Cleared to Disconnect?
A Study of the Interaction between Airline Pilots and Line Maintenance Engineers

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To those who fly aeroplanes
and those who maintain them

Abstract

Accurate information regarding the maintenance status of an aircraft is essential for safe and efficient airline operations, yet there is evidence to suggest that pilots and line maintenance engineers do not always communicate effectively with each other. To date the majority of this evidence has been anecdotal, and formal studies have focused primarily on the shortcomings of the aircraft logbook as a communication medium. Despite the notion that poor communication between these two groups can potentially have undesirable consequences, there has been little discussion about how this might manifest within an airline environment. The studies undertaken for this research examined three distinct aspects of the pilot-maintenance interface: 1) the intergroup relationship between airline pilots and line maintenance engineers, 2) operational radio communications between airline pilots and line maintenance engineers, and 3) the effects of deficient pilot-maintenance communication on aircraft operations and flight safety.

Thematically analysed discourse from a series of focus groups held at a large New Zealand airline, found that communication difficulties are primarily the result of an interrelating set of organisational, physical and psychosocial barriers, all of which influence the nature of the intergroup relationship between pilots and line maintenance engineers. The use of Interaction Process Analysis (IPA) to examine radio calls between pilots and maintenance personnel identified that while the two groups share similar communication patterns and styles, indications of these barriers were present within their communication exchanges. The effects of deficient communication were then examined using data from the United States Aviation Safety Reporting System (ASRS). Using Correspondence Analysis (CA) to map associations between deficient pilot-maintenance communication and adverse outcomes, evidence was found that poor communication can be associated with both schedule disruptions and potential safety ramifications.

Ultimately, this research has important implications for airlines, particularly given the degree to which organisational factors can influence the efficacy of communication between these two groups. In light of the findings which suggest that problematic interactions between pilots and maintenance personnel can have both commercial implications and pose a threat to flight safety, it is recommended that airlines give consideration to facilitating joint Crew Resource Management (CRM) training for these two groups.

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Glossary of Aviation Terms

AAIB	Air Accidents Investigation Branch (UK)
ACARS	Aircraft Communication Addressing and Reporting System
AME	Aircraft Maintenance Engineer
AMEL	Aircraft Maintenance Engineer Licence
AMT	Aircraft Maintenance Technician
AOA	Angle of Attack
AOG	Aircraft on Ground (‘grounded’ due to a defect)
AQP	Advanced Qualification Program
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
ATPL	Air Transport Pilot Licence
ATSB	Australian Transport Safety Bureau
BASI	Bureau of Air Safety Investigation (Australia)
CAA	Civil Aviation Authority (UK)
CAANZ	Civil Aviation Authority of New Zealand
CAR	Civil Aviation Rules (NZ)
CASA	Civil Aviation Safety Authority (Australia)
CRM	Crew Resource Management
DDG	Dispatch Deviation Guide
EGPWS	Enhanced Ground Proximity Warning System
EGT	Exhaust Gas Temperature
FAA	Federal Aviation Authority (United States)
FO	First Officer
FOD	Foreign Object Damage
GPWS	Ground Proximity Warning System
HF	High Frequency
ICAO	International Civil Aviation Organization
IDG	Integrated Drive Generator
LAME	Licenced Aircraft Maintenance Engineer
MEL	Minimum Equipment List
MHz	Mega Hertz
MOC	Maintenance Operations Control / Maintenance Operations Centre
MRM	Maintenance Resource Management
NATS	National Air Traffic Services (UK)
NIGS	Nose-In Guidance System
NTS	Non-Technical Skills
NTSB	National Transportation Safety Board (US)
OTP	On-Time Performance
NASA	National Aeronautics and Space Administration
PF	Pilot Flying
PM	Pilot Monitoring
PIC	Pilot in Command
QRH	Quick Reference Handbook
RTF	Radio Telephony
SatPhone	Satellite Phone
TAG	Trans-cockpit Authority Gradient
TAT	Total Air Temperature
VHF	Very High Frequency

