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Winging It: Key Issues and Perceptions around Regulation and Practice of Aircraft Maintenance in Australian General Aviation

Anjum Naweed [1,*] and Kyriakos I. Kourousis [2]

[1] School of Health, Medical & Applied Sciences, Appleton Institute for Behavioural Science, Central Queensland University, Wayville, SA 5034, Australia
[2] School of Engineering, University of Limerick, V94 T9PX Limerick, Ireland; kyriakos.kourousis@ul.ie
* Correspondence: anjum.naweed@cqu.edu.au; Tel.: +61-(0)-8-8378-4520

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Abstract: The very diverse character of General Aviation (GA) within Australia poses challenges for its effective management of risk and safety in the sector. Improvements for human performance and perceptions of safety within the maintenance environment are among the areas which regulators have targeted for continuous improvement. This paper provides a timely empirical exploration of maintenance engineer perspectives around: (1) Changes in the role of the regulator/regulation that have impacted the sector and diminished safe operations; and (2) specific practical and operational challenges that the GA industry must deal with to sustain safe operations going forward. A thematic analysis of transcribed qualitative data revealed five key themes and identified a number of key issues from sector changes including a decline in training and education, drift in working practices, and wider power-distance gap. Issues with auditing and bureaucratization, negative safety climate, and underlying values and philosophies were also found. Practical and operational challenges going forward included an array of concerns associated with safety, the mismatch between GA and commercial aviation, workforce development and the financial burden in the sector. The results draw attention to the interconnectedness between various components of the GA system, and carry timely implications for regulation in the GA sector. Future research directions are discussed.

Keywords: General Aviation; human factors; engineering changes; regulation; safety; management changes; airworthiness; aviation; industry change; maintenance engineering culture

1. Introduction

Aviation is a heavily regulated industry for the purpose of safe operations. All aircraft maintenance, including those in the General Aviation (GA) sector, falls under the scope of these safety regulations, since maintenance is an essential activity for sustaining airworthiness (denoted as continuing airworthiness). The GA aircraft operation, as defined by the International Civil Aviation Organisation (ICAO), is an aircraft operation other than commercial transport operation or aerial work operation [1]. The nature and the needs of the GA sector are invariably different to those of commercial air transport conducted with the use of a large complex aircraft. The GA sector has a lower risk profile (as measured by the impact of an accident). In particular, if one considers the systems safety view of risk, whereby risk is a combination of the likelihood of the hazard and the consequences of any ensuing accident [2], then, although the probability of having an accident in GA is higher than in commercial aviation [3], the lower severity of such accidents results in a lower risk profile. Moreover, GA is characterized by highly diverse operations, operators and (mostly ageing) aircraft fleets, in conjunction with scarce/unavailable financial, infrastructure and human resources (mainly attributed to the aircraft owner's limited financial capacity). This unique mix has an effect both on the continuing airworthiness rules for GA aircraft and also on how maintenance is actually practiced within this sector of the aviation industry. Thus, we often see that in the drafting of regulations and regulatory oversight in GA, a "one size fits all" approach is not the norm at a worldwide level.

In an attempt to regulate GA operations in a proportionate (and cost effective) manner, continuing airworthiness rules and oversight are typically less stringent than in commercial air transport [4]. Therefore it is interesting to examine the safety performance of the GA sector, namely the safety record in relation to maintenance-related accidents. The GA aircraft maintenance has been identified as an accident-precipitating factor [5], with 30% of accidents in Australia attributed to this [6]. For the Australian GA sector, this observation is alarming when taking into consideration the size of the fleet (nearly 90% of all aircrafts), its flight activity (40% of total flight hours are produced by GA aircraft) [7], and the maintenance burden cost (close to 20% of the total operational expenses for GA aircraft) [8]. In practical terms, retaining the same safety record would increase the absolute number of maintenance-related accidents if there is a continued growth of the activity.

The Australian civil aviation regulator, CASA (Civil Aviation Safety Authority), has recognised the need for safety improvements, via a regulatory reform and modernization/alignment against best practices at the international level. Special attention has also been placed on ageing aircraft issues (structural fatigue, corrosion, etc.), as the Australian fleet has an increasing average age [8]. It is of note that CASA approached this matter with a change management mindset, attempting to achieve a consensus from the regulated parties. The management of change, as a systematic approach/methodology to enable change at an individual and organisation level [9], has also been promoted by CASA for safety management purposes in the wider aviation industry [10]. Past CASA attempts to impose regulations or dictate mandatory actions did not have the expected result, as compliance was found to be problematic. An extensive industry consultation process was employed for this purpose during 2018–2019 [11]. Tailoring of maintenance regulations (framework, oversight, and practice) for the GA aircraft was a topic on the industry's "wish list" from this consultation. This finding has also confirmed the feedback collected by CASA from their previous interaction with the GA sector.

Eventually, CASA decided to introduce a new set of maintenance regulations that mirrored the United States (US) Federal Aviation Administration (FAA) rules for GA aircraft, with these outlined in CASA's consultation accompanying documents [11]. The FAA rules' approach was by far the preferred industry choice, recording a 78% acceptance rate [11]. The decision to follow the FAA regulations for GA aircraft is not consistent with the CASA's overall regulatory structure and philosophy, as the Australian Civil Aviation Safety Regulations (CASRs) largely follow/mirror the European Aviation Safety Agency (EASA) rules. This triggers questions on the underlying reasons that provoke this type of change as well as what challenges may manifest as part of transitional effects.

Given the alarming statistics in the Australian GA sector, research by Naweed and Kingshott [12,13] undertaken in the interstices of work and safe operations in the Australian GA sector, has examined how affect influences decision making and action tendencies in maintenance engineering scenarios. This body of research has identified numerous contextual factors that feature in ways of working and give rise to system behaviours that can have a direct impact on safe operations. Identified contextual factors included distraction under pressure, incorrect manuals, maintenance costs, perceived customer disloyalty, managerial interference, and negative rumination. A number of the findings also echo normalisation of deviant behaviour, a theoretical stance where maladaptive practices come to be accepted as the norm [14,15], and which reflect a complex array of interacting factors at play where Rumsfeldian "unknown unknowns" can often loom large [16].

Empirically exploring the industry's perception on the role of regulations and the regulator, as well as other factors that may directly impact the practice of maintenance on GA aircraft, is necessary to obtain a better understanding of what is happening at an end-user level. The technical staff directly involved in conducting and certifying maintenance, as well as the aircraft owners, are both key stakeholders in the airworthiness sustainment business.

Aims and Objectives

The very diverse character of GA poses challenges to effective risk and safety management within the aviation maintenance environment. Improving human performance and perception around safety are among the areas that have been targeted by regulators for continuous improvement. The present study set out to build on previous substantive research [12,13] and examine this in a comprehensive way through semi-structured interview data elicited from Australian aviation maintenance engineers in GA using the following research questions:

1. What perceived changes in regulation and/or in the role of the regulator have impacted the GA sector in Australia, and to what extent are these changes perceived to have diminished safe operations?
2. What specific practical and operational challenges does the GA industry have to deal with to sustain safe operations going forward?

