varied between ICAO members. EASA seemed to provide the greatest detail on what their expectation were for mandatory reporting. EASA regulations provide a list of what a mandatory occurrence is classified as and details on how it should be reported. Listed in Annex A is an extract from AMC 20-8 of what would be classified as mandatory reporting in aircraft maintenance. These items must be reported to the Authority (and other persons as defined in the regulations) within 72 hours of the occurrence.

Noted in the AMC is a disclaimer affirming that the list of examples of reportable occurrences provided is established from the perspective of primary sources of occurrence information in the operational area (operators and maintenance organisations) to provide guidance for those persons developing criteria for individual organisations on what they need to report to the Agency (EASA) and/or national authority. The list is neither definitive nor exhaustive and judgment by the reporter of the degree of hazard or potential hazard involved is essential (AMC 20-8).

4.4 Sources of Reporting

There are many different methods and options available to maintenance personnel when it comes to reporting. The regulations and company procedures should provide the guidance on what to report, but it is the ultimate responsibility of the company to communicate to all personnel how and what to report. Several methods that are available to maintenance personnel are listed below:

EASA Internal Occurrence reporting System (IORS)

- Regulatory owned.
- EASA reporting system claims to be a proactive and evidence-based approach.

- A four page reporting form, which is downloaded in PDF and can be returned by either email or post.
- Details to be included: company, name, type of incident, written section to give details of incident, method of follow up action / closure and risk assessment results.
- Confidentiality supported and maintained where possible.
- Referral to the regulations for what should be reported (mandatory).
- No place on the form to select whether the reporter would like feedback or a response.
- Reports submitted are a method of advising EASA of an already dealt with occurrence.

(EASA Website, 2015)

UK CAA Mandatory Occurrence Reporting Scheme (MORS)

- CAP 382 provides guidance on the system.
- Two page form, page 2 dedicated to ground incidents.
- Submittal of the form is on completion online.
- Confidentiality supported and maintained where possible.
- If the report is to be treated as confidential it must be stated on the form.
- UK CAA advises that they support voluntary reporting and is defined as a report made by someone not defined in the regulations.
- CAP 382 provides details on what happens to the report after it is submitted.

- It is expected that a report made has already been addressed and adequately closed by the organisation of the reporter, therefore the CAA state under normal circumstances and after assessing adequate closure no further investigation will be performed by them; reports submitted are a method of advising the UK CAA of an already dealt with occurrence.
- No place on the form to select whether a reporter would like feedback or a response.
- The UK CAA state they support a just culture philosophy in order to encourage reporting to support safety:

  > *individuals will not be punished for actions, omissions or decisions taken by them that are commensurate with their experience and training but which result in a reportable event, but where gross negligence, willful violations and destructive acts are not tolerated.*
  >
  > (UK CAA CAP 382, 2011).

Confidential Human Factors Incident Report Program for Aviation (CHIRP)

- CHIRP complements the CAA Mandatory Occurrence Reporting system and other formal reporting systems operated by many UK organisations, by providing a means by which individuals are able to raise safety related issues of concern without being identified to their peer group, management, or the Regulatory Authority. (CHIRP Website).

- CHIRP state they are providing a totally independent confidential (not anonymous) reporting system for all individuals employed in or associated with these industries.
- Personal data is removed before the report is shared with industry databases including UK CAA and EASA.
- CHIRP are a charitable organisation and rely on funding from the UK Civil Aviation Authority.
- Separate two page engineer reporting form which can be completed online, or sent by email or post.
- Details to be included: company, name, type of incident, written section to give details of incident.
- There is an option to select if a reporter would like feedback from CHIRP; normal feedback is via a newsletter.
- The principal of the system is that CHIRP will carry out an independent investigation and advise relevant parties of what was reported and their findings.

(CHIRP Website, 2015).

British Airways Safety Information System (BASIS)

- Developed by aviation professionals to report all occurrences, air and ground, mandatory and non-mandatory.
- Used by many airlines, authorities and manufacturers.
- Accessible and submittable online, but with the option to email.

- The relevant reporting form with regards to working area can be accessed via BASIS online: Air Safety Report (ASR), Ground Operation Report (GOR), Cabin Safety Report (CSR) are among options available.
- Company manuals provide examples of what should be reported.
- After submitted, the quality and safety department will assess if it is a mandatory occurrence report (MOR), and if so will be forwarded to the regulatory authority.
- GORs will be assessed to decide whether a formal investigation is required.
- Details to be included: company, name, type of incident, written section to give details of incident.
- Follow on report in the eBASIS gives details of investigation, actions taken, long-term solutions and risk analysis.
- Confidentiality and level of feedback distributed are unknown and would be dependent upon company policy suggesting differences may exist between organisations.

Transport Safety Board (TSB) Canada

- An online reporting form is available, but indicates should only be used in a small set of cases requiring immediate notification to the TSB.
- Access to the form is available only online
- One page form with basic information to be provided: company, name, incident details.
- Confidentiality falls under the requirements by Canadian law.

- The TSB state that potentially unsafe acts or conditions should be reported via SECURITAS.

(TSB Website, 2015)

SECURITAS

- SECURITAS is the reporting tool of the TSB.
- No dedicated form, but a guide is provided of what information should be given.
- Reports can be emailed, faxed or sent via post.
- Each report is reviewed and entered into their database.
- The TSB initiates action according to the gravity of the safety concern.
- When the reported observation is confirmed to represent a safety deficiency, the TSB forwards the information, often with its suggestion for corrective action, to the appropriate regulatory authority or organization as applicable.

(TSB Website, 2015)

Aviation Safety Reporting System (ASRS)

- A formalised voluntary, confidential, and non-punitive reporting system.
- The ASRS collects, analyses, and responds to voluntarily submitted aviation safety incident reports in order to lessen the likelihood of aviation accidents.
- A joint venture between NASA, who maintains the system, and the FAA who funds the program, relying on the aviation community to use the system effectively.

- Reports submitted to ASRS may describe both unsafe occurrences and hazardous situations.
- One of the longest running reporting systems.
- The FAA views a reported violation via ASRS as a reason not to receive a civil penalty or a suspension, FAA Advisory Circular No. 00-46E provides details on when a violation is made, but where the person may avoid civil penalty or authorisation suspension.
- Reports made either via email or post.
- Data collection and analysis is shared industry wide via alert bulletins and safety notices.
- Information in the ASRS database is available publically with confidentiality of reporters retained by removing personal information before uploading to the database.
- ASRS provides separate reporting forms for pilots, air traffic controllers, cabin crew and maintenance personnel.
- Details to be included: company, name, type of incident, a written section to give details of incident and requests details about the chain of events.
- System that supports and provides feedback individually and industry wide.

(ASRS, NASA.ORG Website, 2015)

FAA Aircraft Accident / Incident Preliminary Reporting

- Designed for mandatory reporting.
- Three page generic reporting form.

- Details to be included: company, name, type of incident, written section to give details of incident.
- Reports can be emailed, faxed or sent via post.
- No place on the form to select whether a reporter would like feedback or a response.

(FAA Website, 2015)

Maintenance Aviation Safety Action Program (ASAP)

- A formalised voluntary reporting system.
- FAA developed non-punitive error reporting program adopted by over 90 Air Operators (FAA Website).
- The intent of the system is to resolve safety issues by means of change rather than using punishment or discipline of individuals.
- FAA AC 120-66B provides guidance for setting up and using a successful ASAP.
- A dedicated department set up to review and analyse reports, the Event Review Committee (ERC); usually consisting of representatives from management, union and at the meetings, a FAA representative.
- Strict set of conditions for accepting a report into the ASAP as not all reports are deemed as meeting the criteria, appendix 3 provides the decision flowchart.
- Some companies advise a reporter should fill out an ASRS form if it is believed a violation has taken place (Merrilat, 2001), this is a method used to provide protection from FAA sanctions.

(FAA AC 120-66B, 2002)

REPCON - Aviation Confidential Reporting Scheme

- Allows any person who has an aviation safety concern to report it to the Australian Transport Safety Bureau (ATSB) confidentially.
- REPCON does not accept anonymous reports.
- REPCON gives the following statement: the ASRS allows for self-reports of unintentional regulatory breaches by persons who are seeking to claim protection from administrative action by CASA. A reporter seeking protection from administrative action by CASA should consider reporting under the ASRS and whether they meet its criteria.
- A two-page generic reporting form submitted electronically, by email or by post.
- Details to be included: company, reporter's name, type of incident, written section to give details of incident.
- A guide of what is reportable is given in the REPCON handbook.

REPCON Handbook, 2009)

Maintenance Error Decision Aid (MEDA)

- Tool designed to support the reporting and investigating incidents specifically related to maintenance.
- Designed and created by Boeing and industry partners in order to better understand the problems experienced by airline customers.
- The fundamental philosophy of MEDA is that people do not make errors on purpose.

- MEDA is based on three main principles: people want to do the best job possible and do not make errors intentionally, a series of factors is likely to contribute to an error and most of the factors, which donate to an error, can be managed (Skybrary).
- If the technician is punished but the contributing factors are not fixed, the probability that the same event will occur in the future is unchanged, therefore it is the intent of the MEDA process to investigate reported events, develop prevention strategies and provide recommendations via feedback.
- The MEDA process will be implemented into an organisation as their chosen reporting platform.
- Consisting of a four page reporting form.
- Depending on company implementation will depend on method of returned forms.

(MEDA User's Guide, 2013)

The above examples are not exhaustive and many other reporting methods are available to maintenance personnel. Organisations have many options to purchase reporting tools from software providers, ensuring a company has a central database available for employees and where quality and/or safety departments can conduct and report on investigations and their findings.

4.5 Reporting Error: The Barriers

Aircraft maintenance in aviation is seeing the benefits of having a proactive reporting and safety system, and is attempting to evolve to provide personnel a supportive environment to encourage reporting. Self-reported safety behaviour and safety attitudes are an alternative to relying on mishap data to evaluate the effectiveness of an organisation's safety program (O'connor, O'Dea, Kennedy & Buttrey, 2011). Thompson Hilton & Witt (1998) noted that workplace incidents often go unreported and unnoticed, yet Thompson (1998) and O'Connor (2011) both agree that these events may be the best indicators of the efficiency of the current safety system.

Reason (1997) highlighted that a written confession is not normally the immediate human reaction to a mishap or error, when it came to divulging ones own errors people tended to avoid putting it into a report for everyone to analyse and scrutinize. Reason (1997) went on to say that even if people could be convinced to report their mistakes, there are still several other hurdles that could stand in the way; extra work, skepticism, denial (a hope the incident will just go away), lack of trust and fear of reprisals. Reporters do not always see the value of making reports particularly if there is no feeling of confidence that submitting a report would make any difference and a lack of trust the report made will be dealt with in its intent.

Uribe, Schweikhart, Pathak & Marsh (2002) found several similarities between aviation and healthcare underreporting. Their investigation looked into why underreporting existed and discovered several different factors contributing to the reporting system's lack of use including; time pressures, motivation to report, complexity of the reporting system, lack of understanding what should be reported and why, and fear of blame.

Figure 7 characterises some of the barriers Uribe et al. (2002) uncovered distinguishing what issues could be deemed as controllable and highlighting the factors that were not. Several parallels exist between healthcare and aviation research into safety systems and error management. Leveson (2011) made similar suggestions to why personnel were being evasive with reporting systems. Uribe et al. (2002) and Leveson (2011) suggested poor reporting system design, lack of information on correct usage and purpose of the reporting system, lack of feedback or evidence of change, and fear of reprisal supported by a blame culture, all hindered the success of a company's reporting system.

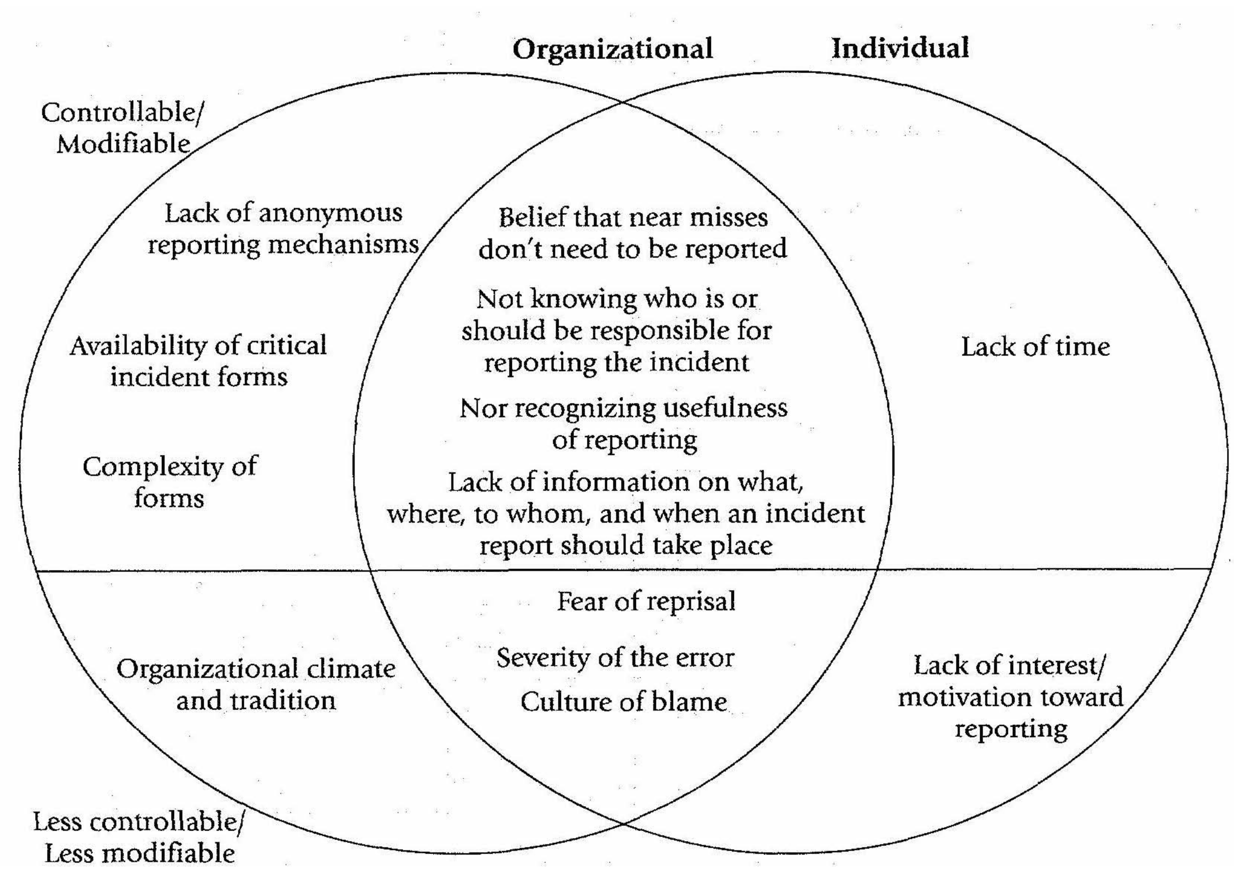

Figure 7: *Barriers that may Influence Under Reporting, Uribe et al. (2002).*

4.5.1 Error Recognition

Knowing what to report is one of the main barriers in reporting systems. If engineers are unclear what is a reportable event or what the company expectations are of what should be reported to support the safety scheme then errors will go unrecorded.

Airbus conducted a survey of 50 airlines, as reported in Airbus Maintenance Briefing Notes (2007), specifically designed for aircraft maintenance engineers. When engineers were asked to identify what they thought were violations, the most common response was not using the technical documentation (i.e. AMM), closely followed by performing a task without a procedure, servicing without a checklist, omitting task steps or changing the order of the task steps. Engineers were asked to follow up with why they would violate and reasons given including; unavailability of technical documentation, the job was carried out several times before and the procedure was deemed unnecessary, and interpretation of the supporting documentation needed more time than the job itself (Airbus Maintenance Briefing Notes, 2007). The survey carried out by Airbus indicated maintenance engineers were able to comprehend they were violation when carrying out a task, but believed to get the job done they had to be. Although recognising a violation, engineers saw no misdemeanor, they viewed it as a necessary requirement to complete the job under the conditions. Under these circumstances there was a perception that no wrongdoing had taken place and therefore nothing to report. In the same survey engineers were asked about their attitude towards reporting, most stated it was their duty to report and felt comfortable doing so.

What to report depends somewhat on the safety culture of the organisation and what management expectations are of their employees. If a company is only interested in ensuring minimum compliance with the regulations then what must be reported is stipulated in the governing authorities rules and guidance material, and additional guidance may not be given. In this case company reporting expectations do not exceed the least possible requirement, which on occasion are ambiguous and difficult to interpret.