CHAPTER ONE

Introduction

1.1 Background to the Study

Pilot write-up in aircraft logbook: Left inside main tyre almost needs replacing

Engineering response: Left inside main tyre almost replaced

The above exchange is one of many that can be found from a pool of jokes regarding communication between airline pilots and line maintenance engineers. However, the way in which these two parties interact is not always so humourous. On January 17, 2015, Air India Flight 143 bound for Paris was delayed due to a physical altercation between the aircraft's captain and a maintenance engineer on the flight deck. The Telegraph[1] reports:

> **Jan. 17:** The pilot of an Air India flight today allegedly punched an aircraft engineer in the cockpit, giving him a bleeding nose, after a dispute over whether a snag had been corrected. An Air India spokesperson said Capt. Maniklal had been grounded till an inquiry into the fracas on the Chennai airport tarmac was completed. The Delhi-bound flight, AI 143, eventually left two hours late with its 118 passengers.
>
> Aviation sources blamed the incident on multiple factors: the habitually tense relations between pilots and ground engineers, a failure to follow standard procedure for resolving such disputes, and nerves frayed by the recent disasters involving Southeast Asian airliners.
>
> The Airbus 319 was to take off at 9.45am but was initially delayed by a technical snag after arriving from Mumbai. Aircraft engineer Kannan entered the cockpit, worked on the fault, and then signed the fitness sheet saying the snag had been corrected. But an unconvinced Maniklal refused to take off. Airline officials quoted other members of the technical team and an airhostess as saying that Maniklal and Kannan began arguing, and the pilot ended up punching the

[1] Source: www.telegraphindia.com published 18 January 2015. Retrieved 1 December, 2015 from: http://www.telegraphindia.com/1150118/jsp/nation/story_8978.jsp#.Vly4vy-6HmI

> engineer. As a bleeding Kannan stumbled out of the cockpit, the pilot locked the cockpit door. The other members of the technical team took Kannan to a nearby hospital. Senior Air India officials rushed to the aircraft and after much persuasion got the pilot to step out of the cockpit. Maniklal was taken to the airline's ground station at the airport. The flight took off at 11.40am with a different pilot, Krishnakumar. About 30 among the passengers were to catch a connecting flight to Paris; airline officials promised alternative arrangements if they missed it.
>
> Aviation sources spoke of a longstanding undercurrent of tension between pilots and ground engineers, caused by the frequent maintenance issues and compounded by egos. They said each group often undermined the role of the other.

Conveniently, my own role within the aviation industry as an airline safety investigator allowed me some insight of the sorts of issues which were possibly contributing to these disagreements between pilots and engineers. I would come across reports where there were differing interpretations of shared documentation, complaints that pilots weren't giving engineers enough information about defects and, in a similar vein, complaints that engineers weren't providing pilots enough information following defect rectification. Much of the time, any disagreements which were occurring appeared to stem from poor communication flow between the two groups. I didn't think that was particularly surprising however, given that pilots and engineers are trained separately, work separately, and are certainly never taught how to communicate effectively with one another. But then I began to wonder whether there were more complex issues involved. Did the tensions run deeper? Did the constant referrals of '*pilots always*…' and '*engineers never…*' indicate more imbedded sources of conflict such as inter-group stereotyping? What psychological – or sociological - behavioural explanation lay behind the personal swipes at each other's professions? Furthermore, what were the implications of these issues? The captain of an aircraft and the certifying engineer both have legal responsibilities for the safety of the aircraft as well as accountability to their airline for operating in an efficient manner. Could this then mean that any difficulties the two groups were experiencing when they interacted could potentially affect both the safety of the aircraft as well as the operating performance of the airline?