2. Materials and Methods

2.1. Study design

The research questions driving this study were applied as part of a focused analysis on an existing dataset, collected in late 2016 using a qualitative research design to gain insight into specific participant perceptions and experiences. Data collection was facilitated by semi-structured interviews and application of the Scenario Invention Task Technique (SITT) [17,18]. The SITT is a pen-paper task that involves scenario-creation and combines principles of the Critical Decision Method [19] and Rich Picture Data method [20] to scaffold interviewing. Participants are asked to invent a challenging scenario specific to their work using illustrations to assist with verbalization and articulation in ways that encourage transitions from analytical and creative thinking, through to systems thinking [21] processes (i.e., holistic perceptions, consideration of changes over time) when answering their questions. The SITT has been used to elicit subject matter expertise and identify critical themes associated with safety, risk, training, and/or ways of working in a number of related complex domains [12,22–26].

2.2. Participants and Recruitment

A total of 10 GA maintenance engineers took part in the study. Participants were recruited using a purposeful sampling approach with ages ranging from 21 to 60 (M_{age} = 41, SD = 11.37). Nine males and one female took part, broadly representing the gender ratio in GA maintenance engineering. Experience in GA maintenance engineering ranged from 1 to 42 years (M_{exp} = 17.8, SD = 10.5).

2.3. Procedure

Table 1 provides an overview of the interview protocol. Each interview session took ~60 min to complete. The first part developed rapport with participants and elicited views of any substantive changes that had occurred across the industry. The second part applied the SITT and required the creation of a challenging workplace scenario (real or hypothetical). An A3-sized paper and felt-markers were provided to develop a pictographic scenario representation (see Figure 1 for example). With the aid of the illustration, the scenario was used to identify decisions, feelings and perceptions, and probe the role of the safety, regulation, impact of training, and the influence of someone with more/less experience. Pragmatic validity was ascertained through follow up checks of understanding with scenarios serving as concrete examples for broader views of safety and industry impacts. The study was approved by the Central Queensland University ethics committee (Approval no. H16/05-146).

Table 1. Overview of the interview protocol.

Topic	Example Content	Example Questions
General experience in aviation	Background, entry into industry, rapport building questions	"What is your background in aviation?" "Do you remember the first aircraft you fixed?"
Current processes and changes in the industry	Training delivery, industry status past and present, challenges	"How has the aviation industry changed over the years?" "What aspects of the industry do you find most challenging?"
Safety in aviation maintenance	Changes in safety, positive and negative influences	"How has the safety of aviation maintenance changed over the life of your work?" "What has a negative impact on safety?"
Factors impacting a maintenance task	Distractions, pressures in day-to-day maintenance work	"What pressures do you feel when completing a job?" "How do you limit distraction during work?"
Scenario Invention Task Technique Activity	Create scenario	"Imagine you are at work and completing a difficult maintenance engineering task. Use the pen-paper to describe this task, using any drawing convention you wish."
	Recall and retell	"What else would be going on around you?"

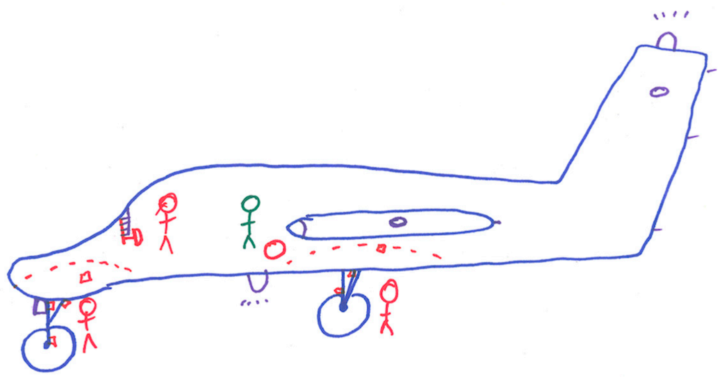

Figure 1. Example pen-paper scenario drawing of a re-rigging landing gear task created by a participant in the study. The green figure (middle-right) depicts the avionics technician and the three red figures depict airframe engineers. Here, the Scenario Invention Task Technique (SITT) is being used to illustrate a coordinated effort of teamwork required between multiple airframe engineers and an avionics technician, highlighting the complexity and dynamism in the aircraft maintenance workplace, but also the perceived threat arising from interruptions, excessive bureaucracy, and issues related to education and training factors, and attitudes on ways of working.

2.4. Data Analysis

All data was analyzed thematically with the aid of CMapTools (v. 6.01.01), a visual concept mapping tool under an inductive approach (i.e., without developing categories *a priori*) [27] to identify perceived changes across the Australian GA industry in recent years, and to draw insight into meaningful relationships between: The role of the regulator/regulation, safety in operations, and links with ways of working. Figure 2 shows an overview of the data analysis process; in short, statements were arranged into clusters (i.e., "meaning units") through gradual and systematic application of open, axial and selection coding via concept mapping to identify ideas and draw connections. Figure 3 shows how the data looked like in CmapTools at different stages of the analysis. Through this process, data were thus coded semantically from description to interpretation, and grouped into overarching themes, and each were individually analysed to identify patterns between themes.

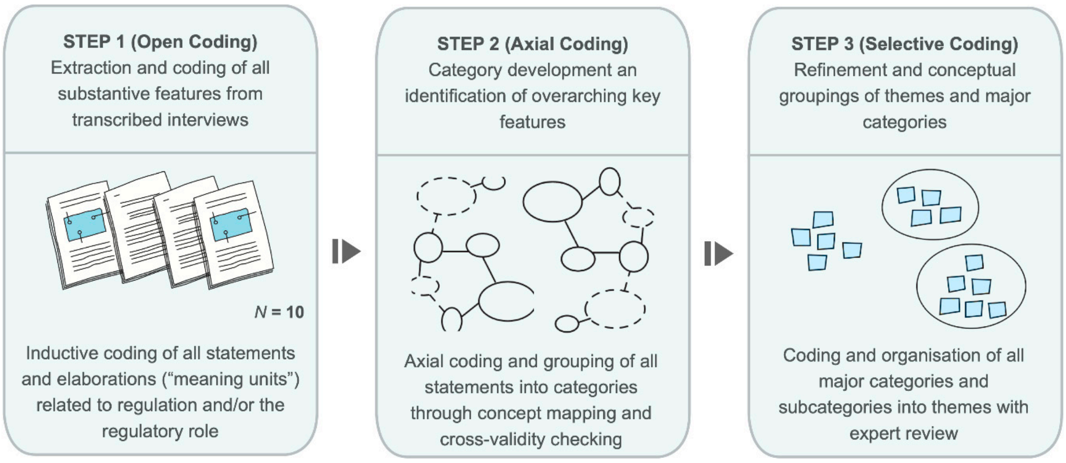

Figure 2. Overview of the data analysis process showing the three main steps of open, axial, and selective coding undertaken. Through this systematic process, data were coded semantically from description to interpretation.