If the organisation safety culture supports error management and a proactive approach to safety, non-mandatory and voluntary reporting will be developed and encouraged through company procedures and policy. However, there is a lesser amount of guidance material on reporting expectations perhaps introducing ambiguity of what is reportable. If there is not a clear understanding of what is reportable then engineers will tend to shy away from reporting.

Dekker (2004) noted that even if engineers did report an error, they often left out critical information not realising it might have been contributing to the incident. For example, why should an engineer report that the error occurred whilst the aircraft was outside the hangar, at night, whilst it was raining, with little access to the job, when this is how the engineer would perform maintenance all the time? Why would an engineer report what he / she perceived to be the normal way to perform the task? Dekker (2004) observed that often environments or working practices were noted as remarkable after the fact, but prior to an incident these factors were just normal practice, and there is no requirement to report normal. Even if an organisation had a reporting culture, learning culture and a just culture allowing engineers to feel comfortable reporting, an engineer will not report what he (or she) distinguishes as normal working practices (Dekker 2004).

4.5.2 Awareness – Individual and System

Patankar and Driscoll (2004) conducted a survey of over 5,000 certified maintenance personnel (FAA), and learned that one of the key factors that safeguarded the success of ASAP programs was a high level of awareness about ASAPs among the maintenance personnel. Part of the ASAP system philosophy was to make users fully aware of system functionality and its purpose as a support tool to aid in company continuous improvement.

Convincing employees to report or acknowledge events involving their own errors is an arduous task. There is a natural desire for persons involved to forget or disregard that an incident happened, they might be concerned that they are bringing trouble upon themselves or their colleagues. Individuals may not see the value of the report or perhaps doubt if any management corrective action will result. Reason (1997) identified several key factors needed to sustain a successful reporting system:

- Indemnity against disciplinary proceedings (within the restraints of the regulations).
- Confidentiality or de-identification of reports.
- Useful, timely, and reasonable feedback to the reporting community.
- Ease of making the report.

Reason (1997) also commented that the above points are the fundamental basis of trust, and that the system should be designed and used to promote error reporting rather than apportioning blame. Making personnel aware of the reason for reporting, providing guidance on company expectation of what should be reported, describing the investigative process after a report is submitted and providing feedback on the findings, could potentially encourage a positive response to the reporting system.

4.5.3 Organisational Influences

Hampson et al. (2012) described the tensions within a work process constrained by regulation prohibiting departures from procedure, but where LAME judgement is vital for safe and profitable airline operation. There is an expectation from the organisation that LAMEs use their judgement to get the job done, on time and without impacting the service, but will not ask how this is achieved until an incident occurs.

Hampson et al. (2012) went on to explain how the LAME must apply skill and discretion, especially when there are managerial pressures to sign off work to avoid disrupting flight schedules when performing maintenance to a satisfactory standard and returning an aircraft to service safely. They believed it was up to the LAME's independent judgement to resist shortcuts and avoid the conflict between the requirements of getting the job done and maintaining all safety requirements. Often, safety and on-time cost-effective operations objectives can become distorted. In times of prosperity, both objectives can be easily balanced and satisfied in full, however there may be times of economic austerity, which demand there is some give and take between the two. Unfortunately, history shows that safety is often the loser in such battles as safety and training are often the first to be cut in organisations having financial difficulties (Hampson et al. 2012).

Hudson (2003) pointed out that most violations were made because of our desire to please rather than wilfulness; a violation materialised because of a LAME's intent to further the organisation operational objectives (on-time departure, cost, working with the tools available). Taylor (2003) discussed the shared characteristics found between LAMEs; highly competent, have a great deal of control and commitment to aviation safety, they have a willingness to take responsibility for their own actions, to make judgements based on reliable data and to actively encourage this responsibility in others involved in aviation safety.

Hobbs (2004) reported that despite heavy penalties, divergences from procedure, mistaken or intentional, were relatively common. Hampson et al. (2012) provided details on a European study carried out in 2000, which reported that 34% of maintenance workers acknowledged their most recent task had been performed in a manner that contravened the formal procedures. Similarly a survey carried out by Hobbs (2004) of Australian LAMEs found that 30% reported having signed off on a task before it was completed, while 90% reported having done a task without the correct tools or equipment. Hobbs (2004) explanation was that LAMEs felt pressure from their management or organisation to get the job done. The UK CAA (2009) also found through their research that maintenance personnel are highly qualified professionals trained to follow procedures on the one hand, yet sometimes unofficially encouraged to violate procedures in order to get the job done.

4.5.4 Feedback

Reason (1997) defined feedback as the transfer of information from the various monitoring functions to potential users at all levels of the system, it is integral to the management of safety and can include audits, reporting, investigation, data analysis and system monitoring. O'Leary & Chappell (1996) determined along with lack or loss of trust, the absence of feedback or noticeable change was the greatest risk to incident reporting. Feedback is paramount to the success of a safety system, McDonald et al. (2000) stated timely appropriate feedback, through a broad range of measurement and communication channels were one of the requirements to support positive effects on the end results.

Slow or delayed feedback during report analysis reduces the ability of organisations to learn from errors (Latorella & Prabhu, 2000). They believed that feedback was often diminished by its delay and contributing factors could remain undetected. Following up on a report made after an extended period of time had lapsed could prevent reporters giving supportive follow up details of the incident. Feedback after an investigation was completed was equally as important, Latorella & Prabhu (2000) noted that reporting systems quickly became inadequate when visible and effective feedback was not provided.

Sarter & Alexander (2000) reported more effective feedback was needed in data driven monitoring, for example a reporting system and shared knowledge provided a more timely and reliable detection of mistakes. Leveson (2011) supported this idea believing inadequate or missing feedback, or delays in feedback hindered the reporting system. She also highlighted the motivational factor of feedback; an individual being made aware they are making a contributing to the system can lead to greater usage.

Taylor (2000) highlighted the organisational effects in aviation maintenance and its contribution to the causes of errors and mistakes, suggesting that lack of communication across and between different levels of hierarchy and separate departments, and their inability to hear or listen to what was trying to be communicated was to blame. Taylor (2000) continued that as a result of accumulated distrust and fear of punishment from management the manifestation of numerous unreported errors and mistakes took place in aviation maintenance.

4.5.5 Strict Regulations

Hampson et al. (2012) observed that the LAME working environment was heavily influenced by the extent and nature of regulation within which it is rooted; regulations gave safety a strong metaphorical force, yet departures from procedure were reported frequently.

Fogarty & Shaw (2010) discussed how stringent procedural guidelines had attempted to automate and standardise behaviour; strict regulations and procedures were used to govern the working environment in order to control error and prevent accidents.

However, regulations and guidelines are attempting to evolve to include the human aspect, acknowledging individual differences and focusing on psychological pressures and factors that influence behaviour (Fogarty & Shaw, 2010). As reported by Fogarty & Shaw (2010), failure to follow procedures is a major causative factor in aviation for creating errors and procedural violations continue to be reported as one of the main contributing factors in accident causation.

4.5.6 Management Commitment

McDonald et al. (2000) suggested that a positive safety culture could propose to include: responsibility of safety at a management level, distributed attitudes of care and concern throughout the organisation, appropriate norms and procedures for handling hazards, and an on-going monitoring of safety practices. Unsupportive management attitudes, including complacency or ignorance about safety weaknesses hinder the success of a reporting system being used as a supportive tool to capture safety issues. This can be achieved through policy, communication, effective leadership, setting performance standards, communicating expectations and evidence of change (McDonald et al. 2000). Following these simple practices ensures safety becomes the responsibility of management; they define the standards, monitor it for effectiveness, and make changes to better the system. Management should promote a safety culture throughout the organisation, making sure every member takes responsibility for it. If a strong safety culture exists it will be easy to implement and monitor, as feedback will flow more freely through communication between the trust that exists in the company.

4.5.7 Confidentiality – Is it assured?

The reporting systems reviewed all applied the principle that reporting should be confidential but not anonymous, since it may be necessary to contact the reportee to obtain more information about the occurrence. No reporting system in aviation was found to apply complete anonymity. Regulations available stated the law regarding confidentiality and protection given, de-identification of reports was performed before sharing results globally, but in all cases the reportee had to give personal details.

The healthcare industry shares many similarities with aviation and reporting safety concerns, equivalent barriers with regards to reliance on self- reporting to support improved safety management was discussed by Pace, Staton, Higgins, Main, West & Harris (2003). They carried out a study in the healthcare industry, which involved evaluating a database that supported both anonymous and confidential reporting. Pace et al. (2003) observed management and employees supported and utilised the anonymous version to a greater extent; anonymity provided an assurance in the system, without fear of blame or legal ramifications promoted its usage.

Although they observed employee support for anonymous reporting Pace et al. (2003) stated that using an anonymous reporting system placed limitations for root cause analysis, which in aviation systems is one of the main objectives of managing error. They suggested the best method was de-identifying confidential reports (although these have their deficiencies) and noted that the ASRS was one of the more advanced reporting systems at succeeding in de-identification thus providing an acceptable level of anonymity to external parties.

Hoffman, Beyer, Rohe, Gensichen & Gerlach (2007) set up an entirely anonymous reporting system for general practice reporting in healthcare. Results were then shared industry wide and open for feedback and recommendations, also anonymously. When compared to other reporting systems in the same field, it had the second highest report rate after a 17-month period. Hoffman et al. (2007) were of the opinion total protection of the reporter could only be achieved through an anonymous reporting system. They felt that reporting systems could not adequately reflect the safety of a system if they were not combined with other methods of risk management such as incident analysis, safety audit, and prospective methods of analysis, however unlike other researchers (Uribe, 2002; Pace, 2003; Leveson, 2011) Hoffman et al. (2007) did not see the requirement for reporter identification to achieve this.

Aviation law with reference to confidentiality binds an organisation, but whether it is assurance enough for reportees that an identity is protected is dependent on past experience and company policy securing confidentiality. If employees have no confidence in the system or the disciplinary policy workers will shy away from reporting. Another consideration is that not all reporting systems are in-house and many external schemes are available; this can provide a positive or a negative effect on reporting. Employees are either going to feel greater protection reporting externally and their identities remaining anonymous to their organisation or they may still remain untrusting towards external systems for the same reasons, expecting external organisations to share confidential details with the organisation in question.

There have been several instances reported on aviation blogs and aviation publications where reportees have had negative experiences with external reporting systems and have suffered the undesirable effects within their organisation. One example, as reported by Holmes (Bloomberg Business, 2008), detailed an inspector working for the FAA, who had made a serious report to the FAA about his current airline at the time, Northwest Airlines. The inspector had witnessed situations which he determined jeopardised safety and lives during an airline strike. The FAA approved inspector conveyed that instead of the airline being immediately investigated he found himself fighting for his job and career within a matter of days from submitting the report. He alleged that within the following days from submitting the report he had his security clearance removed and was assigned to a desk job. Both the FAA and airline worked together to tarnish his claims rather than investigate the safety issues reported.

Another example, more recently, involved Southwest Airlines, where an aircraft engineer removed an aircraft from service during routine inspection due to finding cracks which he deemed a hazard to flight safety (Goglia, 2015). The engineer was accused of working outside his assigned task and was advised further violations to procedures would lead to disciplinary action. Although in this case confidentiality was not an issue, the manner in which the airline dealt with the situation brought in to question a non-punitive culture mandated by ICAO, FAA and EASA.

4.6 Key Components For a Successful Reporting System

ICAO, EASA, FAA, ATSB and many other regulatory authorities provide insightful guidance material on how to establish and maintain a successful reporting system; CAP 718 (UK CAA, 2002) seemed to provide the most comprehensive guide. Below are some of the key elements the UK CAA (2002) suggested are required to implement and to ensure success and sustainability of the system:

- Unambiguous goals and objectives of the reporting system and safety management.
- Noticeable corporate commitment with responsibilities defined.
- Corporate backing of uninhibited reporting.
- Disciplinary policies and boundaries identified and published.
- A clear occurrence investigation process.
- Events that will trigger error investigations identified and published.
- Dedicated investigators selected and trained.
- Education and training for user staff.
- Proper action based on investigation findings.
- Feedback of results to the reporter, the entire workforce and industry wide (if applicable) whilst maintaining confidentiality of sensitive information.
- Analysis of the collective data showing contributing factor trends and frequencies in order to identify patterns of casual and contributory factors and trends over time.
- Occurrence reporting scheme should enable and encourage free and frank reporting of any (potentially) safety related occurrence.

- Establishment of a just culture that ensures personnel are not inappropriately punished for reporting or co-operating with occurrence investigations.
- Ensuring a closed-loop process, ensuring that actions are taken to address safety hazards.

The UK CAA provided CAP 718 as guidance in 2002 and yet there still appear to be deficiencies apparent in current regulation and company policy when it comes to reporting system development and sustainability in aircraft maintenance.

Chapter Five: Method

5.1 Overview

There are multiple error reporting systems available to aircraft maintenance personnel through a variety of methods, however there appears to be little research available assessing the success of reporting systems in aircraft maintenance as a method of error management. Current regulations are evolving to mandate reporting systems and all aircraft maintenance organisations must have a readily available reporting system to support their error management and safety system. Introducing a reporting system is only the initial objective for an organisation; gaining support from front-line staff to actively report hazards and error is the more significant challenge.

The primary aim of the study was to establish if maintenance personnel were actively using available reporting systems. The secondary aim of the study was then to ascertain why maintenance personnel may be resistive to reporting safety concerns. From the literature review, several recurring themes were identified when discussing safety management systems and reporting, and what may be a factor if under-reporting was identified; training, reporting system design, awareness about what is reportable, feedback, company commitment and disciplinary policy.

To assist the design of a questionnaire instrument for the current study, ideas for subject areas were derived from the discussions of the focus group and from that of the literature review. The final constructed questionnaire was accessed via an online platform and an invitation to participate was distributed via email, aviation websites and social media; it was entirely anonymous and voluntary.

5.1.1 Participants

5.1.1.1 Focus Group Participants

A focus group was organised and consisted of 5 individuals from various backgrounds in aviation including, airline, third party maintenance, line and base maintenance, engineering and continuing airworthiness management. Participants were 35-55 years of age with 10-25 years experience in the maintenance environment. Participants were advised that all data collected would be kept confidential; all notes taken during the group had no designation as to who made the input. Participants were encouraged to speak open and freely without concern of confidentiality, but were advised if they discussed matters that indicated they were involved in a wilful or deliberate act, the regulations stated that a report must be made regardless on confidentiality agreements.

5.1.1.2 Main Study Participants

One hundred and sixty surveys were returned completed, however the response rate could not be determined as the survey was available online, and distributed via email and websites. It was considered there could be group differences depending on which area of aviation, trade, qualification level, shift pattern and department a participant was employed. Table 2 provides the results from the first seven questions of the survey, which were aimed at collecting data about group differences without compromising anonymity.

Although there was no practical way to restrict which professionals would respond to the survey, there were clear instructions stating the survey was to be completed by personnel involved in aircraft maintenance. Participants were advised about ethical implications of the study and although deemed a low risk study details were provided in the introduction of the questionnaire on how to report any ethical concerns. The low risk notification letter can be reviewed in Annex E and was provided in the introduction of the online questionnaire to allow participants the opportunity to express concern if deemed necessary.

5.1.2 Materials

There were a variety of methods considered when deciding on the most efficient way to collect the data in the current study. The main objective was to ensure participants had a sense of security that the questions asked could be answered open and freely without concern or fear that responses given would be shared on a company level. Therefore it was believed an online questionnaire could provide the greatest degree of anonymity to the participant. Using an online platform to distribute questionnaires meant there was no direct contact with participants or organisations. The option to complete the questionnaire was completely voluntary with no outside pressure from an organisation on a participant to complete (or not complete) the survey. The guarantee of anonymity was the driving force to use an online questionnaire rather than other methods available. The lack of research into reporting system usage in aircraft maintenance prompted the development of a survey tool from an extensive literature review and conducting a focus group with front-line maintenance personnel who had wide-ranging experience in the industry.

An online survey tool Google Forms was used to collect data for the main study. Rudestam (2007) described the advantages and disadvantages of using the internet as a platform for questionnaire distribution. It was highlighted there may be bias in terms of computer access and computer know-how; however it was noted that there was also the possibility of obtaining geographical diverse results that may not be available when using traditional data collection strategies. In aviation studies this is an important factor, reaching a wider audience across several continents is important to applying the results to the larger population. Also, many participants seem to trust and appreciate the anonymity they have by addressing a machine rather than the researcher directly (Rudestam 2007), which was the main deciding factor for using an online survey as a method of collecting data.