Whenever an airliner is despatched from the gate at an airport, the line maintenance engineer in charge of the pushback and engine start is plugged into the aircraft intercom system so he or she can communicate with the flight deck crew during the procedure. Once the engines have been started successfully and the aircraft is in a safe position to taxi to the runway, a standard dialogue (to ensure the handover procedure is conducted in a safe manner) takes place between the engineer and the pilot. The last phrase of this dialogue involves the pilot giving the despatching engineer permission to unplug themselves from the intercom system, effectively ending their communication for that particular segment of flight. Interestingly, the phrase which is used can also be applied to describe a much wider issue between these two groups, and in doing so, provide the essence of this thesis in a nutshell:

'Cleared to Disconnect…'

1.2 Purpose of the Study

The purpose of this research is to explore the interactions between airline pilots and aircraft maintenance engineers within an academic framework. The research aims to investigate the relationship between the two groups; in doing so the objective is to not only provide an insight into potential barriers and impediments to effective communication between pilots and aircraft maintenance engineers, but also to determine what consequences, if any, ineffective communication can have on both the safety and efficiency of an airline operation.

In addition to my own experiences, other evidence was sourced as verification that there were indeed difficulties with the way engineers and pilots interacted and communicated with each other. A preliminary search of the Aviation Safety Reporting System (ASRS) database which is administered by the National Aeronautics and Space Administration (NASA) was conducted. The database is home to over one million safety reports which have been submitted by flight crew, cabin crew, air traffic controllers and maintenance personnel in the United States since 1976 (NASA, 2014). The following is a small sample[2] of reports found which illustrate some of the frustrations being reported by airline pilots and aircraft engineers (referred to as 'mechanics' in the US):

> During the preflight inspection I [pilot] noticed fluid underneath the number two engine cowling in the vicinity of the drain mast. Upon finishing the aircraft inspection I briefed the Captain and called Maintenance from the jetway telephone….I also showed the Captain three digital photos I had taken of the leak. The Captain then called Maintenance and asked that the mechanic (who signed off the write-up) return to the aircraft. When the mechanic returned, the Captain requested I show the mechanic the leak so that we were all on the same page….When we got to the engine I showed him the fresh fluid on the ground and also wiped a sample off the bottom of the cowling (he never bothered to bend down to look at the underside of the engine). He tried to convince me that this was normal. I told him that I disagreed and he said, 'Well, I already signed it off!' As I returned to the aircraft he continued to lecture me about how fluid coming off the engine was normal. At one point he tried to pass off the fluid as an over-service of engine oil. The mechanic continued to lecture me, at times raising his voice, as we made our way up the jetway. He was very argumentative. In the cockpit he continued to interrupt me as I tried to advocate to the Captain my point of view. At one point he became very agitated and said that fluid leaking from

[2] Reports have been abridged and technical language decoded.

the bottom of engines is normal and that this was just like the DC-8, 727, etc. He also said that if we want he can pull everyone off the airplane, delay the flight for over an hour, open up the cowling, and run the engine. Then he pointedly said, 'but, I will tell you right now, I won't find anything!' The discussion continued for some time which resulted in a pilot delay. ASRS Report No. 863354

I [Mechanic] noticed that the aircraft was in Hotel mode[3] and had not been deiced yet. So I went to the Captain before the door was closed and I told him that he could not deice the aircraft in Hotel mode on that side of the engine. He said he has done this all the time. So I got out of the aircraft and I called the Maintenance Trainer to ask him about this procedure and he said that the right side should not be done in Hotel mode, so I went back to the aircraft and handed the phone to the Captain and he hung it up. So I stopped the Deice crew and I got back in the aircraft and told him my Trainer said that it should not be done. He told me he's the f---ing Pilot in Command and he will do what he wants to; so I told him don't curse me, I don't care who you are, but don't curse me. I then got out of his aircraft and let him do what he wanted to do…suggest the pilots should follow the procedure in the Deicing Manual and not curse at the mechanics when we are trying to do the correct procedure. ASRS Report No. 986919

During preflight inspection, chips were found in the radome that exposed the fiberglass structure. Upon returning to the aircraft the maintenance logbook was returned by maintenance and it was noted as agreed that the damage could be placed on special item. I [pilot] explained to the maintenance control supervisor that the logbook and deferred maintenance were completed but no deferred sticker was on to indicate the new special item. Basically he stated that the sticker was not required. So I mentioned that in my 8 years as a captain and 11 years with the company, I do not remember a situation where there was not a sticker associated with a special item. His reply was that he has been here 14 years and sometimes the mechanic puts them on and sometimes they don’t. That some items are done and some are not. How can we have a special item with no consistent documentation? ASRS Report No. 721106