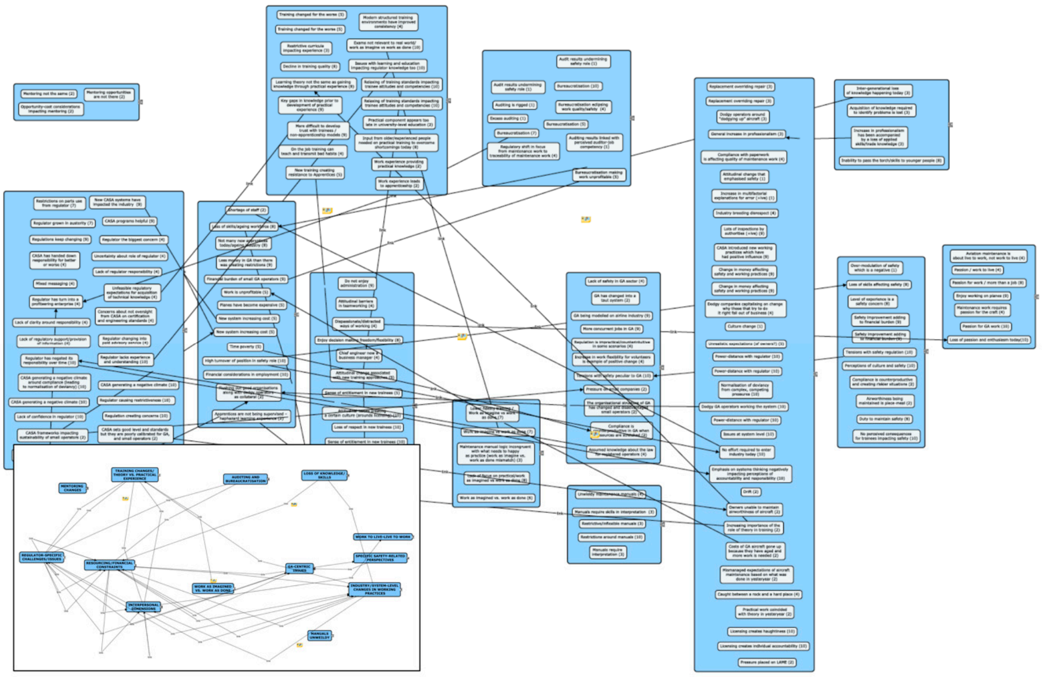

Figure 3. Illustration of concepting mapping of coded data in CmapTools. The large screenshot depicts arrangement of data midway through Steps 2 and 3 (axial and selective coding) and the inset (bottom-left) highlights connections between meaning units across thematic groupings in a collapsed form. Note: writing in picture is designed to provide an overview and is intentionally illegible.

Data collection was performed by a professional working within the GA sector in the capacity of a junior researcher in the service of a psychology Honours project; however, in an effort to maintain internal consistency, reduce chances of personal bias, and address questions of reliability and trustworthiness of the findings, all data analysis for this study was subsequently performed by a senior academic who was well-versed in the research design, but who also worked outside the GA industry (A.N.). Review and checking of findings and final codes was undertaken by an academic with intimate knowledge of the aviation industry (K.I.K).

3. Results and Discussion

Table 2 presents a summary of the thematic findings from the analysis. A total of five superordinate themes were identified. They were: (1) Changes to Industry and Working Practices; (2) Role of the Regulator; (3) (Re)calibration of Underlying Values and Philosophies; (4) Work as Imagined vs. Work as Done; and (5) Practical and Operational Challenges for GA. The first and fifth theme were the most represented within the data, each attracting more than a quarter of the overall coding of statements. Each of these themes also featured the greatest number of major (i.e., subordinate thematic) categories (4). The next sections present the findings associated with each theme. Supporting transcript excerpts are given where necessary via an anonymous ID-tag in parentheses where "(P_x)" indicates "(Participant_number)".

Table 2. Summary of thematic analysis with indication of frequency of statements and theme totals.

Themes	Major Categories	*N* [1]	Frequency of Statements	Theme Totals
Changes to Industry and Working Practices	General decline in training and education	7	16 (10%)	47 (29%)
	Drift in working practices	6	12 (7%)	
	Emphasis and growth of safety culture	5	11 (7%)	
	Wider power-distance gap	3	8 (5%)	
Role of the Regulator	Auditing and bureaucratization	5	10 (6%)	29 (18%)
	Lack of clarity and support	3	7 (4%)	
	Negative safety climate	2	12 (7%)	
(Re)calibration of Underlying Values and Philosophies	Working to live, not living to work	6	15 (9%)	27 (16%)
	Attitudinal stability	5	12 (7%)	
Work as Imagined vs. Work as Done	Theory vs. practical experience	7	10 (6%)	16 (10%)
	Restrictive maintenance manuals	3	6 (4%)	
Practical and Operational Challenges for GA	Mismatch between GA and commercial aviation sector	6	13 (8%	45 (27%)
	Safety-risk and safety concerns	5	11 (7%)	
	Workforce development	4	10 (6%)	
	Financial burden	4	11 (7%)	

[1] *N* indicates the number of individual participants who mentioned the statement (total = 10).

3.1. Changes to Industry and Working Practices

Table 3 decomposes the findings associated with the theme of *Changes to Industry and Working Practices* to show the minor categories in addition to the major ones. The highest represented of all major categories in this theme was *general decline in quality of training and education*, within which the *training changed for the worse* minor category was the most prevalent, both within the data and across participants. As reflected by the title, the consensus was that levels of training and quality had declined: *"the training has changed and I don't think it's been to the benefit of the industry"* (P_8); *"I think these days [the training is] no good"* (P_5), such that there was no longer any real effort required to enter the industry, *"I've seen it myself, [trainees will] do the exam three or four times, and the instructor will go, 'you're just not getting it. Fifty-one percent, okay, next'"* (P_10). This was attributed to a variety of systems factors, such as restrictive curricula, *"[trainees] don't have the . . . as broad of experience s previous times [. . .] these days [the training curriculum is] a lot more restrictive"* (P_3), and key gaps in knowledge prior to the development of practical experience:

> *I think they should learn an air law before they come out on the shop floor for their apprenticeship. In that way, that's just ridiculous to not have air law knowledge before you actually go and work in the industry. It's not a part of the setup which should be*. (P_9)

Table 3. Summary of findings for the Changes to Industry and Working Practices theme.

Theme	Major Categories	Minor Categories
Changes to Industry and Working Practices	General decline in quality of training and education	Training changed for worse Mentoring Regulator knowledge
	Drift in working practices	Unscrupulous operators Aircraft owners Maintenance work
	Emphasis and growth of safety culture	
	Wider power-distance gap	

A perceived relaxing of training standards was also felt to impact trainee attitudes and competencies:

> *[Trainees today] never really learn and they never become accountable for actually [becoming competent]. Since they know that there is—"hang on a minute, if I just cock this up and I don't put any effort in, but I keep turning up, I'm going to get through anyway"*. (P_10)

In many cases, these perspectives explored the tensions between practical work and theory, with views that practical components appeared too late in tertiary education and vocational training, *"there's a lot of university degrees where it's not until the third or fourth year where any practical's done"* (P_3), practical work coincided with theory in yesteryear, and input from older and more experienced people was needed on practical training to overcome shortcomings:

> *I did one year full-time of the Cert IV. That got me, basically, two-thirds of my theory out of the way. During that time, I was doing work experience with four different operators*. (P_2)

> *Younger people coming through with these training organizations need to be trained practically on the job, and they just need the input from the older people.* (P_8)

Another key aspect to a perceived general decline in training and education was issues with *mentoring*, where opportunities for this were no longer there or no longer the same:

> *[Apprentices are] coming out very insecure and very poorly trained, I suppose, because they just haven't had that time being mentored by the good engineers [...] there's just not that same level of mentorship, I feel, anymore*. (P_2)

Even when opportunities were there, prospective mentors were no longer taking on apprentices because of resistance to new approaches:

> *A lot of employers these days don't have the money or the time to baby in a practice. They want them to come in as a second-year apprentice, basically. They are new one year, come in as a second year, and be able to let them go into the work. You can't do that. That happens on a daily basis. That is just how it happens. That's why I don't have apprentices anymore and I will not, I will not, I don't have the time*. (P_5)

Issues with learning and education were also considered to have impacted regulator knowledge, *"They've all got Bachelors of Aeronautical Engineering, but not one of them actually knew their own rules, which undermined the system"* (P_10).