There was very little research available related to under reporting and reporting system usage in aircraft maintenance, although there was extensive research available on safety management systems, which included reporting platforms. The items that made up the current survey were therefore derived from a review of past and current research that identified the main underlying problems in current reporting systems utilised in safety management systems, and feedback from the focus group discussions.

In total, the questionnaire comprised of 50 items; the first seven were related to demographics to help differentiate variables between different groups and participants had the opportunity to make only one selection. The remaining survey questions were based on five recurring topics, determined during the literature review and discussions during the focus group, and considered to be the main issues challenging reporting systems:

Questions 10,13, 30 & 31 were associated with overall reporting system experience and effectiveness; the questions were related to the survey as a whole and not as a single topic. It was not intended to group these questions together with the aim of reducing the possibility of a response set. The items were dispersed throughout the survey and because of this the question numbering may not be sequential in the following paragraphs.

Questions 8, 9 & 12: do maintenance personnel report concerns they may have about safety?

The primary aim of the study was to establish if a reporting system was available, was it being utilised and what was the frequency of reports made in order to confirm reporting system usage by aircraft maintenance personnel. From the literature review there was very little available about the usage of reporting systems by maintenance personnel, current studies focussed mainly on the type of reports made rather than the quantity of reports submitted compared to errors made. CAP 718 (2002), ASAP (as reviewed by Patankar, 2006), ASRS (2013), Boeing MEDA (2013), and CAA NZ (2015), all provided analysis of maintenance error reported, but they did not provide details of who made the reports (maintenance personnel, pilots, ATC, etc.), number of engineers that are mandated to report to reports made, or how many reports were made before an incident or accident occurred. Discussions from the focus group suggested that maintenance personnel were not using the reporting systems available, internal or external, yet studies available were showing that maintenance error was playing a significant part in aviation safety and this was highlighted from the maintenance reports that were received. The current survey wanted to show how many reports a participant had made in total (not just within the current company), this would then be considered with a participant's experience during the analysis, it was considered that a person with more years experience should have made a greater number of reports throughout their career, if reporting systems were being utilised by engineers.

Questions 11, 14, 15, & 16: reporting system design

Leveson (2011) highlighted reporting system design as one of the main causes as to why reporting systems fail. She found poorly designed systems that were difficult to access or contained unrelated questions tended to deter would be reporters. Leveson (2011) also noted reporting forms that were too long or had too many written responses prevented system usage. This theory was supported by Pace et al. (2003) who found one main reason for under reporting was poorly designed reporting systems; difficulty in accessing the system, unrelated questions asked of the reporter, or time consuming reporting forms were some of the factors found in a poorly designed reporting system. O'Leary and Chappell (1996) highlighted issues with form design; correct format, length and content of a reporting form were vital to ensure system usage. The reporting form was the first exposure to the reporting system, if engineers' were deterred from the first point there was limited chance of high system utilisation. A form too long will require a great deal of time to complete, if too short there may not be enough information to conduct a thorough analysis, if questions were too difficult or unrelated they might go unanswered, written responses may provide greater detail or a more realistic picture, but make the form longer to complete and make it difficult to categorise the error in the reporting system. Reporting system design was discussed in the focus group, participants commented that the ease of use of their own reporting system was not a factor discouraging reporting, but did note that if questions were not related to their job area, or if a report took too long to complete, this would affect their decision to report. The main study questions relating to reporting system design asked if the system was easy to access (Q11), ease of use (Q14), amount of information that had to be supplied (Q15) and relevancy of questions asked (Q16).

Questions 17-19: is it known what to report?

Expectations related to what should be reported were not readily available in existing literature. Hobbs, 2004; Patankar, 2006; Zhang, 2006, all discussed apparent confusion as to what to report, a side effect being personnel will choose not to make an effort to submit a report. Current regulations were reviewed (CASA, EASA, FAA, TSB, etc.), but the law could be ambiguous leaving room for interpretation about what was classified as reportable. Additionally, the law only provided guidance on mandatory reporting, and although the regulations on occasion made references to non-mandatory reporting, gave no guidance on what this encompassed. McDonald et al., 2000; Patankar, 2006; Dekker, 2009; and Gilbey et al., 2015, all observed that under reporting may be linked to lack of error awareness; personnel involved in an error may not realise it as such, without the awareness of what is deemed as reportable it cannot be expected to have maintenance personnel utilising reporting tools.

The focus group discussed the definition of reportable error and it was apparent there was no real understanding as to what their organisations expected. Not all participants were aware of the regulations applicable to error reporting although all had held the position of LAME at some point in their career. Generally, all participants felt a duty to report, but when asked what they deemed as reportable it could not be determined.

Questions 20-23: training

One of the main recurring themes from the literature review was the importance of training. Several questions relating to frequency of training and if training would change attitudes towards reporting systems were deemed necessary to be included. Patankar et al. (2008) discussed the shortfalls in training that led to employees and management expectations to diverge, without understanding the intent of the company and the reporting system, employees will not engage in an active reporting system. Reason (1997) highlighted the importance of training for a successful reporting system, and both ICAO (2013) and EASA (2014) emphasised the importance of training in order for personnel to understand what is required from them to support the management of error.

Participants in the focus group discussed the types of trainings they had received with regards to reporting and their company's system. Not everyone had received the same level of training and participants who had received training appeared far more supportive of their company's reporting system. Participants noted training was restricted to their own company's reporting system and its use, they felt that there was uncertainty existing around what the organisation's expectations were with regards to what was reportable in aircraft maintenance, although the goal of the system was to improve safety. All participants had a lack of confidence in the company’s ability to label what was reportable error, making it difficult for an organisation to effectively provide training relevant to identifying reportable error. If the organisation could not define their expectations of what should be reported providing the correct training to system users would not be achievable.

Questions 24-29, & 32: feedback

These questions were related to feedback received from reports made and changes observed. Leveson (2011) reported lack of feedback gives employees the impression nothing happens after a report is made. If a potential reporter believes a report will go unattended or is not aware of the process behind a report being made it may be considered as to why make an effort at the outset. Sarter & Alexander (2000) also supported this theory, which claimed that to uphold a successful reporting and data-monitoring system the feedback loop must be in place, without this reporters become despondent in the effectiveness of the system and their role in reporting. Reason (1997) discussed the importance of feedback not only for the reporter, but for the organisation itself. An organisation can only measure the success of its system by the measure of the outputs. This means that there should be change observed, processes harmonised or reduction in hazards to show the system was functioning correctly which should be achieved as part of the feedback loop.

The focus group highlighted the lack of feedback in their organisations and in previous companies where they had worked. They confirmed that lack of feedback would prevent them following up with a report after an error was committed or detected. It was also commented that lack of observed change in their respective departments made participants feel that perhaps reports made were either deemed unimportant, or there was no structure behind the reporting system and no-one was performing the necessary follow up. Question 32 asked if the company had a dedicated safety department / safety personnel as it was considered employees may have more confidence in the system if they thought there was dedicated personnel to oversee the reporting process. It was also considered that a dedicated department could ensure all reports submitted would be reviewed and investigated, more so if an existing department held the responsibility in addition to their normal daily responsibilities.

Questions 32-40: company support / awareness

Making a report is just the first step of a much larger process and it was considered understanding the complete procedure may support the decision to report. Dekker (2009) & Leveson (2011) both believed that if employees knew the procedure behind the system and felt involved in the process they may be more motivated to use the system and find it an effective tool to support their function. When discussed during the focus group there was a lack of awareness to what happens to a report once it was submitted. When asked if awareness of the process would encourage reporting it was conferred this knowledge would provide a level of confidence that something does happen after a report is submitted, but there was no necessity to know all the steps or inner workings of the complete process.

The aim was to explore whether participants believed current reporting systems were effective as a tool to improve safety within their company (questions 30, 37 & 38). Support from management was noted as an important factor within an organisation to support error management (Reason, 1997; McDonald, 2000; Hobbs, 2004; Dekker, 2009). If it was perceived management were using reports for evil instead of good the system would not be utilised; distrust in the system, management, or the company would ensure the failure of the system (Dekker, 2009).

It was considered a company's disciplinary policy might have an effect on the desire to report (questions 39 & 40). Blame culture in aircraft maintenance has been discussed extensively (McDonald, 2000; Hobbs, 2004; Patankar & Driscoll, 2004; Dekker, 2009; Ward, 2010) and is found to be still of concern (ICAO, 2013; EASA, 2014). It has been reported that without a non-punitive approach to error reporting there is minimal support for a successful reporting system. Maintenance personnel must sense a willingness to report their mistakes or a colleague's error, and reports submitted will not be met with blame and punishment, but will be reviewed in context to what the intent of the action was. The focus group discussed extensively about disciplinary actions and support of management. It was apparent there was some reservation as to whether a just culture actually existed within the organisation; although a company would promote a no blame policy, there was scepticism as to whether to put this to the test, better to be safe and not report rather than find out the company's just culture does not actually exist.

Questions 41-46: maintenance personnel responsibilities

The last set of questions were aimed at determining maintenance personnel understanding of professional expectations with regards to the reporting system. McDonald (2000) discussed not only the reluctance to report a error made personally, but also errors discovered that may have involved a colleague; it was difficult enough to place trust in the organisation to report ones own behaviour, but to report a colleague may feel like a betrayal. Hobbs (2004) noted that it was an engineer's nature upon discovery of an error to just get on with the job of rectification, that reporting was not even considered, questions 41 & 42 asked if a participant would report one's own error and colleagues' if observed or discovered. Questions 45 & 46 asked if reporting to a supervisor was an alternative way of reporting. Although this was not noticed as a point in the literature review, during the focus group discussion it was presented as a viable alternate to self-reporting. It was considered the supervisor in charge of the entire aircraft should take on the responsibility of reporting a pre existing error found during maintenance and not the person of discovery.

The questionnaire was pretested on 7 volunteers from the maintenance and engineering environment to confirm applicability of questions and length of time needed to complete the survey, taking around 5-10 minutes to complete. It was important to keep the time to complete the questionnaire to a minimum primarily to ensure the survey was attempted and secondly to safeguard the questionnaire completion in full. A total of 48 questions were retained in the final survey, two items were removed; does your company have a separate reporting system for maintenance? and; does your company support error reporting for continuous improvement? Feedback from the pretest suggested that these two items were confusing or not quite capturing the intent of what was to be established from the answers received. Table 1 provides details of the questions and their response options (Q1-46). Question 47 gave the opportunity to provide written feedback on any of the 46 questions. Lastly, question 48 was related to personality similarities and was a shorthand version of the Big Five Personality Test. All questions were designed to be clear and concise, with only one response possible.

Table 1*: Online Survey Questions*

Questions								
1	In which area of aviation do you currently work?							
Response Options:	Airline =1	Third Party Maintenance =2	Manufacturer =3	Aviation Support =4	Other =5			
2	What is your trade?							
	Mechanical = 1	Avionics = 2	Support Staff =3	Other =4				
3	What is your current level?							
	Licensed Engineer =1	Mechanic =2	Supervisor / Team Leader =3	Manager =4	Support Staff = 5	Other =6		
4	Total number of years experience?							
	0-5 years =1	6-10 years =2	10-20 years = 3	+20 years =4				
5	What is your current shift pattern?							
	Days only =1	Nights only =2	Days & nights =3	Earlies & lates =4	Other =5			
6	Are you permanently employed by your current company?							
	Yes =1	No=2						
7	Which department do you currently work in?							
	Base mainten ance =1	Line mainten ance =2	Engineering =3	Work-shop =4	Maintenance Control =5	Quality =6	Design (-)	Production =7	Other =8
8	How likely are you to report an error?							
	Never =1	*Not likely =2*	*Don't know =3*	*Likely =4*	*Very likely =5*			

9	How many reports have you made in the past?	*None =1*	*1-3 =2*	*4-7 =3*	*8+ =4*	
10	Does your current company actively promote the use of their reporting system?	*Not at all =1*	*Slightly =2*	*Don't know =3*	*Moderately =4*	*Very =5*
11	Is your company's reporting system easy to access?	*Completely inaccessible =1*	*Fairly inaccessible =2*	*Fairly accessible =3*	*Completely accessible =4*	*Never tried to access =5*
12	Have you made a report using the company's system?	*Yes =1*	*No =2*	*Not applicable (no system) =3*		
13	If used how would you rate your experience with the company's system?	*Very poor =1*	*poor =2*	*Fair =3*	*Good =4*	*Very good =5*
14	Did you find the company's reporting system easy to use?	*Very difficult =1*	*Moderately difficult =2*	*Moderately easy =3*	*Very easy =4*	*Never used the system =5*
15	Did you find the amount of information you had to supply excessive?	Extremely excessive =1	*Very excessive =2*	*Moderately excessive =3*	*Slightly excessive =4*	*Just the right amount = 5*
16	Did you find the questions of the company's reporting system relevant to your job / area?	*Not related at all =1*	*Somewhat related =2*	*No opinion =3*	*Related =4*	*Fully related =5*
17	How much do you know about mandatory reporting?	*Not related at all = 1*	*Not much =2*	*No opinion =3*	*Some =4*	*A great deal =5*
18	How much do you know about non-mandatory reporting?	*Not related at all = 1*	*Not much =2*	*No opinion =3*	*Some =4*	*A great deal =5*
19	Are you likely to report a non-mandatory error?	*Not at all =1*	*Not likely =2*	*Don't know =3*	*Likely =4*	*Very likely =5*
20	Does your company make you aware about reportable events?	*Not at all =1*	*Slightly aware =1*	*Don't know =3*	*Moderately aware =4*	*Fully aware =5*
21	How often does your company provide training on reporting?	*Never = 1*	*Seldom = 2*	*Sometimes = 3*	*Often = 4*	*Regularly = 5*

22	How likely are you to report an error if the company provided training on what should be reported?					
Response Options:		*Not at all = 1*	*Not likely = 2*	*Don't know = 3*	*Likely =4*	*Very likely = 5*
23	Do you agree with the following statement: If my company provided more awareness about the company reporting system I would be more likely to report an error.					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
24	How often have you received feedback from any report made?					
		Never =1	*Rarely =2*	*Sometimes =3*	*Often =4*	*Always =5*
25	Does the current system provide feedback to the reporter?					
		Never =1	*Rarely =2*	*Sometimes =3*	*Often =4*	*Always =5*
26	How often have you received feedback from any report made?					
		Never =1	*Rarely =2*	*Sometimes =3*	*Often =4*	*Always =5*
27	Do you think there is any benefit in sharing information company wide on the findings / results from the investigation?					
		No benefit =1	*Slight benefit =2*	*No opinion =3*	*Moderate benefit =4*	*Great Benefit =5*
28	Were there any noticeable changes in your department from reports made?					
		Insignificant =1	*Minor =2*	*No opinion =3*	*Some noticeable =4*	*Significant =5*
29	If you were made aware that changes in your department were a result of reports made would this be a reason to report more often?					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
30	Do you think the current reporting system is effective?					
		Ineffective =1	*Needs development =2*	*Somewhat effective =3*	*Capable and effective =4*	*Very effective =5*
31	Do you think your current reporting system is a supportive tool for making improvements in safety in your current company?					
		Unsupportive =1	*Somewhat supportive =2*	*No opinion =3*	*Moderately supportive =4*	*Supportive =5*
32	Does your company have a dedicated safety department and / or safety personnel?					
		Yes =1	*No =2*	*Not applicable (no system) =3*		

33	Do you know the process after a report is submitted?					
Response Options:		*No idea =1*	*A little of an idea =2*	*Some idea =3*	*I know the complete process =4*	*Do not care =5*
34	Do you agree with the following statement: Knowing what the process is after a report is submitted would support my decision to report.					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
35	Do you have a level of confidence within the company that your report will be investigated thoroughly?					
		No confidence =1	*Slightly confident =2*	*No opinion =3*	*Moderately confident =4*	*Very confident =5*
36	Do you feel from making a report you will be making a difference to the company's safety system?					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
37	Do you agree that reporting within the company is supported at all levels including management?					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
38	Would the company's current attitude towards reporting encourage you to report error?					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
39	Would you agree the company's current attitude towards reporting encourages you to report?					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
40	If your company had a supportive disciplinary system would you be more encouraged to use the reporting system?					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
41	Would you submit a report about an error you found whilst performing your own task?					
		Never =1	*Considerably unlikely =2*	*Unlikely =3*	*Considerably likely =4*	*Extremely likely =5*
42	Would you submit a report about an error you found whilst performing your own task?					
		Never =1	*Considerably unlikely =2*	*Unlikely =3*	*Considerably likely =4*	*Extremely likely =5*

43	Do you agree with the following statement: After rectifying an error or averting an incident a report should still be made.					
Response Options:		*Strongly disagree =1*	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
44	Do you think there is any benefit in reporting an error or incident If the situation no longer exists?					
		No benefit =1	*Slightly beneficial =2*	*No opinion =3*	*Moderately beneficial =4*	*Completely beneficial =5*
45	Do you think that reporting to a supervisor or manager is an alternate way of reporting?					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*
46	Do you think that once reporting to a manager / supervisor it is their responsibility to make an official report?					
		Strongly disagree =1	*Somewhat disagree =2*	*No opinion =3*	*Somewhat agree =4*	*Strongly agree =5*

Participants were asked to answer all questions as indicated in the questionnaire; all questions had the option to select one answer only. Question 47 gave the opportunity to provide written feedback or expand on any of the questions asked.