During my walk-around, I [pilot] discovered numerous localised dents on the underneath side of the horizontal stabiliser. The aircraft skin reminded me of a golf ball. I was surprised not to see a sticker placed by maintenance after inspecting the area as I thought the damage was very noticeable. Shortly thereafter a mechanic stopped by the cockpit and asked me to come outside and point out the area I was referring to. I came outside and pointed out the area. The

[3] Hotel mode is an operational feature peculiar to ATR-series turboprop aircraft where the engine can run without the propeller spinning.

> mechanic said ‘that’s fibreglass’. I said ‘I know’. He said ‘That’s internal damage’. I said ‘that is what it looked like to me too, which is what concerned me the most’. Then he said, ‘Do you see the area that has been painted along the outer edge of the fairing?’ I said ‘Yes’. He said, ‘That’s the repair’. I said, ‘Well, as we have no official record of this having been reported or repaired and you’re already out here, would you please take a quick look, so that we will know for sure that it’s ok?’ He huffed and turned to go up on the ‘cherry picker’ without any reply. I turned and started to walk away as I was going to return to the cockpit, then changed my mind and decided to watch and make sure that the mechanic did in fact inspect the area. I was about 20ft away when I turned around, saw the mechanic talking to the supervisor, shaking his head and laughing. I found the way I was being treated to be very unprofessional and demeaning. The mechanic might as well have said, ‘You don’t know anything! Why are you wasting my time?’ The demeanour of both the mechanic and supervisor certainly seemed to say that. If, in my professional judgement, I hadn’t thought the item was a legitimate concern, I would not have mentioned it to the captain, much less to maintenance. I felt that their treatment of me was intended to serve as a deterrent for future reporting. ASRS Report No. 813257

The above reports are concerning given the importance of good teamwork within the aviation domain. Communication training in the form of Crew Resource Management (CRM) between the captain and first officer, has origins which can be traced back to the years following World War II (Kern, 2001). Since then, CRM has grown to encompass interaction between the flight crew and those working outside of the cockpit such as flight attendants and air traffic controllers. The benefits of this extension are not insignificant. Two high-profile accidents in 1989[4], were tragic exposés of the ineffective communication between pilots and cabin crew which prevailed at that time. Whilst difficult to quantify, it is generally acknowledged that the move to provide pilots and flight attendants with joint CRM training has been beneficial with regard to more effective teamwork on board the aircraft, Brown and Rantz (2010) referencing the successful ditching of US1549 as an example. Accidents which

[4] British Midlands’ B737 at Kegworth (Air Accidents Investigation Branch, 1990) and Air Ontario Fokker F28 at Dryden (Moshansky, 1992).

have attributed to a breakdown in communication between pilots and air traffic controllers[5] have also lead to the development of joint training for flight crew and controllers, the Multi-Crew Resource Management programme developed by NATS (National Air Traffic Services) in the UK being one such initiative.

Yet despite recommendations to do so (Mattson, Crider & Whittington, 1999; Mattson, Petrin & Young, 2001; Reithmaier, 2001; Munro, Kanki & Jordan, 2008; Ford, 2011) there has been little interest in extending CRM to incorporate maintenance personnel who, by the very nature of their job, are required to interact with flight crew on a daily basis. This may be due to the fact that, unlike those high-profile accidents where a breakdown in communication between pilots and cabin crew or pilots and air traffic controllers has been cited as contributing significantly to the outcome, there have been no such equivalent accidents due to poor communication between pilots and aircraft maintenance engineers. That is not to say, however, that communication deficiencies have not contributed in some form to at least one accident. A lack of teamwork and ineffective communication between a maintenance engineer and the flight crew has been highlighted by Latorella and Prabhu (2000) in the loss of a Nationair DC-8 in 1991. Although this is only one such example, it is important to acknowledge that the absence of accidents is not necessarily indicative of a healthy state of affairs (Reason, 1990; 1997). Heinrich's (1931) 'iceberg' model (Figure 1.1) is one such expression of this in the safety literature despite a certain amount of criticism regarding the validity of the actual ratios[6].