A gradual *drift in working practices* within the industry was attributed to changes to various roles. *Unscrupulous* and "dodgy" *operators* and companies was an important perception here, and a loss of moral principles and honesty was being seen, both with respect to how aircrafts were being maintained and how the system was being *"worked."* For example, *"you still find things in aircraft that have been dodgied up and stuff"* (P_3);

People in General Aviation either can't afford [to maintain their aircraft] or don't want to pay. They will shop around and find the cheapest place, which means that there are unscrupulous organizations out there that will cut corners, that will do it cheaper; (P_4)

And

I've seen airplanes go into a hangar and then an hour later, they roll out and the annual inspection has been done on them. You can't do that in GA. There are some shops around that do it, but they tend to get found out. The industry, as you said before, is quite a small industry. There's enough scuttlebutt around that you hear, that you don't take your pioneer. They're dodgy. Or, if you want a hundred hourly done, fly over the airfield and it'll turn up in the mail a week later; (P_10)

Note: "Scuttlebutt" here is used a slang reference for a rumour, or "word on the street."

In terms of *maintenance work* and practice, replacement was perceived to be overriding repair:

"[You fix faults] in accordance with the maintenance manual and that's it [...] [The new Maintenance Engineer's] idea of fault finding is, 'oh that's loose, or there's the fault.' Fix it by replacement instead of repair quite often. (P_3)

Compliance with regulations/rules was thought to be affecting the quality of paperwork:

[The regulators are] bogging down the engineer with paperwork and not letting the engineer do what engineers do best, which is work on aircraft, or supervise people that are working on aircraft. (P_4)

Perceived changes in the practices of *aircraft owners* were contextualized by changes in the financial landscape which affected safety and working practices. These were considered to provoke unrealistic and mismanaged expectations based on what was done in previous years, greater pressure on (licensed) maintenance engineers, and the burgeoning reality that some owners were simply no longer able to maintain the airworthiness of their aircraft:

We're doing a job at the moment where we're being told to leave things to another year to reduce the cost and then spread it across. More people saying, "Oh, we're going to be changing that in a year and a half. Can you just sign it off?"; (P_9)

And

Some owners simply don't have the funds to be able to sustainably maintain their aircraft in an airworthiness state [...] the LAME has to be the one, I suppose, who makes the decision to go, "I'm just not going to sign this airplane out again until we do $30,000 worth of work"; (P_2)

Note: "LAME" is an acronym for Licensed Aircraft Maintenance Engineer.

By way of extending on the foregoing points, a perceived *wider power-distance gap* between the maintenance engineer and the regulator and customer was seen as a significant change. Power distance has been widely researched as a key dimension of organisational cultures, broadly defined as the extent to which less powerful members of organizations and institutions accept and expect that power is distributed unequally [28]. In line with the findings, the perceptions that power-distance distributions had changed was viewed to affect working relationships, for example if an unhappy aircraft owner contacted the regulator to report perceived issues with an aircraft service *"it seems to be enough that you've only got to say that to the regulator and you're guilty until proved innocent"* (P_10). These perceptions were multifaceted in that they were also associated with normalization of deviance born from complex and competing pressures:

You may be put under a position where it's Friday night and an owner is screaming, to go away kids and family. You go, "Bring it in. We'll do an oil change. I had a good look at it this last time." You know the member. You know the aircraft. You're intimate with it. Maybe you won't do every checklist in there, because last time, you did the whole thing. You sign it off, and you might, six weeks later, have a disgruntled person that leaves there. They then ring the regulator and go, "He didn't do this proper annual". (P_10)

The power that customers had over maintenance engineers were reflected in working practices where aircraft were always serviced with the *"bare minimum"* because engineers were encouraged to *"keep doing these 3 or 4-day hundred hourly's"* (P_2) through lack of provision for major refurbishment.

Power-distance with the regulator was also reported in the context of examination for licensure which impacted working relationships. For example:

> *There is no right of reproach. You cannot go to anyone within [the regulator] and argue it. Recently I did my [aircraft] exam for my license [...] Doing the exam, I noticed there were some discrepancies in the wording [...] When I rang [the regulator], they effectively said "stick your head up your ass, we don't care, we are the regulator and we will do what we want to do." They are not engaging with it*. (P_10)

In terms of general industry changes, the consensus was that the regulator had grown in austerity over the years and become *"stricter"* (P_7), with an added perception that in an industry-wide regulation satisfaction survey, *"they ended up with a 99 percent disapproval"* rating (P_10).

Despite negative participant perceptions around training and education, drift, and ostensible widening of power-distance, an *emphasis and* indeed even *growth of safety culture* was a prominent perceived change in GA and its working practices. More frequent inspections, helpful programs, increase in multifactorial explanations for error, introduction of new working practices with positive influence, increases in work flexibility for volunteers, and general increases in professionalism and attitude were all attributed to a change and maturing in safety culture, for example: *"I think the professionalism [in the General Aviation industry] has increased overall"* (P_3); *"the authorities come and keep us on guard as well, coming in for inspections here, there and everywhere, which is fair"* (P_9); *"that just culture of no blame and trying to find the cause behind errors is really a big, it is a big thing now"* (P_1).

The focus on compliance was perceived to be *"flushing out"* (P_2) dishonest or unreliable operators, and while some perceptions showed ambivalence, there was consensus that new regulator systems had had an impact on the industry:

> *[The regulator is] trying to help more than they have done, and it is happening. Some of the things I've learned over the past and put into the company like doing safety meetings, things like that ... Yeah, that's all stuff that we never used to do in the past, but it's a positive*; (P_9)

> *The small operators are being pushed out now. There's an argument that those smaller dodgy operators get filtered out of the industry. Perhaps that's one of the goals of this increased compliance*; (P_2)

> *[The Regulator] has devolved responsibility in a number of different areas, some good, some bad*; (P_4)

> And

> *[The Regulator] bought out a SID's program, which is causing a few dramas and ripples around the industry but in some ways, is actually a good thing because we're finding ... like we recently found some tail plane cracks on a Cessna because of ... we would have found them anyway, but it was a part of the SID's program*; (P_9)

Note: Supplemental Inspection Documents – a regime that aims to maintain the structural integrity of the airframe of CESSNA 100 series aircraft as they age, due to growing concern of the safety of the ageing fleet [29].

3.2. Role of the Regulator

By way of extending on the foregoing theme, Table 4 decomposes the findings associated with the perceived *role of the regulator*, which invited much critique from participants. Most in this theme commented on *auditing and bureaucratization* where the level of auditing was considered to be *excessive*, *"rigged,"* and with results that *undermined* the safety role:

> ... *we get audited constantly, and you know just picking up little things like where it tool—we used a tool tag system for tool control, one of the numbers was a bit worn off on a tool tag, it then becomes an audit finding [* ... *] at the end of the day that bit of paint worn off a tool tag is not going to make an aircraft come down [* ... *] I've never seen an audit come through with a clean slate.* (P_1)

Table 4. Summary of findings for the Role of the Regulator theme.