Finally, a 10-item short version of the Big Five Inventory (BFI) was presented (Q48). This was an abbreviated version of the BFI-44, which was used to explore whether there were noticeable personality similarities between the participants as a reason that might influence the decision to report. McDonald et al., 2000; Thomas & Taylor, 2003; Hobbs, 2004; Hampson, 2010; described the similarities LAMEs shared and the unique set of skills needed, indicating maintenance personnel may convene with a defined criteria of personality type.

Rammstedt and John (2006) reported that the abbreviated version of the Big Five Inventory (BFI-44) retained significant levels of reliability and validity, and confirmed the BFI-10 was a useful tool for research settings with limited time constraints. They chose two items for each big five dimensions (openness to experience, conscientiousness, extraversion, agreeableness and neuroticism (or emotional stability)). It was decided to use the BFI-10 to keep survey completion time below 5-10 minutes in order to ensure participants completed the questionnaire in full. Participants were prompted to give a response to each of the ten items on a Likert type scale (strongly disagree (=1), somewhat disagree (=2), either agree or disagree (=3), somewhat agree (=4), strongly agree (=5)). Each question was phrased “I see myself as someone who….”

1. is reserved
2. is generally trusting
3. tends to be lazy
4. is relaxed, handles stress well
5. has few artistic interests
6. is outgoing, sociable
7. tends to find fault with others
8. does a thorough job
9. gets nervous easily
10. Has an active imagination

Reverse scoring was applied for questions 1, 3, 4, 5, & 7, as instructed by Rammstedt and John (2006).

5.1.3 Procedure

5.1.3.1 Focus Group Procedure

A small office was made available for use allowing the focus group to take place at a neutral location, not related to any of the participant's place of work. The participants were all highly experienced licensed aircraft maintenance engineers, three of which had relocated to other areas, but still within a Part 145 organisation. The discussion lasted around three hours. The focus group discussion was organised with the intent to better understand the problems that may exist with error reporting in an aircraft maintenance environment. It was the objective to broaden understanding of the real issues existing with current reporting systems, regulations, company support; to discover whether fear of reporting still existed and if current disciplinary polices were in fact non-punitive, and if they were, did this made a difference to the decision of to report or not. Analysis of the focus group discussion was used to guide the design of the items used in the main survey, related to issues facing the maintenance environment with respect to reporting.

The focus group discussion was successful in providing greater clarity on the current issues that influence reporting decisions. An open discussion was difficult at first, but once participants started sharing their experiences and views a more open and relaxed atmosphere ensued. Participants were asked to provide real life experiences with past and present company reporting systems, experience using a regulatory run system, and if anyone had experience with an independent third party reporting system.

5.1.3.2 Main Study Procedure

The survey was accessed via an online platform and an invitation to participate was distributed via email, aviation websites and social media; no airlines or maintenance organisations were contacted directly. An online method was chosen so that maintenance personnel could feel they had freedom to comment openly about their current company without the worry of their organisation knowing they had participated in the survey or concern the results would be known to the company.

A brief description at the beginning of the survey was given to the participants providing information on the study and the basis of the questions. Participants were advised the questionnaire was completely confidential and to support this there were no questions related to which company an individual worked for. Participants were instructed to select one option for each question, and one option for each point in the last question. An independent email address was set up with the intent to provide any participant the ability to provide additional feedback.

Chapter Six: Results

The level of statistical significance was set at $\alpha = 0.05$ for all statistical tests, and all tests were conducted as two-tailed.

During the six-week data collection period, a total of 160 surveys were completed and useable, no surveys were returned spoiled or substantially incomplete. The raw survey data was imported directly to excel by the online survey program. The raw excel data was subsequently exported to SPSS (version 23) for the purpose of the analysis.

Table 2 shows the results from the first seven questions of the survey that were aimed at collecting data about group types without compromising anonymity. Table 2 provided results showing airline personnel making up the largest percentage of responses, and the majority of respondents were licensed engineers of a mechanical trade.

Table 2*: Demographic information of participants in the main study*

		Participants	
		No.	**%**
Area of Aviation	Airline	91	56.9
	Third Party Maintenance	41	25.6
	Manufacturer	3	1.9
	Aviation Support	12	7.5
	Other	13	8.1
	Total Sample	*160*	*100%*
Trade	Mechanical	106	66.3
	Avionics	21	13.1
	Support Staff	17	10.6
	Other	16	10.0
	Total Sample	*160*	*100%*

Level	Licensed Engineer	91	56.9
	Mechanic	9	5.6
	Supervisor / Team Leader	15	9.4
	Manager	26	16.3
	Support Staff	11	6.9
	Other	8	5.0
	Total Sample	*160*	*100%*
Experience	0-5 years	7	4.4
	6-10 years	33	20.6
	10-20 years	53	33.1
	20+ years	67	41.9
	Total Sample	*160*	*100%*
Shift Pattern	Days Only	63	39.4
	Nights Only	15	9.4
	Days & Nights	54	33.8
	Earlies & Lates	22	13.8
	Other	6	3.8
	Total Sample	*160*	*100%*
Department	Base Maintenance	35	21.9
	Line Maintenance	67	41.9
	Engineering	21	13.1
	Workshop	1	0.6
	Maintenance Control	14	8.8
	Quality	11	6.9
	Production	3	1.9
	Other	8	5.0
	Total Sample	*160*	*100%*

6.1 Reporting Likelihood

Survey questions 8 & 9 were related to likelihood to report and the number of reports an individual had made in the past. One-way ANOVA was used to determine if there was any significant difference. Table 3 provides evidence that there is no significant difference between the likelihood to report (Q8) and area, trade, level, shift pattern and department currently employed.

Table 3*: Relationship between demographics and likelihood to report an error*

Demographics	ANOVA		
	df	*F*	*sig*
Area (Q1)	4, 155	2.08	.09
Trade (Q2)	3, 156	.06	.98
Level (Q3)	5, 154	4.77	.66
Experience (Q4)	4, 156	7.38	<.001
Shift (Q5)	4, 155	*2.43*	*.05*
Department (Q7)	4, 155	*2.53*	*.04*

It can be seen there was a significant difference in likelihood of an individual to report an error (Q8) and experience in the industry (Q4), $F(3,156) = 7.38$ $p < 0.001$. *Post hoc* comparisons (HSD) indicated individuals with 0-5 years experience were the more likely to report an error ($M = 4.44$) than individuals with 6-10 years of experience ($M = 2.82$).

There was no evidence the number of reports participants had made in the past (Q9) were affected by any of the comparisons made as shown in table 4, suggesting a participant's decision to report (or not report) was unrelated to their area of employment, trade, experience level, current shift pattern, or department currently assigned.

Table 4*: Relationship between demographics and how many reports an individual made*

Demographics	ANOVA		
	df	*F*	*sig*
Area (Q1)	3, 156	.44	.78
Trade (Q2)	3, 156	3.52	.03
Level (Q3)	3, 154	3.64	.01
Experience (Q4)	3, 156	2.57	.09
Shift (Q5)	4, 155	4.66	.01
Department (Q7)	7, 152	2.23	.04

How many reports a participant had made in the past gave a low calculated mean as shown in table 5 which may be indicative of lack of reporting, therefore table 6 provides a breakdown of frequency of responses when asked how many reports had been made in the past.

Table 5*: Descriptive statistics showing mean and SD of participants decision to report*

Question		*M*	*SD*	*N*
08	How likely are you to report an error?	3.59	1.200	160
09	How many reports have you made in the past?	1.87	1.082	160

Table 6 provides a breakdown of frequency of responses when asked how many reports had been made in the past. Fifty three percent of respondents indicated they had never made a report, whilst 19% claimed to only have made between 1-3 reports in the past.

Table 6*: Frequency of previous reports*

Number of reports made	Frequency	Percentage %
None	85	53.1
1-3	31	19.4
4-7	24	15.0
8+	20	12.5
Total	*160*	*100*

6.2 Reporting System Design

Questions were related to ease of access, ease of use, amount of information to be supplied and applicability of questions with regards to a participant's reporting system. Respondents were then asked about their overall experience with the reporting system.

There was no evidence that the dependent variables relating to reporting system design (as listed in table 7) differed according to participants' area of aviation (Q1), trade (Q2), employment level (Q3), experience (Q4), shift pattern (Q5), and department currently employed (Q7); in all cases $p > 0.05$, suggesting a participant's current reporting system design did not affect whether a person used the reported system.

Table 7*: Descriptive statistics showing mean and SD of participants' response to reporting system design*

Question		*M*	*SD*	*N*
10	Does your current company actively promote the use of their reporting system?	3.57	1.371	159
11	Is your company's reporting system easy to access?	3.38	.863	159
14	Did you find the company's reporting system easy to use?	3.30	.803	149
15	Did you find the amount of information you had to supply excessive?	3.83	1.028	143
16	Did you find the questions of the company's reporting system relevant to your area / job?	2.58	1.296	160
13	If used how would you rate your experience with the company's reporting system	3.16	1.044	141

Promoting the use of their reporting system (Q10) and area of aviation (Q1) showed a statistical difference, $F(4,154) = 2.98$, $p = 0.02$. *Post hoc* comparisons (HSD) revealed that airlines ($M = 3.84$) appeared to be more active in promoting their reporting systems than third party maintenance organisations ($M = 2.98$).

6.3 Knowledge about Reportable Error

Survey questions were aimed at discovering if participants were aware of what should be reported. The mean and *SD* of items measuring knowledge of reporting types and training may be examined in Table 8.

Table 8: *Descriptive statistics showing mean and SD of participants' knowledge of reportable events*

Question		*M*	*SD*	*N*
17	How much do you know about mandatory reporting?	3.94	1.005	158
18	How much do you know about non-mandatory reporting?	3.48	1.217	157
19	Are you likely to report a non-mandatory error?	3.03	1.140	157

Knowledge about mandatory reporting (Q17) differed between the different areas of aviation participants were employed (Q1), $F(4,153) = 3.78$, $p = 0.005$). *Post-hoc* comparisons (HSD) revealed that airline-employed engineers were more aware of what were mandatory reportable events ($M = 4.13$) than engineers employed by third party maintenance organisations ($M = 3.45$). Knowledge of non-mandatory reporting (Q18) also confirmed a difference between areas of aviation (Q1), $F(4,152) = 6.057$, $p = 0.001$. The *post-hoc* comparison (HSD) confirmed airline-employed engineers were again more aware about what was reportable ($M = 3.73$) than third party maintenance employees ($M = 2.74$).

Employment level (Q3) and knowledge about mandatory reporting (Q17) showed a significant difference between groups, $F(5,152) = 3.72$, $p = 0.003$. The *post-hoc* comparison (HSD) confirmed managers indicated to know more about mandatory reporting ($M = 4.65$) than licensed engineers ($M = 3.81$) although both groups claimed to know a great deal. Knowledge of mandatory reporting (Q17) and experience level also showed some group variance as shown in table 9. *Post-hoc* comparison (HSD) established participants with more experience (10-20+ years) had greater knowledge of what was a reportable event than the less experienced (0-10 years). This was a similar result for non-mandatory reporting; *post-hoc* comparison (HSD) showing participants with more experience had greater knowledge.

There were no other significant differences with respect to trade (Q2), shift pattern (Q5), and department currently employed (Q7), and comparison with Q17 & 18 (awareness of reportable events) as presented in tables 9 & 10.

Table 9*: Relationship between demographics and how much a participant knows about mandatory reporting*

Demographics	**ANOVA**		
	df	***F***	***sig***
Area (Q1)	4, 153	3.78	.005
Trade (Q2)	3, 154	1.19	.32
Level (Q3)	5, 152	3.72	.003
Experience (Q4)	3, 154	5.29	.002
Shift (Q5)	4, 153	1.95	.10
Department (Q7)	7, 150	1.42	.02

Table 10*: Relationship between demographics and how much a participant knows about non-mandatory reporting*

Demographics	**ANOVA**		
	df	***F***	***sig***
Area (Q1)	4, 152	7.95	<.001
Trade (Q2)	3, 153	.65	.58
Level (Q3)	5, 151	3.34	.07
Experience (Q4)	3, 153	13.81	<.001
Shift (Q5)	4, 152	3.01	.08
Department (Q7)	7, 149	1.39	.21

Likelihood of reporting non-mandatory error (Q19) differed between areas of aviation worked (Q1), $F(4,152) = 4.68$, $p < 0.001$. *Post-hoc* comparisons (HSD) revealed that airline-employed engineers were more likely to report ($M = 3.22$) than engineers employed by third party maintenance organisations ($M = 2.46$). Employment level (Q3) and the likelihood of reporting a non-mandatory error (Q19) showed difference between groups, $F(5,151) = 3.55$, $p = 0.005$. P*ost-hoc* comparison (HSD) confirmed managers were the most likely to report ($M = 3.69$) and licensed engineers the least likely (M = 2.78). Non-mandatory reporting (Q19) and experience level also showed some group variance as shown in table 11. *Post-hoc* comparison (HSD) established participants with more experience (20+ years) were more likely to report ($M = 3.33$) than less experienced participants, 0-5 years ($M = 2.71$) and 6-10 years ($M = 2.34$).

Table 11*: Relationship between demographics and likelihood of reporting a non-mandatory error*

Demographics		**ANOVA**	
	df	***F***	***sig***
Area (Q1)	4, 152	4.68	<.001
Trade (Q2)	3, 153	2.88	.04
Level (Q3)	5, 151	3.55	.005
Experience (Q4)	3, 153	6.27	<.001
Shift (Q5)	4, 152	3.79	.01
Department (Q7)	7, 149	1.64	.13

There was no evidence in the likelihood to report a non-mandatory error (Q19) differing according to participants' trade (Q2), shift pattern (Q5), or department currently employed (Q7).

6.4 Training

Questions related to training are listed in table 12 with their reported mean and *SD*. Survey questions were aimed at determining if an organisation was providing the correct training related to system usage, error identification, and company expectations.

Table 12*: Descriptive statistics showing mean and SD of participants response to training*

Question		*M*	*SD*	*N*
20	Does your company make you aware about what are reportable events?	3.19	1.397	159
21	How often does your company provide training on reporting	2.58	1.240	159
22	How likely are you to report error if the company provided training on what should be reported?	3.91	.845	159
23	If my company provided more awareness about the company reporting system I would be more likely to report an error	3.91	.84	159

Being made aware of reportable events from the company (Q20) displayed no significant differences when compared across area of aviation (Q1), trade (Q2), employment level (Q3), experience (Q4), shift pattern (Q5), and department currently employed (Q7), and whether a participant would report; in all cases $p > 0.05$ as shown in table 13.

Table 13*: Relationship between demographics and being made about reportable events*

Demographics	ANOVA		
	df	***F***	***sig***
Area (Q1)	4, 154	5.25	.03
Trade (Q2)	3, 155	1.10	.35
Level (Q3)	5, 153	2.30	.05
Experience (Q4)	3, 155	3.21	.03
Shift (Q5)	4, 154	1.52	.20
Department (Q7)	7, 151	1.07	.38

The frequency of training (Q21) did not differ with respect to area of aviation (Q1), trade (Q2), current level (Q3) or department currently employed (Q7); in all cases $p > 0.05$.

There was a positive correlation between the degree to which the company made employees aware about reportable events (Q20) and how much participants' knew about mandatory error (Q17) $r_s = .53$, $p < .001$. This was also the case for non-mandatory reporting (Q18) and the company providing awareness about what is reportable (Q20) $r_s = .36$, $p < .001$. If the company were to make employees aware about what was reportable (Q20) an individual was more likely to report an error (Q8) $r_s = .37$, $p = .005$. It could also be shown that if the company provided training on what was reportable (Q22) an individual would be more likely to report an error (Q8) $r_s = .49$, $p < .001$, with 76% of respondents indicated they would be more likely to report an error if they were provided training on what should be reported.

6.5 Feedback

Questions relating to feedback, as listed in table 14, were aimed at determining the frequency and usefulness of feedback received.