[5] e.g. KLM and PAN AM collision at Tenerife, 1977 (ALPA, 1979) and Dan Air B727 Controlled Flight into Terrain, 1980 (Job, 1996).
[6] Wright & van de Schaaf (2004) provide a review of the literature concerning the empirical evidence of this.

Figure 1.1. Heinrich Model: for every visible event of a serious nature, there are many more events which may share similar latent conditions.

The ASRS reports, above, can be related to this model. Not only are difficulties between the pilot-maintenance interface apparent, the implications are troubling with respect to both aircraft safety and an airline's operating schedule. Flights operating without the correct documentation, doubt as to the airworthiness of the aircraft, and, perhaps most concerning, discouragement to report safety concerns, are all examples of potential safety threats for an airline. Additionally, with delay costs estimated to be over US$9 billion[7] in 2014 for airlines in the US alone, one would imagine that a late departure caused by a quarrelling pilot and maintenance engineer would be particularly unpalatable to airline management.

However, while anecdotal evidence of poor communication between pilots and aircraft maintenance personnel is plentiful, as the literature review will reveal, academic research

[7] This data is provided by Airlines for America and calculates the per-minute cost of delays for passenger airlines within the US. In 2014 total delay costs were estimated at US$9,149 million. http://airlines.org/data/per-minute-cost-of-delays-to-u-s-airlines/ retrieved 1 December, 2015.

with a view to formally identify the underlying causes of such issues is scarce. Similarly, while it might be a logical assumption to make, there is a lack of empirical evidence to suggest that a problematic interface between these two groups has a negative effect on an airline in any way. The aim of this research is to move beyond the anecdotal reports, and to more systematically research the nature of the interactions between flight crew and line maintenance personnel.

With consideration to the overall research problem, the following central research question was identified:

> *What difficulties with regard to communication processes do airline pilots and line maintenance personnel experience when they interact and how do these difficulties manifest with regard to airline operations?*

1.3 Methodological Considerations

The over-arching research design was developed in such a way so as to allow the investigation of three distinct areas of inquiry in order to enable a dedicated exploration of:

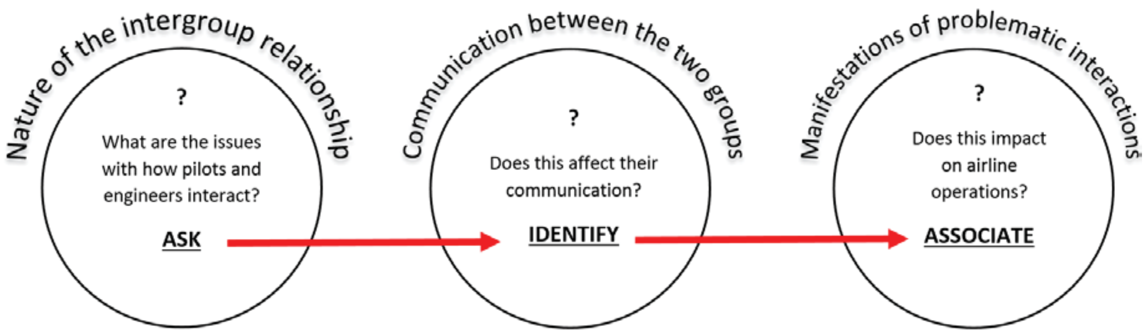
1. The nature of the intergroup relationship between airline pilots and line maintenance engineers
2. The communication between the two groups within an operational context
3. The manifestations of problematic interactions between the two groups

Given that this research was primarily exploratory in nature, a strategy was chosen so as to facilitate an inductive pattern of enquiry. Therefore, while the methods to be used for each study were chosen as part of the overall research design, a certain degree of flexibility remained in order that the findings from each proceeding study could inform the scope and context of the next.