Theme	Major Categories	Minor Categories
Role of the Regulator	Auditing and bureaucratization	Auditing excessive, rigged and undermining safety Excessive bureaucracy
	Lack of clarity and support	
	Negative safety climate	Regulation turned into a profiteering exercise Negation of responsibility No confidence

The regulator was also perceived to be too bureaucratized, where this excessive bureaucracy was viewed to eclipse work quality/safety and made work unprofitable for many in the sector:

> *Paper work's always good. You have to have it but, jeez, it's gotten ridiculous now. Back in the day, you'd change a light bulb and go to the pilot, "Yep, you're good to go." I change a light bulb and now, is still takes me ten minutes to change it, but it is an hour of paperwork.* (P_5)

> *The regulatory body is less concerned about the quality of the work that the engineers are doing and more concerned about the paperwork that they're producing.* (P_4)

In many ways, these perspectives resonate with notions of a general bureaucratization of safety and bureaucratic accountability, which have gained force in recent years, and refer to the types of activities that are expected of organization members which account for the safety performance of those they are responsible for [30].

A lack of clarity and support from the regulator were also shared, with some participants highlighting perceived deficiencies around the regulator's responsibility, level of experience and understanding, and its provision of information:

> ... *recently, we had three airworthiness inspectors [from the regulator] turn out at a local airfield. They spent three days going over a flying school. They called up the LAME, and they were standing there with a fistful of papers saying, "Blah blah blah blah blah blah blah. You've done wrong. You've done wrong." The [LAME] turned around and said, "Well, actually no, what you're citing as a reference isn't applicable, because that's for an airline. These aircraft are a lesser weight".* (P_10)

> *It's a lack of education. It's like when I registered the aircraft in my name, or put my name down as a registered operator, did I get a leaflet from [the regulator] saying, "as the registered operator you are required to bang, bang, bang?" I think there's a misunderstanding in the industry, particularly in the private aircraft sector of who holds responsibility and what those people are required to do [* ... *] It's law you should know it. I personally think there should be some onus on CASA too, you're the registered operator of this aircraft.* (P_4)

There was some uncertainty about the regulator's overall role, and feelings that regulation kept changing, *"A few of the dramas we have is that it's just the changing regulations. It's hard to keep up with all of that"* (P_9). Concerns were also shared about little to no oversight from the regulator on certification and engineering standards:

> *I have a lot of concerns, not only about the engine. I have a lot of concerns about, first of all, the certification of the aircraft, I have a lot of concerns about the engineering of the aircraft, the standards of the engineers. How they check the engineering standards, there was no oversight happening from [the regulator] at all.* (P_4)

In a stark contrast to the overall growth in safety culture construed by the previous theme, the regulator itself was suggested to be contributing to the generation of a *negative safety climate*, particularly around compliance on issues that were viewed to not be safety-related:

> *[The regulator] impacts the industry because [maintenance engineers] will then do things that they shouldn't do. They know [what to do] they've done it that way for years. They know that it isn't a safety case, it's more a compliance issue, but they just do it because they've done it that way for years. Then, the regulator comes in and smacks them down, so then they don't do it. That increases the cost. It increases the time. People don't want to own aircraft. They sell aircraft, so we see these gradually diminishing infrastructure and system that shouldn't need to be that way [...] we have a regulator who sees it's better to regulate than to educate and to assist.* (P_10)

Central to perceptions of mixed-messaging and excessive regulatory oversight were notions that *regulation* had *turned into a profiteering exercise* and paid advertising service:

> *It's this regulatory oversight that's happening on everything all the time. Every time I pick up the phone and talk to [the regulator] they want to send a bill, so the government funded safety authority, that is also funded out of the levy that is put on fuel. Yet every time I do something, they want to charge me for it. I'm not sure how all of that works, are they double dipping? Are they now a profit center for the government? Yet they [are] supposed to be the safety authority [...] at the moment it's as the authority and the regulator aren't telling you "you need to do this", [they are saying that] to do that you need to come to us and when you come to us we're going to charge you.* (P_4)

This was accompanied by views that the regulator had negated its responsibility, created concerns, and ultimately, feelings of *no confidence* in the regulator for many:

> *I've worked on the spinners with guys that were too lazy to do their LAME license. They were more than happy for me to sign for their work. Those people are now [working in the regulator office], in regulatory roles, enforcing rules that they really don't have the privilege to [enforce].* (P_10)

3.3. (Re)calibration of Underlying Values and Philosophies

Table 5 decomposes the findings associated with perceived *(re)calibration of underlying values and philosophies*. A large representation of this theme was within a subtheme highlighting that staff were now *working to live, not living to work* (i.e., working to survive rather than feeling highly motivated or enthusiastic to work). *Engineers* had purportedly *now become business managers*, *"There is no getting away, if you take on the role of chief engineer you're taking on a life of paperwork"* (P_4)—a perspective that was ascribed various feeling and behaviours, including: no joy around administration, *"I don't particularly enjoy the days I'm sitting in an office all day and trying to deal with issues with customers and trying to look after all the staff on the shop floor"* (P_9); pre-occupation with non-skill-related activities and office work, *"those with the most skills and abilities and experience, rightly or wrongly, are ending up driving the office and shuffling the paperwork"* (P_2), and dispassionate and distracted ways of work.

Table 5. Summary of findings for Calibration of Underlying Values and Philosophies theme.

Theme	Major Categories	Minor Categories
(Re)calibration of Underlying Values and Philosophies	Working to live, not living to work Attitudinal stability	Engineers are now Business Managers GA requires passion Licensing culture Teamworking Trainees and their sense of entitlement

These feelings were strongly advocated on the basis that maintenance work in *GA requires passion* and is more than just a job but something which should provide enjoyment, decision-making freedom and flexibility:

Fault finding is what I love doing. I like having a customer come in and say I have a problem with this, and I go search the memory bank and you try and find a solution to it. That, to me, is the best part [...] I enjoy being the chief engineer because I can make the decisions. (P_8)

In short, the sense of duty and responsibility to maintain the level of safety that behoves maintenance work was a by-product of real passion and enthusiasm:

Engineers are either passionate and believe in what they're doing and want to do it the right way [...] or they're tainted by the industry, they have no respect for the industry, they have no respect for what the industry is trying to achieve. Consequently, they'd rather spend more time on their telephone organizing the building of their new house, while they're charging the client. (P_4)

Attitudinal stability was a key emerging subtheme in the *(re)calibration of underlying values and philosophies*. For instance, attitudinal issues created a certain *licensing culture*; while on the one hand, it gave rise to individual accountability, on the other, it was also felt to produce arrogance:

I've never come across such a toxic, mind state as aviation. Everyone's an expert. The only people they should listen to LAMES because they've earned their right, but anyone feels that, well, hey, I can work on a mower, I can work on an airplane. Why would I need to pay you 120 dollars, 150 dollars an hour to do something I can do myself? Then they will use commercial-grade hardware. We refer to it as "Bunnings Aerospace"; (P_10)

Note: "Bunnings Warehouse" is an Australian household hardware chain; and

You, effectively, really only start to learn when you become licensed. From that day, when you're accountable for you own action is when you actually start really learning. (P_10)

Attitudinal barriers were also encountered in *teamworking* and linked to attitudinal change associated with new training approaches, mismanaged expectations, and a broader "breeding" of disrespect:

I've worked with some engineers that I've basically said, "I don't want those engineers working on my aircraft again [...] I can see what they're doing, I don't like what they're doing, I don't like their attitude"; (P_4)

[Trainees] have all sorts of funny preconceived ideas about what their first job's going to look like and how the industry actually is or is not; (P_2)

And

The guys that come in for work experience, they've already done their one-year course and they don't want to be there. They already believe that they know more than you. (P_5)

Much of this was attributed to an entrenched *sense of entitlement in trainees*; this was based on a lack of respect and accountability which also made it more difficult to trust, and therefore, provoked distrust in non-apprenticeship models of learning:

[Trainees] have done their year course, they've paid all the money, they're ready to work on planes—and they're not; (P_5)

I believe that there is no respect anymore. Kids these days, we see them coming through industry. They want to sit there with their thumbs on their phone [...] There is certainly a lack of accountability amongst younger people these days. They want everything for nothing. They don't want any hard work to do it; (P_10)

and

You can't put full trust in somebody straightaway as they walk in the door, but you need to trust that they can use a screwdriver or spanner properly and things like that. They don't seem to have that sort of thing when they come into the shop as an apprentice. (P_9)

3.4. Work as Imagined vs. Work as Done

Many of the issues observed within the GA industry were thematically consigned as problems of a *Work as Imagined* vs. *Work as Done* mismatch (see Table 6), a category named after recent theoretical conceptualizations where explicit or implicit assumptions of how work should be done is different to how something is actually done [31], [32]. A large category here was *theory* vs. *practical experience*, and in the true essence of this theme, illustrated some very varied perspectives of the *relevance of classroom teaching to the real-world setting*, as well as the value of *work experience*. The GA work as imagined was thought to bear little to no resemblance to work on the "shop floor". In this way, the classroom was thought to provide lower fidelity training, a lack of focus on practical work, and exams were seen to have little relevance:

> *People coming from the college were a bit off with experience, and they've been working on an engine or aircraft that's in their facility, that's been pulled apart last month and put back together, whereas they come here and it's a plane that hasn't been pulled apart for ten years and everything's rusted and corroded*; (P_7)

> *Everyone that I've come across has come out without any knowledge of what we're actually doing on the floor*; (P_8)

> *When you get trained it's always this perfect picture, and then the real life. It's not so perfect. Definitely certain places have different methods to other places. Some I agree with, some I don't*; (P_6)

And

> *Because [the exam is] written by bureaucrats, there's no real relevance to what you actually do in the field to what you learn in the exam*. (P_10)

Table 6. Summary of findings for Work as Imagined vs. Work as Done theme.

Theme	Major Categories	Minor Categories
Work as Imagined vs. Work as Done	Theory vs. practical experience	Relevance of classroom to real-world setting Work experience
	Restrictive maintenance manuals	Inflexible Require interpretation

Alternatively, some views ascribed increasing importance to the role of theory in training, "nowadays, employers are wanting to see the apprentices actually complete all their theory before they'll want to take them on" (P_2). Similarly, work experience was heralded as a mechanism that provided practical knowledge, and afforded knowledge acquisition in a way that learning of theory could not:

> *[Work experience] giving the apprentices the appreciation as to what it is actually like in the working environment, I think there's a lot of benefit in that. Yeah and in my case, it led into an apprenticeship at the end of it. I highly recommend that apprentices and people in the airline industry do that*. (P_2)

However, work experience in the form of on-the-job training was also felt to be a platform that could easily teach and transmit bad habits:

> *I think, go back many years it was all on the job training, and so the bad habits that an engineer taught to another engineer, taught to another engineer, taught to another. Just got passed down and then got even made worse to the point where you have an apprentice who's being taught by someone whose got a license, yet the work's crap*. (P_4)

Restrictive maintenance manuals were given as a specific example of how work as imagined seldom translated into how work was actually done. Maintenance manual logic and perceptions of compliance were considered to be incongruent with what was required in practice, therefore considered restrictive, *inflexible*, demand certain skills, and *require interpretation* in ways that ultimately made them very unwieldy.

> *You read the maintenance manual and it just says, "Fix it." There's no interpretation, you know? [. . .] Quite often the manual will give you all of the information you need to know on how to build it from the nut up, but you're not doing that. You need to dive into that particular part that you're involved with, you know? Then use the manual to repair it from there, not from go to whoa. Understanding the manual and interpreting it is a real challenge*. (P_3)

> . . . *having this mindset that the regulator tells you that you are not to refer to anything mentally. You are to refer to a manual to do any servicing and maintenance*. (P_10)

3.5. Practical and Operational Challenges for GA

As shown in Table 7 the last major theme in the study (representing 27% of all coded data) was centered around the *Practical and Operational Challenges for GA*. Following on from notions given within the forgoing theme, a key element here was the perceived *mismatch between GA and the commercial aviation sector*. Due to this, *regulation and compliance was seen to have a poor fit* and calibration with GA and small operators:

> *[In] Australia, unfortunately, you haven't really learnt from the mistakes made in the UK, so they're trying to make the General Aviation industry the same as the [commercial] airline industry, which doesn't work [. . .] [they] are very different ballgames*. (P_9)

Table 7. Summary of findings for Practical and Operational Challenges for the GA theme.

Theme	Major Categories	Minor Categories
Practical and Operational Challenges for GA	Mismatch between GA and commercial aviation sector	Regulation and compliance have poor fit with GA needs Implications for sustainability
	Safety-risk and safety concerns	From over-modulation of safety From loss of skills
	Workforce development	Loss of knowledge and skills Staff turnover Mentorship
	Financial burden	Safety improvement increasing cost Age and cost of aircraft

By modelling GA on the commercial airline sector, regulation and compliance was felt to be impractical, counterintuitive, and cause restrictiveness in some scenarios, for example when resources were stretched:

> *"One of the problems is we do a lot of the maintenance on vintage aircraft, and some of the parts just, you can't get a new part with a release note and then there's perfectly good serviceable parts that are available from the parts bin. You're not allowed to use it theoretically*; (P_7)

And

> *The levels that [the regulator] are wanting people to come up to, and the standards that they're wanting us to comply with, are good. But they need to be careful, though, particularly with small operators, that the effort and the cost and the time required with compliance doesn't detract from actually getting the job done properly and getting the job done safely. It can start to be counterproductive, particularly in small organizations where resources are having to be divided to the compliance side of thing*. (P_2)

The mismatch was also thought to *create implications for sustainability*. By placing undue pressure on small companies, they were reportedly being caught 'between a rock and a hard place', and the requirement for more concurrent jobs coupled with time poverty was having other effects, for instance, *"flushing out good organisations along with dodgy operators"* (P_2);

> *The most difficult point is when [your company] grows to the size that you can't afford the overhead of having someone like a business manager, but you can't afford not to because you physically can't do it and it's not your forte*; (P_4)

> *How do we still make profit trying to do all this paperwork, trying to help apprentices? It goes back to that again—you don't get time*; (P_5)

> *[The implication of the regulator's] high standards that they're trying to promote throughout the industry is there's a real ... Small operators are real disadvantaged [...] It's basically only able to be done sustainably with bigger organizations. Middle level and larger organizations seem to be the only organizations that can continue to be able to be sustainable*; (P_2)