Table 14*: Descriptive statistics showing mean and SD of participants response to frequency and usefulness of feedback*

Question		*M*	*SD*	*N*
24	How often have you received feedback from any report made?	2.99	1.387	156
25	Does the current reporting system provide feedback to the reporter?	3.01	1.464	153
26	Does the current reporting system provide feedback company wide?	2.69	1.287	155
27	Do you think there is any benefit in sharing information company wide on the findings / results from the investigation?	4.52	.802	159
28	Were there any noticeable changes in your department from reports made?	2.88	1.329	156
29	If you were made aware that changes in your department were a result of reports made would this be a reason to report more often?	4.11	.785	160
32	Does your company have a dedicated safety department and / or safety personnel?	3.09	1.418	158

One-way ANOVA was used to determine if there was any significant difference between groups. Frequency of feedback received from a report made (Q24) did not differ with respect to area of aviation (Q1), trade (Q2), current level (Q3), experience (Q4), shift pattern (Q6) or department currently employed (Q7); in all cases $p > 0.05$. When asked if a participant's current reporting system provided feedback (Q25) there was a significant difference reported in area of aviation employed, $F(4,148) = 5.109$, $p < .001$. *Post hoc* comparisons (HSD) revealed a difference existed between airline employed personnel ($M = 3.37$) who were more likely to receive feedback than third party maintenance personnel ($M = 2.20$). No other statistical differences were observed; in all other cases $p > 0.05$. When asked if a participant's current reporting system provided feedback company-wide (Q26) there was no significant group difference with respect to area of aviation (Q1), trade (Q2), current level (Q3), experience (Q4), shift pattern (Q6) or department currently employed (Q7); in all cases $p > 0.05$.

Comparison between the likelihood of reporting an error (Q8) and having a dedicated safety department (Q32) presented a statistical difference, $F(2,157) = 12.76$, $p < 0.001$. *Post hoc* comparisons (HSD) indicated an individual was more likely to report an error ($M = 3.84$) if the participant was aware that there was a safety department to one who was unaware of a dedicated safety department ($M = 2.47$). There was no evidence showing that having a dedicated safety department (Q32) made a difference to the frequency of receiving feedback (Q25), $F(2,153) = 2.2$ $p = 0.113$.

6.6 Company Support / Awareness

There were 11 questions related to individual awareness about the reporting process, perceived management support for the current system, observed effectiveness of the reporting system and supportiveness of the current disciplinary policy, as shown in table 15.

Table 15*: Descriptive statistics showing mean and SD of participants response to company support & awareness of the reporting system*

Question		*M*	*SD*	*N*
30	Do you think the current reporting system is effective?	2.82	1.144	156
31	Do you think your current reporting system is a supportive tool for making improvements in safety in your current company?	3.58	1.201	158
32	Does your company have a dedicated safety department and / or safety personnel?	2.82	1.144	156
33	Do you know the process after a report is submitted?	3.58	1.201	158
34	Do you agree with the following statement: Knowing what the process is after a report is submitted would support my decision to report.			
35	Do you have a level of confidence within the company that your report will be investigated thoroughly?	3.09	1.418	158
36	Do you feel from making a report you will be making a difference to the company's safety system	3.57	1.131	158
37	Do you agree that reporting within the company is supported at all levels including management	3.31	1.224	157
38	Would the company's current attitude towards reporting encourage you to report error?	3.26	1.223	156
39	Would you agree the company's current disciplinary policy supports reporting	3.12	1.189	157
40	If your company had a supportive disciplinary system would you be more encouraged to use the reporting system	4.00	.855	157

Using one-way ANOVA it was anticipated to confirm if any statistical difference existed between perceived effectiveness of the reporting system (Q30) and the demographic factors shown in table 16. Effectiveness of the reporting system (Q30) and area of aviation employed (Q1) showed a significant difference, $F(4,151) = 4.12$, $p = 0.003$. *Post hoc* comparisons using the Tukey showed participants employed by an airline ($M = 3.01$) believed their reporting system was more effective than participants employed by a third party maintenance organisation (*M* = 2.24). Effectiveness of the reporting system (Q30) and current employment level (Q3) showed a statistical difference $F(5,150) = 4.54$, $p < 0.001$. *Post hoc* comparisons (HSD) showed that management (*M* = 3.62) regarded the reporting system as being more effective than a LAME (*M* = 2.56).

Table 16*: Relationship between demographics and knowing the complete reporting system process*

Demographics	ANOVA		
	df	*F*	*sig*
Area (Q1)	4, 151	4.12	.003
Trade (Q2)	3, 152	2.72	.05
Level (Q3)	5, 150	4.54	<.001
Experience (Q4)	5, 152	4.07	.008
Shift (Q5)	4, 151	2.93	.23
Department (Q7)	7, 148	2.38	.03

Supportiveness of the reporting system (Q31) and area of aviation employed (Q1) showed a statistical difference, $F(4,153) = 3.82$, $p = 0.005$. *Post hoc* comparisons (HSD) showed a statistical difference between airline employed participants (*M* = 3.81) felt their system was more supportive than third party maintenance employees (*M* = 2.98). No other statistical differences were apparent; in all cases $p > .05$. Supportiveness of the reporting system (Q31) and experience level also showed some group difference as shown in table 17. *Post-hoc* comparison (HSD) determined participants with more experience, 10-20 years (*M* = 3.33) and +20 years (*M* = 3.68) believed the current reporting system was a more supportive tool compared to participants with less experience, 6-10 years (*M* = 2.82).

Table 17*: Relationship between demographics and supportiveness of the current reporting system*

Demographics	ANOVA		
	df	***F***	***sig***
Area (Q1)	4, 153	3.82	.005
Trade (Q2)	3, 154	1.94	.13
Level (Q3)	5, 152	4.55	.01
Experience (Q4)	3, 154	8.72	<.001
Shift (Q5)	4, 153	3.60	.01
Department (Q7)	7, 150	1.72	.11

Level of confidence (Q35) and level of employment within the company (Q3) showed a statistical difference, $F(4,152) = 7.10$, $p < .001$. *Post hoc* comparisons using the Tukey showed management had a greater level of confidence in the system ($M = 4.35$) than a LAME ($M = 2.77$) and an AME ($M = 2.22$). Level of confidence (Q35) and experience level (Q4) also showed some group difference as shown in table 18. *Post-hoc* comparison (HSD) established participants with more experience, 20+ years ($M = 3.43$) had a greater level of confidence in the system than participants with between 6-10 years experience ($M = 2.35$). These were the only group with differences observed; in all other cases $p > .05$.

Table 18*: Relationship between demographics and a company's current attitude encouraging reporting*

Demographics	ANOVA		
	df	*F*	*sig*
Area (Q1)	4, 153	3.3	.01
Trade (Q2)	3, 154	3.51	.02
Level (Q3)	5, 152	7.10	<.001
Experience (Q4)	3, 154	4.56	.005
Shift (Q5)	4, 156	.97	.33
Department (Q7)	7, 150	1.72	.11

Support for the reporting system at all levels of the company (Q37) and area of aviation employed (Q1) showed a statistical difference, $F(4,152) = 4.51$, $p = 0.002$. *Post hoc* comparisons (HSD) showed participants employed at an airline ($M = 3.48$) observed greater support throughout the organisation than participants from a third party maintenance organisation ($M = 2.68$). Level of employment (Q3) and perceived company support (Q37) showed a significant difference, $F(5,151) = 5.33$, $p < .001$. A *post hoc* comparison (HSD) showed that managers ($M = 4.28$) conveyed a greater belief that support was apparent throughout the company than LAMEs ($M = 3.03$). Table 19 provides full details of questions relating to perceived company support and the relationship with area, trade, level, experience, shift pattern and department employed.

Table 19*: Relationship between demographics and perceived support throughout the company*

Demographics	ANOVA		
	df	*F*	*sig*
Area (Q1)	4, 152	4.51	.002
Trade (Q2)	3, 153	2.73	.05
Level (Q3)	5, 151	5.33	<.001
Experience (Q4)	3, 153	4.30	.006
Shift (Q5)	4, 152	3.50	.03
Department (Q7)	7, 149	2.40	.02

A participant's current company and its level of encouragement for the reporting system (Q38) was compared with the demographic factors as listed in table 20 using one-way ANOVA. Employment level (Q3) provided a significant difference when compared with the company's encouraging attitude towards reporting (Q38). A *post hoc* comparison (HSD) showed that management ($M = 4.27$) had a greater belief that current company support was encouraging reporting compared to a LAMEs perception ($M = 2.97$). There were no other group differences evident; in all other cases $p > .05$.

Table 20*: Relationship between demographics and company's current attitude encouraging reporting*

Demographics	**ANOVA**		
	df	***F***	***sig***
Area (Q1)	4, 151	2.92	.006
Trade (Q2)	3, 152	3.04	.03
Level (Q3)	5, 150	5.25	<.001
Experience (Q4)	3, 153	3.86	.01
Shift (Q5)	3, 152	3.63	.03
Department (Q7)	7, 148	2.18	.04

Whether a company's disciplinary policy was perceived as supportive (Q39) was compared for any relationship with area (Q1), trade (Q2), level (Q3), experience (Q4), shift pattern (Q5) and department employed (Q7). Table 21 provides the results from the one-way ANOVA comparison. Current level of employment (Q3) and perception of the disciplinary policy showed significant difference, $F(4,151) = 4.49$, $p < .001$. *Post hoc* comparisons (HSD) showed management ($M = 3.96$) had a greater confidence the current disciplinary policy was supportive compared to a LAMEs perception ($M = 2.91$). There were no other group differences evident; in all other cases $p > .05$.

Table 21*: Relationship between demographics and company's current disciplinary policy supporting reporting*

Demographics	**ANOVA**		
	df	***F***	***sig***
Area (Q1)	4, 152	2.97	.02
Trade (Q2)	3, 153	2.15	.10
Level (Q3)	5, 151	4.49	<.001
Experience (Q4)	3, 153	1.99	.12
Shift (Q5)	4, 152	3.41	.01
Department (Q7)	7, 149	2.15	.04

There was evidence of a positive relationship existing between the likelihood of reporting an error (Q8) and effectiveness of the system (Q30) $r_{s} = .42$, $p < .001$. There was also evidence of a positive relationship between likelihood to report an error (Q8) and if a supportive disciplinary policy existed (Q39) $r_{s} = 0.339$, $p < 0.01$. Lastly, a supportive company attitude (Q38) $r_{s} = .510$, $p < 0.01$ likelihood to report (Q8) displayed a positive relationship.

6.7 Maintenance Personnel Responsibilities

Maintenance personnel should be aware of what is expected from them on a professional level with regards to reporting. Questions hoped to assess a participant's interpretation of what their responsibilities were on discovery of an error. The mean and *SD* of items related to maintenance personnel reporting awareness are shown in table 22.

Table 22*: Descriptive statistics showing mean and SD of participants' reporting awareness*

Question		*M*	*SD*	*N*
41	Would you submit a report about an error you found whilst performing your own task?	3.81	.911	158
42	Would you submit a report about an error a colleague was involved in?	3.57	.973	158
43	Do you agree with the following statement: After rectifying an error or averting an incident a report should still be made	4.2	.835	157
44	Do you think there is any benefit in reporting an error or incident if the situation no longer exists?	3.96	1.134	158
45	Do you think that reporting to a supervisor or manager is an alternate way of reporting?	2.92	1.128	158
46	Do you think that once reporting to a manager / supervisor it is their responsibility to make an official report?	2.89	1.265	158

The likelihood to self-report (Q41) was compared together with area of aviation (Q1), $F(4,153)$, 4.07, $p = 0.005$ confirming a significant difference. *Post hoc* comparisons (HSD) showed participants employed at an airline ($M = 3.93$) were more likely to self-report than participants from a third party maintenance organisation ($M = 3.37$) although both groups showed a tendency to self-report. Current level of employment (Q3) and likelihood to self-report showed significant difference, $F(5,152)$, 4.82, $p < 0.001$.

Post hoc comparisons (HSD) showed management (*M* = 4.35) believed there was a greater possibility of self-reporting compared to a LAMEs perception to self-report (*M* = 3.58), however both showed the intention to self-report. There were no other group differences evident. Table 23 provides details of the relationship between the likelihood of self-reporting and a participant's area, trade, level, shift, experience and current department; in all other cases $p > .05$.

Table 23*: Relationship between demographics and likelihood of self-reporting*

Demographics	ANOVA		
	df	*F*	*sig*
Area (Q1)	4, 153	4.07	.004
Trade (Q2)	3, 154	3.34	.02
Level (Q3)	5, 152	4.82	<.001
Experience (Q4)	3, 154	3.94	.01
Shift (Q5)	4, 153	3.17	.02
Department (Q7)	7, 150	2.27	.03

Current level of employment (Q3) and likelihood to report a colleagues error (Q42) showed significant difference, $F(5,152)$, 4.39, $p < 0.001$. As with the self-reporting results of the *post hoc* comparison (HSD) showed management (*M* = 4.08) believed there was a greater possibility of them to report a colleague when compared to a LAME (*M* = 3.30), again both showed the intent to report. There were no other group differences evident; in all other cases $p > .05$ as shown in table 24.

Table 24*: Relationship between demographics and likelihood of reporting a colleague's error*

Demographics	ANOVA		
	df	***F***	***sig***
Area (Q1)	4, 153	1.80	.132
Trade (Q2)	3, 154	3.90	.006
Level (Q3)	5, 152	4.39	<.001
Experience (Q4)	3, 154	1.05	.37
Shift (Q5)	4, 153	3.46	.06
Department (Q7)	7, 150	2.34	.03

When asked if reporting an error after it no longer exists (Q44) was necessary there was no group differences evident; in all cases $p > .05$ as shown in table 25.

Table 25*: Relationship between demographics and reporting error after it is rectified*

Demographics	ANOVA		
	df	***F***	***sig***
Area (Q1)	4, 153	2.26	.07
Trade (Q2)	3, 154	1.09	.36
Level (Q3)	5, 152	3.26	.006
Experience (Q4)	3, 154	2.31	.08
Shift (Q5)	4, 153	2.50	.05
Department (Q7)	7, 150	1.61	.14

Reporting to a supervisor as an alternate to using the reporting system (Q45) was found statistically insignificant; all cases $p >.005$ as reported in table 26.

Table 26*: Relationship between demographics and reporting to a supervisor as an alternate*

Demographics	ANOVA		
	df	*F*	*sig*
Area (Q1)	4, 153	.81	.52
Trade (Q2)	3, 154	.84	.46
Level (Q3)	5, 152	.74	.59
Experience (Q4)	3, 154	.14	.94
Shift (Q5)	4, 153	.07	.99
Department (Q7)	7, 150	11.79	.09

There was a positive correlation between participants believing it was the responsibility of the manager to report an error (Q46) once an individual has made them aware about an error (Q45), $r_s = .48$, $p < 0.01$.

6.8 Changes in the reporting System and its Possible Effect on Reporting

To establish what changes could be made to allow personnel to adopt a different attitude about reporting the survey posed several questions enquiring about participants' attitudes if certain things were changed in their organisation. Table 27 shows factors likely to encourage reporting if the company adopted a change; training (Q22), awareness (Q23, 29 & 34), and to the disciplinary policy (40).

Table 27*: Factors likely to encourage reporting*

Question		*M*	*SD*	*N*
22	How likely are you to report error if the company provided training on what should be reported?	3.91	.84	159
23	If my company provided more awareness about the company reporting system I would be more likely to report an error	3.91	.84	159
29	If you were made aware that changes in your department were a result of reports made would this be a reason to report more often?	3.97	.95	160
34	Knowing what the process was after a report is submitted would support my decision to report	3.68	.97	158
40	If your company had a supportive disciplinary system would you be more encouraged to use the reporting system?	4.00	.85	157

The results from responses received indicated that if an organisation provided any of the 5 factors; training, reporting system awareness, evidence of change and a supportive disciplinary system, engineers could be encouraged to engage with the reporting system.

6.9 BFI-10

The following guidelines as reported by Rammstedt & John (2006) were used to define which Big Five factor related to which survey question (R = item is reversed scored) with reported mean and *SD* shown in table 28:

- Extraversion: Q48-1R & Q48-6
- Agreeableness: Q48-2 & Q48-7
- Conscientiousness: Q48-3R & Q48-8
- Neuroticism: Q48-4R & Q48-9
- Openness: Q48-5R & Q48-10

Table 28*: Reported mean & SD for the Big Five Factors*

Big Five Factor	*M*	*SD*
Extroversion	3.45	.87
Agreeableness	3.49	.76
Conscientiousness	4.22	.77
Neuroticism	2.13	.71
Openness	3.21	.82

A Kruskall-Wallis H test was conducted to evaluate differences in the BFI-10 factors (Q48) compared to participants' trade (Q2) as shown in table 29. There was a statistically significant difference between a participant's trade and agreeableness, $X^2(3) = 8.80$, $p = .03$. Follow up tests were conducted to evaluate pairwise differences among the four groups (Q2), the results of the Mann-Whitney *U* test indicated participants' of a mechanical trade (*Mdn* = 3.50) rated higher on the agreeableness scale than support staff (*Mdn* = 3.00), $Z = -2.97$, $p = .003$.