It was decided that a 'mixed-method' approach would be used, allowing for each of the three areas of focus to be investigated using the most suitable method. As a result, both qualitative and quantitative studies were undertaken to achieve the research goals. Methodological pluralism lends itself well to research that commences as exploratory (Robson, 2002; Johnson & Onwuegbuzie, 2004) and aligns with the epistemological assumptions of pragmatism (Robson, 2002; Denscombe, 2010) supported by the researcher and described here by Greene and Caracelli (1997):

> The philosophical assumptions of the two paradigms are logically independent and can therefore be mixed and matched in conjunction with choices about methods to achieve the combination most appropriate for a given inquiry problem. (p.8)

As Part III of the literature review will reveal, with previous research in this field being limited to either pilot (trial) studies, or survey-based questionnaires, the opportunity presented to utilise methods which had not previously been employed for research in this particular field. As it so happened, the three areas of interest for the current research naturally aligned with differing methods of inquiry:



Given the exploratory nature of the research, it was decided to utilise a research strategy which facilitates theory generation as opposed to an ability to generalise the research findings; i.e. depth as opposed to breadth. Moreover, the subject matter lends itself well to intensive examination, Descombe (2010) advocating that:

> Opting for a depth of coverage, by contrast [to breadth], allows researchers to obtain detailed data and to deal with the complex interrelationships that characterise many social phenomena. (p. 102)

With this in mind, it was decided to undertake the research within a single organisation; a New Zealand airline to which access to participants and data was negotiated. Consequently, while it is acknowledged that this reduces the extent to which inferences can be made with regard to a wider population, analytical generalisation in terms of theory development are a possibility (Yin, 1994). As it transpired, the airline which participated in the research was only appropriate for the first two of the three studies (as detailed in Chapter Six) allowing for a wider extension of the research in Study Three.

1.4 Outline of the Thesis

Chapter Two of the thesis begins with an overview of the study context by providing a description of the structure and regulation of airline maintenance activities within New Zealand. The tasks and functions specific to line maintenance are detailed as it is within this environment that interactions between flight crew and maintenance engineers take place. Chapter Three contains a review of the literature relevant to this research. Here, the importance of effective communication and teamwork within aviation are discussed and the behaviours which can influence communication interactions are explored from a wider social psychology perspective. A critical review of the previous studies in this field leads to the identification of a central research question, which aligned with the three areas of interest. Chapter Four details the first study where the nature of the intergroup relationship between airline pilots and line maintenance engineers is explored using a qualitative approach. Through thematic analysis, a conceptual framework identifying the impediments to effective communication between the two groups is developed. Chapter Five then describes the second study which examines the nature of communication between airline pilots and line maintenance engineers in an operational context. Utilising the technique of Interaction Process Analysis provides a quantitative insight to the characteristics of communication exchanges between these two groups and lends support to the findings from Study One. Chapter Six reports the final research study which is also exploratory in nature. Correspondence Analysis is used to ascertain what associations there are, if any, between poor communication in the line maintenance environment and negative operational and safety-related outcomes for an airline. The thesis is organised such that the results and discussion relating to each of the studies is contained within the applicable chapter. Chapter Seven, therefore, presents a more generalised discussion on the overall research and its relevance to the wider literature within the field. Conclusions and recommendations for future research are contained within the final chapter, Chapter Eight.

CHAPTER TWO

The Study Context

For the majority of the travelling public, opportunities to observe pilots or maintenance engineers in their respective work environments is limited; contact with operational personnel is generally restricted to the standard interactions between passengers and cabin crew during flight. While keen observers may spot a pilot on the tarmac inspecting an aircraft, flight crew are typically seen away from their place of work, often walking through the terminal pulling flight bags. Sighting an aircraft engineer tends to be a rare occurrence as singling them out from the multitude of other employees on the tarmac in high visibility clothing is nigh on impossible. Consequently, while their vantage point in the cabin allows passengers to watch flight attendants communicating with pilots at certain times during the flight via the interphone, the interactions between those who fly aircraft and those who maintain them are not, for the most part, observable. If an aircraft 'breaks', the pilot needs to tell an engineer so it can be 'fixed'. But how, and where, does this communication take place? It may be a surprise to some that the vast majority of aircraft maintenance engineers have no contact with pilots in any shape or form. Others, however, will talk to them every working day. This chapter provides an overview of a typical line maintenance environment within a large airline. The responsibilities of line maintenance within the wider engineering division of an airline are numerous, therefore this description is limited to the processes and documentation specifically related to those activities which also concern the flight crew. The chapter concludes with an overview of the participant airline.