And

> *Most of the maintenance goes abroad these days for the heavy stuff. To the lower maintenance, you still have 2 or 3 engineers that are available to work on their airplanes, where in General Aviation, we generally have maybe 1 to 2 for the entire airplane. We have 25 multiple jobs happening at (any) one time*. (P_9)

Going forward, there were also practical and operational challenges around *safety-risk and safety concerns*. An *over-modulation of safety* was attributed to tensions with the regulator and were peculiar to the GA industry, *"[the regulator has] potentially, maybe [gone] too far in some respects they've gone over what (level of safety) it has to be"* (P_1), were perceived to leading to the development of a tauter system, where airworthiness was piece-meal and the compliance, counterproductive:

> *[Aircraft owners] simply just can't afford to repair their aircraft, so there's compromises need to be made in terms of, "Okay, we'll do these jobs this time. We'll stretch these other jobs out for another hundred hours for the next inspection," or what have you*. (P_2)

Paradoxically, the product of this over-modulation was therefore the perceived creation of riskier situations and safety decrement leading to general lack of safety in GA:

> *We're entering a very interesting time in the aviation industry, particularly in GA, where the best competent engineers are in the office, off the tools, and the least competent engineers are operating hands-on on the aircraft*; (P_2)

And

> *Those that are trying to do it the right way can't afford to stay in business, so they fall out of business. Which means that all you end up with is are those that have cut the corners and you now have an unsafe engineer environment in General Aviation. End of story*. (P_4)

Safety-risk and concerns were also forecast based on a *loss of skills* within the industry, and the level of experience, *"the safety aspect [of concern] would be the experience level of the people"* (P_8), and the notion that there will continue to be no perceived consequences for trainees:

> *Back in my day, you were taught, you were given a competency, when you expressed that you knew what you were doing, you were examined and tested on that. You were then given that privilege. If you didn't know and you made a mistake, you got a thick ear. You were off your machine, you were out sweeping floors. There was a consequence for you not putting that effort in. These days, there's no consequence*. (P_10)

A series of problematic *workforce development* issues were also perceived to be a major practical and operational challenge going forward. An intergenerational *loss of knowledge and skills* from an ageing workforce was perceived to be a major industry affliction, where the acquisition of the knowledge required to identify problems was being lost:

> *If I could know half of what [my Dad] knows [about aviation maintenance engineering] I'd be doing well, you know? I think there's still a bit of a concern now that there's not that much experience coming out of the schools and apprentices and stuff* ; (P_3)

And

> *The sad thing is that the guys at my age are becoming less and less, and those young people aren't getting the experience from them.* (P_8)

A loss of applied skills and knowledge was also being attributed as a by-product of the increase in professionalism, *"[...] I think the downside to the professionalism is the loss of the knowledge how [sic] to fix things yourself"* (P_3). Directly related to these issues was the perception of a high *staff turnover* of people within general safety roles, *"basically, there's just enough staff employed to do what's required, and that's it"* (P_2), and a shortage of staff which meant that there not many apprentices in the industry and less opportunity to "pass the torch" onto younger people through *mentorship*:

> *There's not many apprentices coming through [...] I just loved working with older [engineers] because they could give me hints and guidance on where to go and what to do. I'm, me now as being one of those older people, don't have the opportunity to teach the young.* (P_8)

These concerns were further complicated by a belief that when the opportunities were arising, apprentices were not being supervised or mentored effectively, creating a haphazard learning experience, and opportunity-cost considerations were impacting this:

> *The apprentices are just having to learn by trial and error and on their own. They're coming out very insecure and very poorly trained [...] As bigger companies try and keep costs down, those budgets that training apprentices, they don't have those budgets for extra people on the floor to mentor and to guide and to hand over those skills to the apprentices.* (P_2)

Following on from the last point, the *financial burden* in the GA sector, and financial considerations in employment, was a final key practical and operational challenge. The organisational structure of GA was perceived to have changed in a way that disadvantaged small operators, and the new system was increasing cost with the *safety improvement increasing cost* and adding to the financial burden:

> *Small operators are real disadvantaged. The days of having a small operator, be it a charter company or be it a maintenance organization with just the chief engineer, the owner, and a couple of LAMEs ... Those days are gone because you need so many senior persons now just to be able to meet requirements*; (P_2)

> *The main thing for me is money. That's the biggest negative at the moment is that you're always fighting it [...] For some reason, the General Aviation industry, people think that everyone should ... We should be a bank for them. [...] It's like, "well, we're a small business, we can't afford to do that." In the same respect, it's ... Then [maintenance engineers] have problems paying our people and our suppliers and, by law, we're supposed to be able to afford to operate*; (P_9)

And

> *The cost of parts have gone up because of the new system. The cost of maintenance has gone up because of the new system. Owners can't afford planes these days and when they do, they can only just afford them. However, they still want the plane maintained perfectly and they still have to have their plane yesterday.* (P_5)

Lastly, the age and cost of the aircraft was thought to be contributing to the financial burden; the expensive nature of planes coupled with their age, which despite a link for more work perpetuated the view that work was simply unprofitable:

> *Back when it was [the aircraft] only 10 years old, yeah, $150 is fine because it didn't need all this major work. Now, you need to be putting money aside for not just your mandatory component overhauls, but major refurbishment: air frame and avionics upgrades, paint interiors, things that have never been replaced in the aircraft's life*; (P_2)

> *We haven't made profit in two years. It's not possible to make a profit, but the customers still complain about the bill*; (P_5)

> And

> *The hardship now, really, is that there's a lack of money in the industry, not only, from an engineering perspective, but from the customer's perspective. Everyone's trying to scrimp and save.* (P_9)

Figure 4 depicts a bleeding brakes scenario created by a participant in the form of their own concept map/mind-map/list which involves many of the central themes and issues across the results of the study, such as competency/experience and manuals, but also shows how concerns and worries around time, cost, business viability, and regulation may telegraph into the work and impact safety and performance.

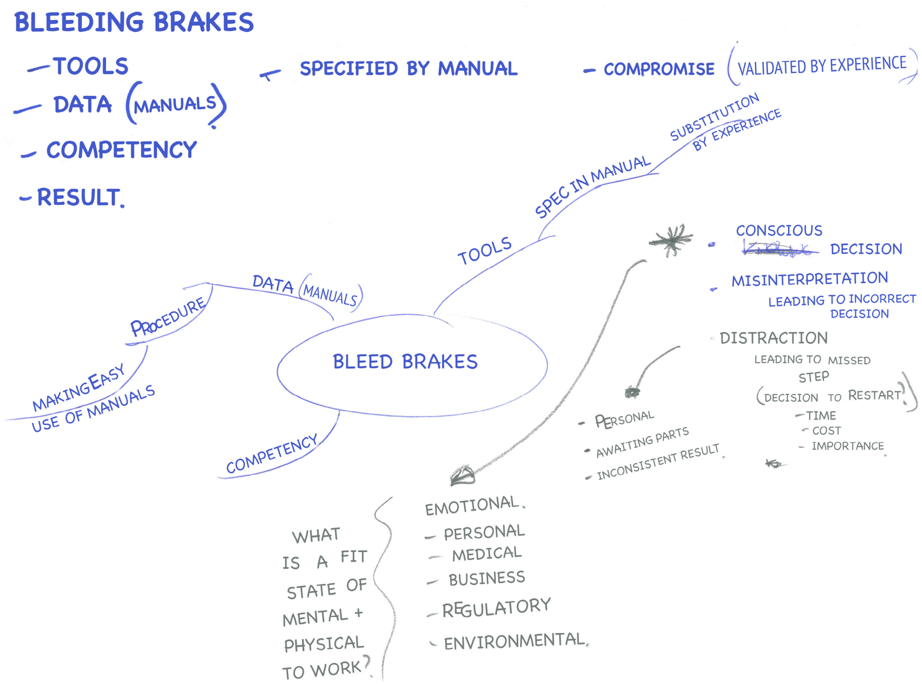

Figure 4. Example SITT scenario constructed as a mind-map by a participant depicting various factors and considerations perceived to be involved in bleeding brakes. Note: Handwriting has been replaced by a typescript to preserve anonymity of participant; size, colour and placement are the same.