A statistically significant difference was observed between a participant's trade and neuroticism, $X^2(5)$, = 7.92, $p = .04$. Pairwise comparisons using Mann-Whitney *U* test indicated participants' of a mechanical trade (*Mdn* = 2.00) rated higher on the neuroticism scale than support staff (*Mdn* = 1.75), $Z = -2.22$, $p = .002$.

Since support staff may not always incorporate maintenance personnel of a technical background it is reasonable to accept that a difference might exist between the groups without rejecting the assumption of personality patterns in aircraft maintenance workers.

Table 29*: Relationship between big five factor and trade*

Big Five Factor	Kruskall-Wallis H Test				
	M	*N*	χ^2	*df*	*sig*
Extroversion	3.45	160	4.35	3	.227
Agreeableness	3.49	160	8.80	3	.032
Conscientiousness	4.23	160	5.91	3	.227
Neuroticism	2.15	160	7.92	3	.048
Openness	3.23	160	.57	3	.904

The reported median for each trade is given in table 30 to provide greater clarity of the results. It can be seen that there is some variation in responses to the BFI-10 test across the trades; extroversion, conscientiousness and openness testing resulted in no significant differences, participants responded in a similar manner suggesting maintenance personnel may display similarities in personality characteristics.

Table 30*: Reported median between big five factor and trade*

Trade	Big Five Factor *MDN (N* = 160*)*				
	Extroversion	Agreeableness	Conscientiousness	Neuroticism	Openness
Mechanical	3.50	3.50	4.50	2.00	3.00
Avionics	3.00	3.50	4.00	2.00	3.00
Support Staff	3.50	3.00	4.00	2.50	3.00
Other	3.50	3.25	4.50	1.75	3.25

The Kruskall-Wallis H test was also used to determine if a relationship existed between differences in BFI-10 categories (Q48) and participants level of employment (Q3) as shown in table 31. There were no BFI-10 factors reported as statistically significant when compared to a participant's current level in aviation, suggesting maintenance personnel regardless of level (licensed, mechanic, supervisor, etc) may exhibit similarities in personality characteristics.

Table 31*: Relationship between big five factor and level of employment*

Big Five Factor	Kruskall-Wallis H Test				
	MDN	*N*	χ^2	*df*	*sig*
Extroversion	3.45	160	3.57	5	.612
Agreeableness	3.45	160	7.70	5	.174
Conscientiousness	4.36	160	2.89	5	.717
Neuroticism	2.14	160	5.10	5	.404
Openness	3.15	160	6.06	5	.300

6.10 Respondent Comments

Participants were given the option to provide written feedback at the end of the survey with regards to their reporting experiences. The following excerpts were interpreted as being the most insightful.

Several comments were related to a blame culture still being present in some companies preventing the reporting system being used effectively, and distrust in the reporting system because of management commitment or response to reports made;

Excerpt 1

Although our system is easy to use and I have reported things in the past I believe the no blame culture needs to be worked on to promote free and open reporting. I said I would report my own error but not a colleague as

> *it's up to the individual concerned to make the report at this time. We are small teams and raising a report on a teammate would be seen as a negative, but you may give guidance that a report should be raised but that's as far as you would go.*
>
> *(Airline, LAME B1)*

The engineer suggested that having an easy to use reporting system is not enough to encourage reporting. A just culture that it positively enforced would be required to support a functioning reporting system. The engineer also commented on whose responsibility it was to make a report stating that it was an individual's own responsibility.

Excerpt 2

> *In reporting of incidents, I believe most companies will be looking to attach blame. My company is all about whom to blame; there is no incentive to report.*
>
> *(Airline, LAME B2)*

Distrust in the reason behind reporting is preventing reporting. Believing that the company is only looking to appoint blame to a single individual does not provide any encouragement to use the reporting system.

Excerpt 3

> *A reporting system is installed for one reason only. To show the Ministry of Transport the Company is internally active in safety and to avoid Government Audits.*
>
> *(Airline, LAME B1)*

When believing that the company has established its reporting system to meet the minimum regulatory requirement and has no real interest in its usefulness or purpose will ensure that the reporting system is not taken as a supportive tool to sustain and improve safety.

Excerpt 4

> *There is no such thing as a no blame culture, it is in most cases not worth the paper it is written on. My experience in the industry is that companies will put all their investigative effort into finding that one person to blame.*
>
> *(Airline, LAME B1)*

Distrust in the company and management is preventing the effective use of the reporting system. Believing that a trap is being set by the company to apportion blame ensures the reporting system will fail.

Excerpt 5

Sometimes when an incident is averted or after it is rectified, it is decided (together with middle management) not to make an incident report because this may cause a major problem for my company's reputation with the customer/authorities.

(Third Party Maintenance, LAME B1)

A lack of commitment from management where they encourage not using the system as a supportive tool to improve safety does not set the right example for engineers to utilise the system.

There were several comments aimed at the lack of process or support once the report had been submitted:

Excerpt 6

I strongly feel that, if people had more follow up on reports they'd submitted its would definitely encourage more reporting, I personally have submitted reports and 6 months later been approached and questioned about the event, which is far from ideal, enquires by the safety department should be made as soon as possible while the event is still fresh in people's memories as the smallest of details can make massive differences.

(Third Party Maintenance, LAME B1)

The engineer defined the importance of feedback to encourage active usage of the reporting system. Without a commitment from the department dealing with the reports the engineer felt that his or her report might become obsolete, as too much time had passed between the occurrence and the investigation.

Excerpt 7

> *The main issue with reporting systems is the end user's qualifications to review the reports, especially with in-house systems. A system is of no use if reviewer is an operations type over maintenance.*
>
> *Second, with any in-house system there never is complete autonomy in the process. Somebody always knows something of the event. On the other side, the reporting of minor to intermediate level errors would choke a reporting system and dilute the results. This is where reporting to a manager/supervisor would help filter those reports prior to entering into the system.*
>
> *(Airline, LAME B1)*

Submitting a report is only the first step of a much bigger process, if engineers are encouraged to report there must be a system behind to deal with submissions. When a company does not invest in the whole process the reports made are of no value to improving safety. The company must commit to using correctly qualified investigators and should consider the establishment and use independent department to ensure an impartial investigation.

Excerpt 8 and 9 both indicate a good, functioning and well used reporting system, but with a lack of infrastructure behind prevents reports being quickly processed and dealt with in a timely manner to ensure a thorough investigation and feedback issued to the reporter so he / she has a feeling the process behind the report functions.

Excerpt 8

> *We have a reporting system, which is easy to use, and a reporting culture, which provides the reporter a response. The system does take a long time to process a report and can often be up to several months before a response is given.*
>
> *(Airline, Quality)*

Excerpt 9

> *Our company system is very effective. All reporting is encouraged around basic health and safety to aircraft engineering, flight ops and ground ops. Everyone is encouraged to report but sometimes the system has been used for reporting what some would consider being minor things i.e. I turned up to my stop over hotel and the quality was poor, Perhaps not a great thing but did the pilot manage to rest etc.*
>
> *(Airline, Manager)*

The last excerpt makes reference to under-reporting only being noticeable in maintenance as they are solely responsible for reporting their own errors and mistakes, whilst pilots are observed and reported by ATC, customers, etc. It is also noted that errors made by pilots or ATC can be fixed in real-time, whilst engineers' errors may go unnoticed at the time of the occurrence. To conclude it is noted that if an engineer decides to engage in unsafe behaviour, which includes not reporting his or her own error, that the supportiveness of the reporting system cannot prevent this, it is down to individual integrity:

Excerpt 10

> *I don't think mechanics/engineers are any less guilty in reporting errors. They simply fix or take care of the item in real time because they can. Whereas, I believe the level of reporting on the pilot side would be lower if it not were for others involved in their work environment, e.g., ATC, other crew, customers/passengers on-board, etc. As for the mechanics personality an influence on reporting, if an individual encounters an error and cannot conclude/fix the error in an acceptable, safe, and airworthy manner, and fails to report it...or lie about it...no reporting system can ever correct that situation.*
>
> *(Airline, LAME B1)*

The written feedback from participants provided a small insight into perceived issues with actual company reporting systems. There was apparent concern if a just culture actually existed and several participants were sceptical of the no blame policy promoted by their company. The process behind the reporting system was also a concern for several participants, believing the structure behind the reporting system was inadequate seemed to influence if an employee would report.

Chapter Seven: Discussion

The primary objective of the research project was to identify if maintenance personnel were actively using available reporting systems to report safety concerns and highlight potential hazards; it was then anticipated the results of the study would allow some of the underlying reasons to be distinguished as to why reporting systems might not be utilised. The focus group discussions brought attention to several issues facing reporters within a company including, problems with trust, confidentiality, company commitment to the reporting system, lack of feedback, lack of support after making a report and the absence of guidance regarding error identification. The online questionnaire prompted responses related to system design, training, feedback, company support, disciplinary policy, and reporting awareness (knowing what to report). These factors were highlighted in the literature review as recurring themes as what may be the barriers preventing the success of a reporting system.

7.1 Reporting Error – Removing the Barriers

7.1.1 Reporting System Usage

The primary aim was to identify if personnel were utilising the reporting methods available. Although the reported mean (see table 3) revealed the likelihood to report was high, the amount of reports submitted by participants did not complement this, which was surprising as reporting error is mandated in all ICAO member states. Table 4 provided details on the number of reports submitted by participants; 53% claimed to never have made a report, yet the likelihood to report an error indicated participants were prepared to report safety issues. The results presented could suggest maintenance personnel are unaware that observed safety issues are going unnoticed and unreported, or they may not aware of their responsibilities when it comes to highlighting safety concerns. Whatever the underlying reasons engineers believed they would report safety concerns, however they seemed to be unwilling to make an actual contribution to the reporting system. It was also expected that a participant with more years' experience would have made a considerable contribution to the reporting system, however the results showed that there was no significant group difference in reports submitted, either maintenance personnel similarly reported, or likewise did not report regardless of experience. This was a comparable result for area of aviation worked, trade, or department worked, showing maintenance personnel were equally reporting or under-reporting.

7.1.2 Reporting System Design

From the questions asked related to reporting system design there seemed to be no significant difficulty with access, ease of use, amount of incident information to be provided and question relevance, yet overall experience was not highly rated. Both Pace (2003) and Leveson (2011) emphasised the importance of a well designed reporting system, and both survey response from the current study and feedback during the focus group indicated reporting systems that participants had contributed to met all the criteria for a good structured reporting platform. As highlighted in the literature review reporting system design does not only include the reporting platform; the reporting tool may be harmonised with the maintenance environment, but without the infrastructure behind the reporting system employees will lose interest and may not use it as a supportive means to capture error (Leveson, 2011).

7.1.3 Training and Error Awareness

Reason (1997) and Patankar (2008) both believed training was vital to the success of reporting. Training must be provided on the type of reporting system adopted by the company, what the company's expectations are on what should be reported and classification of error. Of the responses received from the current study, 76% of participants reported infrequent training provided by their company, however knowledge about error and the company making employees aware about reportable error was evident, perhaps it may be companies are providing awareness in other forms other than training. It was suggested by Dekker (2009) and Leveson (2011) organisations must share investigation results company wide.

The main study results showed there was a likelihood to report a non-mandatory error which was contradictory to number of reports made by participants, again this is perhaps personnel not truly understanding error identification, although believing one has a good interpretation. The company has a responsibility to provide personnel guidance on what is defined as reportable error. For this to be successful the company must also ensure it is educated in what is reportable, although there still seems to be a lack of guidance available on error identification.

Training provides the company an opportunity to present to employees how they would like the reporting system to strengthen the overall safety environment. The company can provide information on system usage, system processes, how, what and when to report, and help remove the ambiguity that might exist around the reporting system by reinforcing its intended usage.

7.1.4 Feedback

Leveson (2011) stated lack of or no feedback gives employees the impression nothing happens after a report is made. If an employee perceives that there is no system in place behind the actual reporting tool they will not take the time to highlight safety concerns, the system then fails at the first stage. The responses received from the current study indicated a lack of feedback and system structure behind the reporting process.

Reporting is of little value unless supported with investigation and analysis. Personnel who are aware of the factors that support the manifestation of an error must carry this out. It was considered that if a company had a committed safety department / safety personnel, prospective reporters may have more assurance in the system if they believed there were dedicated personnel assigned to the process. A designated safety department has the possibility to show commitment to the system providing an infrastructure that exceeds the minimum regulatory requirement, as the law does not determine the need for separate personnel. It was also believed that if there was a dedicated department there would be a greater chance of receiving feedback from reports made due to solely assigned personnel available to carry out investigations, however the reported results showed no significant difference in feedback if a safety department existed or not.

Airline employees were more likely to receive feedback than third party maintenance with 41% reporting they had never received feedback. The results did highlight that if the company were to share findings an individual might be more likely to report. All groups indicated that receiving feedback or sharing the findings from reports was of great benefit proposing that if a company ensured a strong feedback loop individuals may have a greater interest in using the reporting system. Additionally, the organisational safety system success is measured through the feedback loop as reported by Reason (1997). The company can use the measure of reports made, changes implemented and feedback received from employees to gauge the success of the system and make the necessary adjustments to the organisation as required, a continual assess and change loop.

Stolzer (2014) reported the success of the aviation coast guard reporting system was somewhat attributed to the annual safety survey performed, which allowed all maintenance personnel to report back on the functionality of the system. Survey response highlighted problematic areas as perceived by system users allowing management the opportunity to adapt and amend the system to remove any unwanted reported problem areas. The importance of receiving feedback from the system users will reflect in the success of the operating system.

When asked if an individual would be more likely to report if their company provided awareness about the reporting system, 85% agreed they would be more likely to use the system. It is important for the company to share details of the reporting system, either through training programs or other methods, if they expect employees to actively engage. If personnel are not made aware about the system and its intent it cannot be expected that it is used effectively, if personnel do not know what tools are available and how they should be used the company cannot expect the system to be utilised.

7.1.5 Company Attitude & Disciplinary Policy

McDonald et al. (2000) and Dekker (2009) highlighted the importance of setting the right atmosphere to ensure a positive safety culture, which could only be sustained by management showing the way. Unsupportive management attitudes, including complacency or ignorance about safety weaknesses hinder the success of a reporting system; if the management is not setting the right example the company's employees will not support what they perceive as the company trying to peddle and the scene is set for distrust and resistance to any kind of system regardless of its importance.

Questions relating to company attitude showed a significant difference between individuals employed at an airline and those of a third party organisation; airline personnel reported higher levels of support and confidence when using the reporting system. There was a similar result when asked about the effectiveness of the current reporting system, where airline employees had greater belief in the effectiveness of their reporting system than third party maintenance organisation employees. Lastly, support throughout the company was perceived greater in airlines than third party maintenance organisations. Unfortunately the current study did not assess why differences would exist between airlines and third party maintenance, however it was suggested, from the focus group discussion, there were significant differences in management attitude, reporting awareness, training, and general support for a positive safety culture above the minimum regulatory standard.

The importance of a supportive disciplinary system was evident: participants of the main study indicated if a supportive disciplinary policy were in place there would be a greater willingness to report. Several of the written comments received signified individuals did not trust the company to apply the philosophies of a just culture and expected individual punishment if a safety concern was highlighted. This was also noted in the focus group, where participants were sceptical of their organisation's promoted just culture attitude and noted this was only something stated to meet the minimum regulatory standard and in real cases was not adhered to. In all instances, participants from the focus group were not aware of their company's actual disciplinary policy and several participants felt that it could not be trusted even if individuals were made aware.

Non-punitive reporting does not mean a discipline free organisation. Dekker (2009) highlighted the importance of a strict and clear discipline policy to complement a reporting system. He believed no policy was as bad as a policy that was not enforced; employees needed guidelines on what was classified as acceptable behaviour to be able to report with confidence allowing the company to identify unacceptable behaviour. Individuals must be aware of what is expected of them in terms of behaviour and performance, but they also need the security that they will not be punished for reporting safety concerns even when they result from unintentional errors (Stolzer, 2014).