2.1 Regulation of Airline Maintenance Activities in New Zealand

Within New Zealand, airline operations are regulated by the Civil Aviation Authority of New Zealand (CAANZ) in accordance with the *Civil Aviation Act 1990*. Certification and governance depends upon the size of aircraft utilised by the airline in accordance with Civil Aviation Rule (CAR) Part 119 *Air Operator Certification.* Holders of an air operator certificate issued under this rule part, are required to have procedures in place to ensure the continuing airworthiness of their aircraft in the form of a maintenance programme (CAANZ, 2016a). Those organisations[8] which are approved to perform maintenance must be certified accordingly (2016b).

Certification for maintenance personnel is conducted under CAR Part 66 *Aircraft Maintenance Personnel Licensing.* In essence, whilst maintenance on an aircraft may be conducted by unlicensed personnel under appropriate supervision, in order to be able to release an aircraft or component to service after maintenance has been performed, an Aircraft Maintenance Engineer Licence (AMEL) must be held (CAANZ, 2016c). Licences are particular to various categories of aircraft and various aircraft systems for which ratings are held. Thus, following a period of training and apprenticeship, an engineer will specialise in a particular area of aircraft maintenance (e.g. powerplants, avionics, electrical systems) and become qualified to certify maintenance applicable to that rating. The AMEL is comparable

[8] Depending on the size of the fleet, an airline may elect to conduct their own maintenance ‘in-house’ or alternatively, out-source its maintenance to a contracting company.

to the Airline Transport Pilot Licence (ATPL) for flight crew; the licence is valid for the lifetime of the holder[9] provided certain currency requirements are met.

Within New Zealand, maintenance personnel are generally referred to as aircraft maintenance engineers (AME). The term LAME is used to denote that an engineer is licenced under CAR Part 66. Terminology differs between countries. In North America, for example, the term aircraft engineer is reserved for holders of a professional degree and maintenance personnel are referred to as aircraft maintenance technicians (AMT), or simply ‘mechanics’ or ‘technicians’.

2.2 Types of Maintenance

Two types of aircraft maintenance are conducted within an airline; scheduled maintenance and unscheduled maintenance. Scheduled (or ‘preventative’) maintenance, takes the form of a series of scheduled services based around set periodic inspections for which the aircraft is removed from flying service. Inspection periods are typically limited by either calendar time or hours in service and this is referred to as ‘scheduled maintenance’. Scheduled maintenance can be defined as:

> those maintenance activities predetermined and identified in a programme as being required to maintain the continued airworthiness of the aircraft and its components (CAANZ, 2007, p.5)

Scheduled maintenance takes place in a hangar (or dedicated maintenance facility area) where human resource as well as equipment and tooling is allocated accordingly. The type

[9] Unless suspended or revoked under Civil Aviation Act 1990 (CAANZ, 2016c).

of inspections which take place in the hangar tend to be lengthy in nature, requiring a good deal of resource and earning the moniker of ‘heavy’ maintenance. Work is undertaken in shifts, with each team of maintenance personnel completing a particular work assignment under a shift supervisor. As scheduled maintenance takes place in a hangar, aircraft engineers working in this environment will generally only interact with other maintenance personnel.

Unscheduled maintenance, on the other hand, refers to those occasions when maintenance is not planned:

> those maintenance activities that occur from unplanned occurrences. This maintenance may require action outside the maintenance programme schedules (CAANZ, 2007, p.6)

Unscheduled (or ‘corrective’) maintenance takes place in situ where possible. Thus if an aircraft taxis to the gate carrying a defect, the maintenance will be undertaken at the gate provided another aircraft is not scheduled to be using it. In the case of the gate needing to be used, then the aircraft is generally towed to an area away from the terminal called a ‘remote gate’ in order for engineers to work on the aircraft. The reason aircraft are not taken directly to an airline’s maintenance base is that hangars, and their associated resources, tend to be limited given the on-going nature of the scheduled maintenance inspections.