3.6. General Discussion

The next sections provide a general discussion and reflection of findings based on the research questions, followed by a discussion of the strengths and limitations of the study, its implication, and potential future research directions.

3.6.1. Changes and Impacts in Regulation and to the Regulator Role to the GA sector

The results draw attention to an interconnectedness between the various components of the GA system, and illustrate how easily system behaviour can change overtime based on various feedforward and feedbacks loops associated with the regulatory/policy layers. Many of the findings reflect perceptions and statements on ways of working that carry safety implications, but are also a reflection of behaviours in an ostensibly complex and highly dynamic system. Proportional regulatory requirements, compliance, and safety oversight were among the main issues raised by participants (i.e., maintenance engineers/technicians). This set of issues are vital for operation of the GA industry, primarily due to the sustainment challenges brought by ageing fleets.

The results echo the industry's wish to balance safety and cost in a way that will allow the GA to remain profitable. Similar efforts have taken place in Europe and the US, thus, this finding indicates the international connectedness of the Australian GA industry, as well as the high degree of awareness of Australian maintenance professionals around these matters. On the other hand, it also helps us understand the driving forces behind the recent adoption of the US (FAA) regulatory model for GA. The choice of the FAA regulatory model offers greater autonomy to the Australian GA sector, but only at the cost of creating disconnection with the EASA-based CASA regulatory framework.

The existence of perceived power distance issues between "regulated entities" (i.e., maintenance technicians) and the regulator is insightful. Power distance has been well-researched in many different contexts [33–35], and in this study, responses suggest that GA technicians do not necessarily see themselves as the regulator's "long arm" in the effort to safeguard airworthiness. This was reflected both directly and indirectly (i.e., reference to the educational role of the regulator) through a wide range of narratives. This is an important research finding, since power distance can have an impact on the level of regulatory compliance and the effectiveness of reforms and changes attempted by the regulator. Interestingly, the results suggest that authority gradients—which relate to perceived power hierarchies in decision-making within teams or groups—also exist in the ranks of maintenance technicians, between those working on the "floor" and those in maintenance management and administration posts. As a natural extension of power distance, authority gradients between specific teams have also been explored at length in different safety-critical contexts [22,36]. In the aircraft maintenance context, it is a common expectation that the more experienced maintenance technicians have more opportunities (and do) take up office-based roles, especially in larger organizations. However, authority gradients also draw attention to cultural impacts in dynamic teams that can also impact and create fissures in safety culture.

3.6.2. Practical and Operational Challenges in the GA Industry

The availability of funds for maintenance has always been a strident issue for the GA sector, and this was confirmed in findings. Interestingly, participants expressed numerous concerns in relation to the role of owners in sustaining the airworthiness condition of their aircraft, broadening the systems perspective. The relationship of technicians and aircraft owners was highlighted over several narratives, offering indications of safety discrepancies. This relationship, in turn, has a negative effect on the job satisfaction of technicians since they may perform their work (i.e., maintenance tasks) within a stressful environment. This view was supported in a previous related research [12,13].

Another key finding was related to the attractiveness of the GA sector as a career pathway for aircraft technicians. This was recognized by participants as a challenge, given the high demand for more technicians (as the ageing GA aircraft required more maintenance) and the ageing workforce at large. Moreover, there was a perception that this demand cannot be met by the current supply of newly qualified technicians, as they generally lack the necessary training, skills, and motivation. These highly critical views expressed by participants may reflect a generation gap mindset, but also draw attention to perceived issues and hindrances with recruitment and retention of the workforce.

3.6.3. Strengths and Limitations of the Study

A key strength of this study was the use of the methodology that underpinned the data collection. Integration and application of the SITT elicited rich and concrete examples of system-level behaviours from the technician and engineer (i.e., end-user) perspective associated with the regulator and regulation and other challenges facing everyday operations. This enabled participants to harness and articulate the technical complexity of their work succinctly, but also allowed them to share their first-hand views in a more vicarious manner.

While relatively modest, the sample size did not serve as a limitation of the methodology as data saturation within data was reached, however, the small sample does limit the ability to make broad generalizations across the GA sector. Although the perceptions received were common across many participants, they are nevertheless subjective and nuanced and require care with interpretation.

3.6.4. Implications and Future Research Directions

In 2019, CASA decided to rearrange the GA aircraft maintenance regulatory framework in Australia. Changes within aviation can happen relatively quickly, but building a long and lasting positive culture is a slow process. For this reason, the impact of any change (either positive or negative) will be witnessed in the years to come. This analysis of data collected during late 2016—prior to the extensive industry consultation process which CASA employed for this purpose—offers important empirical insights which may be of value during transition, and also in years to come for benchmarking the sector's cultural maturity. It is likely that the regulatory changes happening in the GA sector will not be as fruitful as expected if the issues identified in this study are not tackled, and if the understanding between the regulator and those who are regulated is not improved. Issues in the key *human* factors cannot be addressed through new regulation, or through forced compliance. This paper reports some of these issues and it is believed that further independent research and publications (from external researchers, not associated with the regulator or the regulated bodies), can assist in the overall effort. Given the larger systems-oriented processes uncovered in the findings, further research could seek to unpack these dynamics relationships, for example through application of specific systems mapping processes that identify and attribute the feedback and feedforward loops for different elements [37–39].

Lastly, while this paper has focused on the Australian GA sector, comparison of the GA safety performance at an international level may be helpful in garnering further insights of the underlying regulation, practice, and safety culture issues [40]. A comparative analysis of these safety statistical data and practice could provide an indication of the effectiveness of the policies now being pursued by the Australian regulator. Therefore, a follow up research and study in this space is likely to constitute a valuable retrospective evaluation of the issues identified and discussed in the present paper.

4. Conclusions

In Australia, the diverse profile of General Aviation does, indeed, pose challenges for effectively managing safety and performance in aircraft maintenance operations. Based on the perceptions of this study, it is unsurprising that this has been a targeted area for continuous improvement.

The findings highlight that for the most part, perceived changes in the role of the regulator and regulation within the sector are not only perceived to have impacted the behaviours of the system underpinning the sector, but also diminished operations around safety and invoked a general view of a negative safety climate.

There are many perceived practical and operational challenges in the GA sector that must be dealt with to sustain safe maintenance operations going forward, many of which require change and growth across various cultural dimensions, and not only in how maintenance engineers and technicians work, but also other areas of the system, including the regulator, policy and practice, customers/owners, and tertiary education and vocational training.

In nearly every regard, if a central theme was to be assigned to this study it is that the GA sector is an ostensibly complex system, with high stakes in safety, and would therefore benefit from systems thinking when seeking to facilitate change management.

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