7.1.6 BFI-10

The purpose of the short BFI-10 question was to identify group patterns existed between respondents. McDonald et al., 2000; Thomas & Taylor, 2003; Hobbs, 2004; Hampson, 2010; described the similarities LAMEs shared and the unique set of skills needed by a aircraft engineer. Respondents showed a near balance of extrovert and introvert, which could be envisaged for engineers; they have the ability to be independent, work alone, detached and are quiet or reserved in social situations, but must also be assertive, interactive with people, action-orientated and enthusiastic. Respondents fell into the balance range of agreeableness; the possibility to be questioning and tough, but with the capability to be part of a team, altruistic, trusting and helpful. Conscientiousness scored higher suggesting a more focussed attitude; dependable, disciplined and organised rather than experimental and unorganised. Neuroticism scored low suggesting respondents were more resilient; unflappable, rational and secure rather than worriers, highly strung and excitable. Lastly openness was balanced suggesting respondents could be practical, conservative and efficient, but with the aptitude for curiosity and imagination.

The intention of the BFI-10 in the current study was to determine if maintenance personnel displayed personality patterns as theorised by McDonald et al., 2000; Patankar & Taylor, 2008; Hampson et al., 2010. Agreeableness and neuroticism did show apparent differences between mechanical engineers and supporting staff, however supporting staff can include personnel non-technical staff, therefore it could still be considered maintenance personnel share comparable attitudes. Extroversion, conscientiousness and openness showed no significant group differences, suggesting LAMEs could share a set of unique attributes needed to carry out the role in such a demanding environment.

7.2 Changing Illusions about Reporting

For a reporting system to be accepted by personnel and integrated into the organisation's existing culture successfully it must be seen to be useful to the operation. Leveson (2011) stated if personnel were not using the reporting system that the company should not place the blame on the engineers; the reasons behind why personnel are not utilising the tool must be considered. She went on to say there could be several causes for an ineffective reporting system including: poor design, lack of feedback or no evidence of change, and a fear of reporting with expectations of negative consequences.

ICAO SMM (2013) noted that accurate and timely reporting of relevant information related to hazards, incidents or accidents is a fundamental activity of safety management. But to achieve this, a supportive system must be established that allows positive usage with the feeling of security and protection from suffering any negative effects from highlighting potential deficiencies in the safety system. If the company wants engineers to actively use the reporting system the company itself must show commitment to the system through output, feedback and evidence of change that demonstrates the mechanisms working behind the system.

7.2.1 Evidence of Corporate Commitment

Sexton and Klinect (2001) described safety culture within an airline as a combination of individual practices, attitudes, and competencies of the organisation's members, surrounded in the environment of organisational policies, rules and procedures. How the members of the organisation react and adapt to situations in a heavily regulated environment often sets the tone of an organisation's safety and reporting culture. Zhang, Weigmann, Thaden, Sharma & Mitchell (2002) further defined safety culture as the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, actively learn from incidents and accidents, and adapt and modify behaviour based on lessons learned from mistakes. Both studies agree that safety must come from the top down, start at corporate management level, which will set the standard and define the accepted culture, and filter down through the organisation to the different groups and individuals throughout the organisation. It is a simple expectation from employees that management are seen to support and utilise the intent of the safety system; management must lead and act with the commitment they expect from their employees.

The goal of just culture and error management is control of error through identification and observation meaning there is no longer a desire to conceal error or such a heavy intent on finding that one individual to blame; it is recognised the organisation and the company working practices, at all levels, contribute to the bigger picture. Safety and error management is the responsibility of everyone, and for the tools that are put in place to support a working safety system; commitment is needed from every person in the organisation with management setting the right example.

Fogarty & Shaw (2010) reported the perceptions of management attitudes had a direct effect on the shaping of a subordinate's own attitudes. Workers saw their managers as exerting control over the quality of their work through the importance managers' place on such things as quality versus production, working safe versus working quickly and the attitude of management towards errors and violations. Without commitment from management a relationship based on trust and communication cannot be sustained, two of the key elements required for a successful reporting system.

7.2.2 Disciplinary Policy

All agreed (Weick, 1999; McDonald et al., 2000; Hobbs & Williamson, 2003; Dekker, 2009; Ward, 2010) that there are complex relationships between human and organisational influences which need to be taken into consideration when planning and implementing improved policies, and to establish a successful reporting and safety culture. Reason (1997) stipulated measures that involve sanctions, threat, fear and punishment have only a limited (short term) effectiveness, but can cause harm to any positive relationship built up between management and employees, therefore a clearly defined and fair disciplinary policy needs to be established and maintained.

Ensuring everyone is aware that the company understands error exists and that it is the organisation's policy is to manage it rather than ignore or punish it should lead to a successful reporting system. Taylor (2000) stated a strong company policy and continuous communication between departments provided the greatest layers for improving quality and safety. He went on to say how a change in behaviour from management towards safety often improved the attitudes of employees (Taylor, 2000). He attributed the impeccable safety record of Qantas Airlines to their open and sharing communication policy, and the supportive reporting system that employees could freely use without fear of reprisal or punishment. A clear communication and disciplinary policy are required to give employees the confidence that the reporting system is there to improve company working practices to support safety, and will not be misused by the company to apportion blame. A well-defined and published disciplinary policy gives both the company and the employees' confidence that individuals are aware of the boundaries and are clear on the consequences of their actions. Staying within the defined lines of safe practices, employees can report freely knowing the purpose of the system. The ICAO Human Factors for Aircraft Maintenance Manual (2003) stated a disciplinary policy needed to have the following key elements:

- Independent, transparent and fair;
- Routinely and universally enforced; *and*
- Proper process and proportionality in the sanctions, taking into account mitigating circumstances.

These few key principles establish a disciplinary policy that is clear and concisely defined, leaving no room for misinterpretation. The policy should by readily enforced when required, giving employees the confidence that boundaries are set, and staying within the confines of the regulation and the working practices of the company, safety concerns can be reported freely.

McDonald et al. (2000) emphasised the importance of ensuring disciplinary policies were correctly established, implemented and managed. Although the regulations define boundaries for disciplinary requirements McDonald et al. (2000) suggested a company's policy should allow for focus on appropriate norms and rules for handling hazards, that it was important to seek to record or measure important aspects of working norms (actual working practices to regulated working practices). Working polices and procedures must close the gaps between prescribed procedures and practice.

Dekker (2009) provided guidelines on sustaining a reporting culture and the importance of the disciplinary policy by balancing accountability and learning. The policy is not only there to protect employees who submit reports and to give them the confidence that there will be no negative repercussions, but to also define acceptable and unacceptable behaviour. Dekker (2009) reiterated a disciplinary policy should be used as a tool to regulate behaviour by defining normal and abnormal, and was critical to maintain the boundary between order and disorder.

Policies must distinguish wilful acts of misconduct from inadvertent errors, providing for an appropriate punitive or non-punitive response, and are essential to assure the effective reporting of systemic safety deficiencies (ICAO SMM). If a system does not distinguish between wilful misconduct and unintentional errors it will impede the intent of the reporting system. If personnel avoid reporting for fear of punishment, management does not gain important safety information highlighting that it is essential clear guidelines and policies are made available to reporting staff in order for them to trust the system and use it as its intended.

7.2.3 Company Reporting System

The reporting system must be an engineer friendly reporting tool. From the literature review it was notable the reporting system must be easy to access, avoid unnecessary data entry requirements and must not be time consuming. The system must have clear and concise reporting forms covering all eventualities, but specific to maintenance ensuring that it will collect all information needed to conduct an adequate investigation and improve the learning of the organisation, but also avoid time consuming and complicated questions. It should evade any confusing questions or error classifications (as required by many regulatory authorities), but ensure it maximises on detail collection to obtain the bigger picture. Furthermore, it should ensure easy accessibility remembering that if the whole company does not have on-line access other methods for submittal should be available.

Patankar & Taylor's (2008) research focussed on maintenance resource management and how ASAP programs supported employee-management trust in organisations which had implemented the program. Although an organisation does not have to implement the ASAP program, in recent years ASAPs have started to take hold in the aviation maintenance community. These programs are participatory by design and hence offer great opportunities to build trust and proactively address systemic safety concerns. Taylor (2004) noted that "community standards" recognized and verbalized under an ASAP could be highly effective in differentiating between reckless behaviour and honest mistakes. Also, Patankar and Driscoll (2004) discovered companies with maintenance ASAPs had significantly higher levels of employee–management trust.

Once the systems are established and put into practice they must be maintained; markets change and companies evolve to meet the current demands. This is no different in the maintenance environment where the roles of personnel may change or daily workloads may shift. Many different changes can happen for whatever reason, but what is important that safety system and support tools adapt to meet the new demands.

It is also important to have systems in place that reduces the gap of what an expected safety and reporting system should achieve and what it actually does achieve. Akselsson, Koornneef, Stewart & Ward (2009) defined these as the gaps between espoused theory and theory in use; a good safety system should analyse the gaps between what the management and the safety system say or do (espoused theory) and what happens in real life context (theory-in-use) and allow encourage change to decrease the gaps.

Leveson (2011) noted a reporting system must be designed to be able to evolve and change if it is not working correctly. Poor design, lack of feedback, fear of disciplinary actions could all be reasons a reporting system is not being utilised, and once the organisation can identify the factor affecting usage they can make the changes necessary. Stolzer et al. (2014) stated a company should not rest once the system is successful; it should be continuously monitored to ensure long-term functionality. Stolzer et al. (2014) interpretation of continuous improvement and management of change was that companies grow, departments evolve and cultures mature, but to maintain the positive direction of the company's safety vision the safety and reporting system must have room to adapt.

The aviation coast guard has an established annual safety survey which is available to every member of the team (Stolzer et al., 2014). The purpose is to ascertain the status of the safety system and confirm its effectiveness; Stolzer (2014) called it an annual snapshot of the command climate (safety culture) of the department. It also provides an opportunity for employees, who may have not done so previously, report hazards. One safety officer reported the annual safety survey was sometimes the only time a person would highlight concerns and although not ideal (preferred would be at the time of the finding), it was better than something going completely unreported (Stolzer et al., 2014). The results from the annual survey could then be used as a to-do list or action list; the results should provide trends and areas of concerns, these can then be highlighted and corrected.

To be effective, safety reporting tools should be readily accessible to operational personnel. Operational personnel should be educated on the benefits of safety reporting systems and provided with positive feedback regarding remedial actions taken in response to the report. The alignment of reporting system requirements, analysis tools and methods can facilitate exchange of safety information as well as comparisons of certain safety indicators (ICAO SMM, 2013).

7.2.4 Responsibilities

Goals and expectations must be transparent throughout the company. What the company would like to achieve from the reporting system must be reported back to the users. It is important to keep employees engaged in the system, allow them feel the system is not only for the company's benefit, but also for supporting LAMEs in their job.

Maintenance personnel must be capable to understanding the event to be able to successfully report it. As discussed engineers have to recognise an error (or violation); once this is programmed the engineer must be able to observe and analyse the bigger picture in order to provide as much detail as possible. It is the responsibility of the company to provide adequate training on error identification, but it also the responsibility of the engineer to ensure he (or she) is informed through current regulations and sources of guidance material.

Leveson (2011) detailed the importance of feedback, or as a minimum, acknowledgement of a submitted report. Even after an investigation has been conducted and there were no significant findings, feedback should be given. Without this acknowledgement reporters will become despondent with the system, believing that there is no process behind the reporting system. Individuals require visual progress and a response to know that their input is valued to ensure they continue to utilise the system.

7.2.5 Feedback

Carroll (1998) described feedback as the most significant learning in the error management process; he noted several accident findings reports that had inadequacies in the feedback loop and these shortfalls were a significant contributor to the whole accident.

It should be decided what feedback is to be provided. The intent is not to share the intricate and confidential details of the whole investigation, but provide a brief summary of the investigation process; individuals should feel like there is a process behind making a report, but not all details collected require publishing. An organisation should decide the best method for sharing findings on an individual level and company-wide basis; feedback should be useful to current duties and hopefully prevent an occurrence happening again.

There is no regulatory requirement to have a dedicated safety department and safety investigating personnel. Knowing there are support personnel in the background dedicated to the reporting culture and safety program gives employees the confidence that their efforts and due diligence are warranted. In some companies it is often the job of the quality department to take care of the reporting system, but this role can be the effect of inheritance from the old system of reporting error (reactive) rather than reporting error to support continuous improvement and safety (proactive). Participants were asked if they had a dedicated safety department: 114 participants stated they had a safety department of which 70% said their reporting system was effective, 30 participants had no safety department of which only 48% deemed their reporting system as effective, however both groups still reported poor feedback regardless of a dedicated safety department, only 35% of participants had received feedback from reports made.

Latorella & Prahbu (2000) suggested training should be provided to managers and employees on how to provide better feedback (positive and negative). It should not be assumed that individuals know how, what and when to give feedback; the company should define feedback methods, what feedback to supply and at what stages feedback should be given. For example both ASRS and MEDA reporting systems provide feedback to the reporter confirming their form has been received and processed before the report is de-identified (O'Leary & Chappell, 1996). Actively engaging the reporter at an early stage gives them the sense that their contribution is valued and is being dealt with.

7.2.6 Recognition – Evidence of Change

Publicise change: show what changes have been made because of reports made, promote the success of the reporting system through cooperation, honesty and trust. Patankar (2003) stated the effectiveness of a reporting system should be measured by the amount of successful changes coming from reporting rather than the percentage of reports made. These changes should be made apparent to the workforce to reinforce the success of the reporting system. Showing employees their inputs do make a difference will support the success of the system.

7.2.7 Error Awareness

What is a reportable error remains the biggest challenge. Current regulations do not provide adequate guidance on what is reportable, therefore it is up to the company to define what their expectations are to support their safety system. Aviation safety research does not go into detail about issues with lack of awareness on what is reportable; although it was evident from the current study results and the focus group conducted there remains much ambiguity as to what is classified as a reportable event. Patankar and Driscoll (2004) felt the largest issue facing reporting was awareness about the system, but the results from the current study showed not knowing what to report could be classified as a major stumbling block in engaging the workforce in actively using the reporting system. Gilbey et al. (2015) linked under-reporting in aviation to lack of awareness of what is reportable and expectations of personnel to use reporting tools remains in question whilst there is no clear guidance available.

7.2.8 Confidentiality

The FAA (AC120-92, 2015) stipulates the key attribute of a confidential reporting system is that it is confidential. Methods of employee reporting and de-identification processes must be published so that system users are aware the company takes confidentiality seriously within their non-punitive reporting system. If the company adheres to its clear and established reporting procedures employees will gain trust in the system, this in turn has the affect of stimulating greater participation from employees reporting safety concerns (AC120-92, 2015).

7.3 Ultimate Goal

A seamless and integrated reporting system that blends into the daily working environment without impacting the day-to-day tasks of individuals should be the ultimate goal of the system. Easy to access and simple to use, providing all the essential data to follow through with an investigation if required, but maintaining the confidentiality and anonymity of the reporter, as practical as possible. The reporting system should have a proper process set up behind it so that each report made is properly collated, analysed and investigated as required. Sharing the findings with the reporter, the company and the industry if deemed necessary should close the loop and is essential to the success of the system.

The ASAP is a good example of an integrated program. Johnson (2012) was invited into an MRO using the program and observed well-intentioned maintenance employees, voluntarily reporting hundreds of hazards that contribute to risk every day. He was able to see first hand that ASAP was about the corporate and regulatory commitment to collect and analyse the reports and then consider how to improve maintenance practices accordingly. He could see that ASAP was about a work culture which takes the time to report hazards, to reasonably consider a worker error and corrective action, to improve every applicable process, and then do it over and over again. The program also included commitment from all areas of the company from senior management to the front-line staff and with support from the regulatory authority it has all the elements of success.

Reporting systems are not an infallible method of data collection, they can be subject to the prejudices and fears of the individuals who use them. Voluntary error reporting cannot be considered an illustrative sample of the underlying population of the errors and hazards they highlight, due to the reasons described previously, but if the front-line users are encouraged to report the safety problems they encounter to a program they can trust, safety goals will be reached much sooner than if the stories of lessons learned are never told. Lessons learned provide the industry the opportunity to learn from experience and adjust the system to counter future occurrences.

7.4 Limitations of the Study

Data was collected regarding whether a respondent was permanently employed or contracted, but there seemed to be no significance to the findings. Details were not collected concerning region or country although it was anticipated engineers from around the world would complete the survey and that there may be a difference in responses depending on region. There may have been some significance to demographic region, and reporting system usage and attitude towards reporting. The results had the potential to reflect what engineers think they might do rather than what they would actually do.

To maintain anonymity questions related to organisation worked were limited, although it was believed there could be significant difference in responses depending on type of airline (legacy, low cost, charter) or type of third part maintenance organisation (performing outsourced airline maintenance, leasing company maintenance, individual aircraft contract maintenance).

7.5 Future Research

The literature review showed the lack of research with regards to under-reporting in aircraft maintenance. There is extensive research on the leading maintenance reporting aids (MEDA, ASAP, ASRS, etc.) and their usefulness as a data gathering and sharing tool, but little is available on the maintenance personnel who choose not to use them and why. It was also noted that in current research old statistics (2003) are still being referenced to when discussing maintenance error's role in accident causation. Future research should focus on why maintenance personnel are under-reporting and what this means for current analysis of accident causation.

Many of the ideas discussed regarding sustainability of a successful reporting system and error management are issues raised by industry experts as far back as early 2000, CAP 718 (2002) would be an example of this. It would seem industry experts including authorities, aircraft manufacturers, designers and researchers, appear to be unable to understand the complex maintenance practices and personnel involved in maintaining aircraft. Perhaps a reaction to this is bridging the gap between the industry experts and maintenance personnel (CAP 718, 2002).

A noticeable observation from the results of the current study were the significant differences between airlines and third party organisations towards reporting and their current organisation's reporting system. Future studies should determine the significant differences between areas of employment in aircraft maintenance and barriers perceived as obstructing reporting system success.

Aviation regulatory authorities and industry experts are trying to move away from reliance on reporting systems and move towards the approach of initiating change through investigation and findings. The industry is slowly moving into utilising a predictive error management system where error is averted before it happens, more research into how maintenance personnel are being trained and utilised in the process would be essential to the success of this kind of approach to error.

Chapter Eight: Conclusion

Human operators are responsible for the maintenance and airworthiness of aircraft. They are the last line of defence before an aircraft is declared serviceable and is released for flight. The human element cannot be removed; the system must be designed to function with error and manage mistakes at an acceptable level to ensure hazards do not develop into incidents. Unsafe behaviours, intentional or unintentional, are the most unforgiving danger to safety due to the complex relationship between aircraft and the sociotechnical environment in which maintenance personnel work. Organisations have the ability to prevent accidents and cause them (CAP 718, 2002). If a company does not have the correct safeguards in place then accidents will happen. Taking a proactive approach to error rather than reactive requires the support of the organisation as a whole, all levels of the organisation must maintain a positive attitude towards safety.

Using proactive and predictive safety systems takes the dependence away from reporting to some extent. Safety management systems focus on hazard identification and risk analysis as well as error reporting to safeguard an acceptable level of safety. The industry is trying to actively manage error, not waiting for mistakes to be made or discovered, or solely relying on safety reports being submitted. Companies are dynamically trying to change the process before mistakes happen and building up defences in the system to protect the aircraft, the public and the engineer. Regulations are also changing, moving more towards self-regulation, bringing with it good and bad points.

Laws are being redefined; the rigid boundaries of right and wrong are being replaced with a more flexible approach of achieving high standards of safety through an organisations management system, complemented with hazard identification and risk analysis methods. In this new approach identifying an error is just the first stage in the safety management process, by detecting error it is hoped that it does not manifest into a cause, and recurrence is then limited.

Creating a reporting culture that collects, analyses and distributes the findings from near misses, by personnel who are qualified to identify human, technological, environmental and organisational factors will ensure the system continues to support maintenance personnel in their responsibilities.

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Appendices

Annex A: Mandatory Reporting as required by EASA AMC 20-8

Section III: Aircraft Maintenance and Repair

- Incorrect assembly of parts or components of the aircraft found during an inspection or test procedure not intended for that specific purpose.
- Hot bleed air leak resulting in structural damage.
- Any defect in a life controlled part causing retirement before completion of its full life.
- Any damage or deterioration (i.e. fractures, cracks, corrosion, delamination,
- disbonding etc) resulting from any cause (such as flutter, loss of stiffness or structural failure) to;

    (1) primary structure or a principal structural element (as defined in the manufacturers' Repair Manual) where such damage or deterioration exceeds allowable limits specified in the Repair Manual and requires a repair or complete or partial replacement of the element;

    (2) secondary structure which consequently has or may have endangered the aircraft;

    (3) the engine, propeller or rotorcraft rotor system.

- Any failure, malfunction or defect of any system or equipment, or damage or deterioration found as a result of compliance with an Airworthiness Directive or other mandatory instruction issued by a Regulatory Authority, when;

(1) it is detected for the first time by the reporting organisation implementing compliance;

(2) on any subsequent compliance where it exceeds the permissible limits quoted in the instruction and/or published repair/rectification procedures are not available.

- Failure of any emergency system or equipment, including all exit doors and lighting, to perform satisfactorily, including when being used for maintenance or test purposes.
- Non compliance or significant errors in compliance with required maintenance procedures.
- Products, parts, appliances and materials of unknown or suspect origin.
- Misleading, incorrect or insufficient maintenance data or procedures that could lead to maintenance errors.
- Failure, malfunction or defect of ground equipment used for test or checking of aircraft systems and equipment when the required routine inspection and test procedures did not clearly identify the problem when this results in a hazardous situation.

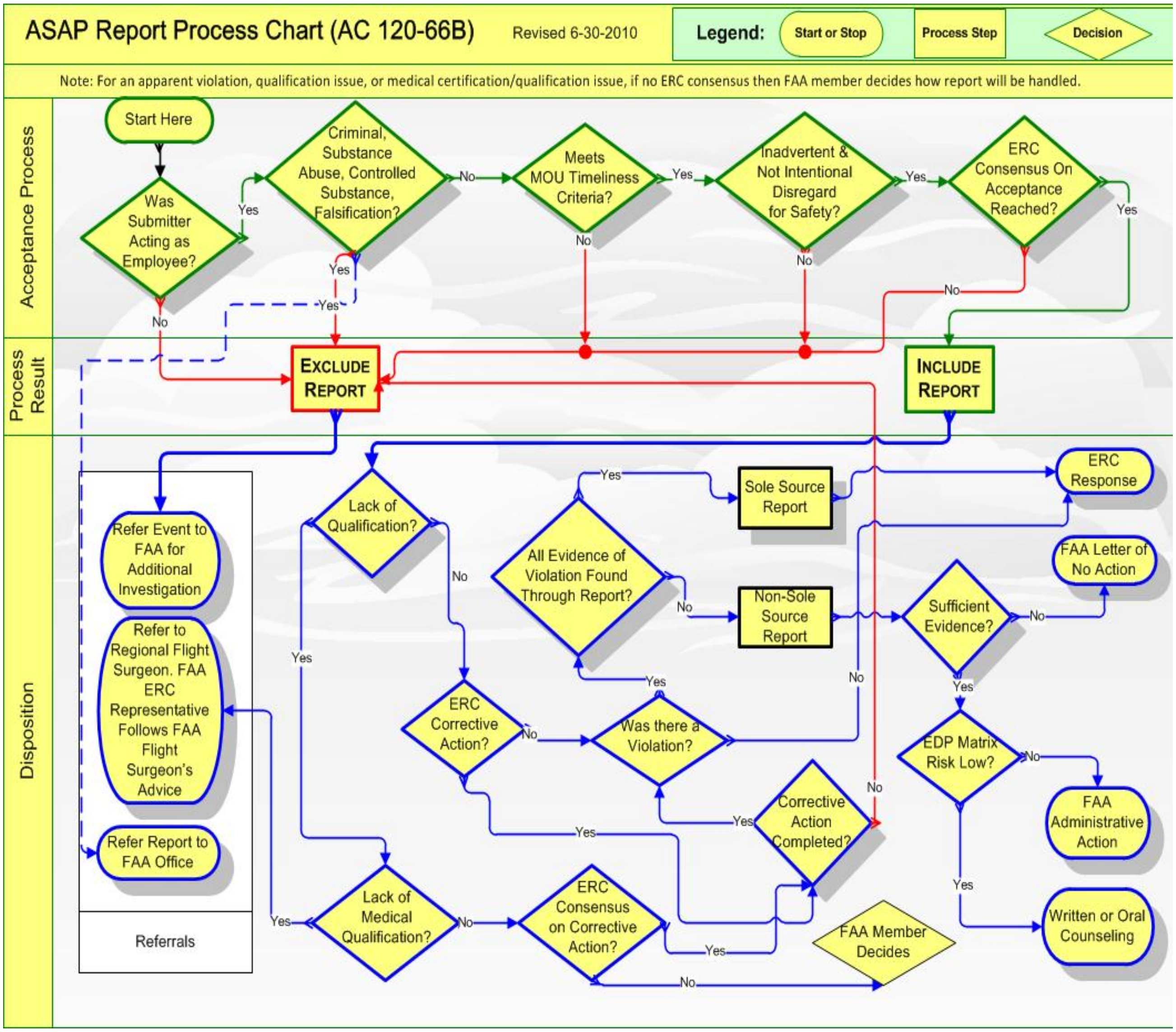
Annex B: Mandatory Reporting as required by EASA EU Regulation No. 2015/1018

Annex II Section 3: Maintenance and Continuing Airworthiness Management

- Serious structural damage (for example: cracks, permanent deformation, delamination, debonding, burning, excessive wear, or corrosion) found during maintenance of the aircraft or component.
- Serious leakage or contamination of fluids (for example: hydraulic, fuel, oil, gas or other fluids).
- Failure or malfunction of any part of an engine or powerplant and/or transmission resulting in any one or more of the following:
  - (1) non-containment of components/debris;
  - (2) failure of the engine mount structure.
- Damage, failure or defect of propeller, which could lead to in-flight separation of the propeller or any major portion of the propeller and/or malfunctions of the propeller control.
- Damage, failure or defect of main rotor gearbox/attachment, which could lead to in-flight separation of the rotor assembly and/or malfunctions of the rotor control.
- Significant malfunction of a safety-critical system or equipment including emergency system or equipment during maintenance testing or failure to activate these systems after maintenance.
- Incorrect assembly or installation of components of the aircraft found during an inspection or test procedure not intended for that specific purpose.
- Wrong assessment of a serious defect, or serious non-compliance with MEL and Technical logbook procedures.

- Serious damage to Electrical Wiring Interconnection System (EWIS).
- Any defect in a life-controlled critical part causing retirement before completion of its full life.
- The use of products, components or materials, from unknown, suspect origin, or unserviceable critical components.
- Misleading, incorrect or insufficient applicable maintenance data or procedures that could lead to significant maintenance errors, including language issue.
- Incorrect control or application of aircraft maintenance limitations or scheduled maintenance.
- Releasing an aircraft to service from maintenance in case of any non-compliance which endangers the flight safety.
- Serious damage caused to an aircraft during maintenance activities due to incorrect maintenance or use of inappropriate or unserviceable ground support equipment that requires additional maintenance actions.
- Identified burning, melting, smoke, arcing, overheating or fire occurrences.
- Any occurrence where the human performance, including fatigue of personnel, has directly contributed to or could have contributed to an accident or a serious incident.
- Significant malfunction, reliability issue, or recurrent recording quality issue affecting a flight recorder system (such as a flight data recorder system, a data link recording system or a cockpit voice recorder system) or lack of information needed to ensure the serviceability of a flight recorder system.

Annex C: ASAP Report Process Chart (AC 120-66B)



Annex D: Glossary

CFR Title 49_Subtitle B_ Chapter VIII_Part 830 – Notification and reporting of Aircraft Accidents or Incidents of Overdue Aircraft, and preservation of Aircraft Wreckage, Mail, Cargo, and Records

EU Regulation No 1321_2014 - on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks;

- Part M – consolidated (user) version of EU Regulation No 1321_2014 Annex I
  This Section establishes the measures to be taken to ensure that airworthiness is maintained, including maintenance. It also specifies the conditions to be met by the persons or organisations involved in such continuing airworthiness management.
- Part 145 - consolidated (user) version of EU Regulation No 1321_2014 Annex II
  This Section establishes the requirements to be met by an organisation to qualify for the issue or continuation of an approval for the maintenance of aircraft and components.

EU Regulation No 376/2014 – on the reporting, analysis and follow-up of occurrences in civil aviation

NZ Civil Aviation Rule Part 12 - notification, investigation, and reporting of accidents and incidents

Transport Safety Investigation Act 2003 Act No. 18 of 2003 as amended –
An Act to provide for investigation of transport accidents and other matters affecting transport safety, and for related purposes.

Airworthy - the aircraft must conform to its type certificate and be in condition for safe operation. (FAA, CFR 49, Part 830 definition).

Acceptable Means of Compliance (amc) - AMCs are non-binding standards adopted by EASA to illustrate means to establish compliance with the Basic Regulation and its Implementing Rules. Although AMC material is not mandated, EASA take the view that if the AMC is adopted in full into the company procedures then the system is fully compliant with the law.

Certifying staff - personnel responsible for the release of an aircraft or a component after maintenance (1321_2014 definition).

Incident - an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations (FAA, CFR 49, Part 830 definition).

Hazard – Condition, object or activity with the potential of causing injuries to personnel, damage to equipment or structures, loss of material, or reduction of ability to perform a prescribed function (Etzold & Ma, 2014 definition).

Maintenance - any one or combination of overhaul, repair, inspection, replacement, modification or defect rectification of an aircraft or component, with the exception of pre-flight inspection (1321_2014 definition).

Base Maintenance - Aircraft maintenance activity carried out once the aircraft has been removed from the operating environment for scheduled check activity or for unplanned defect investigation and rectification activity (Skybrary definition).

Line Maintenance - Aircraft maintenance activity carried out whilst the aircraft remains in the operating environment and is substantially fit to fly subject to specific, relatively straightforward, rectification tasks such as replacement of any component designated as an line replaceable unit (LRU). Routine in-service Inspections and day-to-day check actions in accordance with predetermined schedules form a significant part of line maintenance activity (Skybrary definition).

Aircraft Maintenance Engineer;

Mechanical - responsible for maintaining and certifying all aircraft mechanical systems (structure, powerplant, mechanical and limited electrical systems).

Avionics - responsible for maintaining and certifying all aircraft electrical and avionic systems.

Support Engineer - specialised on one system / area of the aircraft and provides technical (theoretical) support to aircraft maintenance engineers.

Quality Engineer - monitors compliance and safety normally through auditing and reporting systems.

Sociotechnical system - a theory that recognizes the interaction between people and technology in the workplace of a complex organisation.

Skybrary - an electronic repository of safety knowledge related to flight operations, air traffic management (ATM) and aviation safety in general. SKYbrary was initiated by EUROCONTROL.

Error management - The process of detecting and responding to errors with countermeasures that reduce or eliminate the consequences of errors and mitigate the probability of further errors or undesired states (ICAO Annex 9 definition).

Error Tolerance – the ability of a system to remain functional even after a maintenance error (ICAO definition).

ICAO – working with 191 Member States and industry groups to reach consensus on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector. Ensures local civil aviation operations and regulations conform to global norms – standardisation (ICAO Website Definition).

System operated unsafely during maintenance - Activating an aircraft system such as flaps or thrust reversers when it was not safe to do so, either because personnel or equipment were in the vicinity, or the system was not properly prepared for activation (Hobbs, 2004).

Material left in aircraft - maintenance related item such as a tool was inadvertently left behind by a maintenance worker (Hobbs, 2004).

Annex E: Low Risk Notification

Kirsty Twyman
14 Bush Road
Waiatarua
AUCKLAND 0604

Dear Kirsty

Re: Error Reporting Culture in Aircraft Maintenance

Thank you for your Low Risk Notification which was received on 16 April 2015.

Your project has been recorded on the Low Risk Database which is reported in the Annual Report of the Massey University Human Ethics Committees.

You are reminded that staff researchers and supervisors are fully responsible for ensuring that the information in the low risk notification has met the requirements and guidelines for submission of a low risk notification.

The low risk notification for this project is valid for a maximum of three years.

Please notify me if situations subsequently occur which cause you to reconsider your initial ethical analysis that it is safe to proceed without approval by one of the University's Human Ethics Committees.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

> *"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.*
>
> *If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director (Research Ethics), telephone 06 356 9099, extn 86015, e-mail humanethics@massey.ac.nz".*

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to provide a full application to one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

Brian T Finch (Dr)
Chair, Human Ethics Chairs' Committee and
Director (Research Ethics)

cc Dr Andrew Gilbey
School of Aviation
PN833

Mr Ashok Poduval, CEO
School of Aviation
PN833

Massey University Human Ethics Committee
Accredited by the Health Research Council

Research Ethics Office, Research and Enterprise

Massey University, Private Bag 11222, Palmerston North 4442, New Zealand T 06 3505573; 06 3505575 F 06 350 5622
E humanethics@massey.ac.nz; animalethics@massey.ac.nz; gtc@massey.ac.nz **www.massey.ac.nz**