To lessen the demands on the hangar, some scheduled maintenance is also conducted on aircraft in the terminal area. These checks are much shorter in length and are generally associated with inspection requirements whilst the aircraft is in service such as transit checks or pre-departure checks. This practice of both repairing and servicing aircraft whilst at the gate, is deemed ‘Line Maintenance’ in reference to the aircraft being scheduled in service - on the ‘flight line’ - as opposed to being scheduled out of service for preventative maintenance.

Aircraft engineers working in a line maintenance environment tend to work by themselves; if an aircraft has a defect which requires rectification, the work will be allocated to whomever is available at the time. Unlike maintenance personnel who work in the hangar, the nature of their work means that line maintenance engineers interact with many other airline employees, including flight crew, cabin crew and ramp workers. Table 2.1 summarises the main two types of aircraft maintenance within an airline operation.

Table 2.1 *Characteristics of Scheduled and Unscheduled Maintenance*

	Scheduled Maintenance	**Unscheduled Maintenance**
Purpose	Preventative	Corrective
Known as	Heavy maintenance	Line maintenance
Location	Hangar	Gate and Terminal Area
Length of Scheduled Checks	Weeks to months	Minutes to Hours
Unscheduled Maintenance	Only if unable to be rectified on line	Yes
Engineers work	In teams	Individually
Engineers interact with	Other maintenance personnel	Other maintenance personnel, flight crew, cabin crew, ramp staff

The differences between scheduled and corrective maintenance mean that both work areas are unique for maintenance personnel. As this research is concerned with the interface between flight crew and aircraft engineers, it is the line maintenance environment which will provide the contextual setting for the studies. The following describes the line maintenance environment, specifically the aircraft turnaround process, and the procedures for identifying and rectifying defects whilst an aircraft is in service. It is within this environment where the majority of flight crew and engineering interaction takes place

2.3 The Line Maintenance Environment

Anybody who has watched an aircraft taxi into the terminal gate at an airport will have observed the fast-pace atmosphere which is created almost as soon as the aircraft stops moving. The engines will still be spooling down when ramp workers and loading equipment suddenly materialise and appear to descend on their target as if it were prey. Cargo and bags are unloaded and employees wearing high visibility vests duck and dive around the aircraft with purpose; no one is loitering. Amongst these workers will be aircraft maintenance engineers, who must inspect and service the aircraft before it departs and perhaps be involved with refuelling and pushback[10] activities too. The ramp is a busy place, certainly more so than working in a hangar environment (ICAO, 2003).

In terms of a base location, line maintenance personnel will generally have facilities close to the airport terminal in order to have ready access to aircraft at the gates. Resources will include space for tooling and equipment as well as a technical library to house computers, aircraft manuals and engineering documentation. Unlike maintenance undertaken in a hangar, aircraft parked at a gate are exposed to the elements and line maintenance engineers will work in adverse weather conditions at times. Similarly, while a hangar environment

[10] As airliners cannot reverse under their own power, the term pushback refers to the process of manoeuvring the aircraft away from the terminal gate using specialised ground equipment.

offers specialised equipment designed to facilitate ergonomic access for personnel working on the aircraft, maintenance conducted on the line means that engineers are frequently standing, kneeling and bending in awkward positions while they work (ICAO, 2003; Kinnison & Siddiqui, 2013).

The very nature of line maintenance means those aircraft engineers who are employed to work in this environment must have a unique set of skills. From Kinnison and Siddiqui (2013):

> It is often thought that, because of the simple nature of the work – turnaround maintenance and servicing – the line maintenance unit can be manned by the newer, less experienced personnel. Nothing could be further from the truth. The work done by line maintenance covers a broad scope of activity. While the workshops and hangar can employ specialists who work essentially on one or a few items repeatedly, line personnel need to know the entire aircraft: all of its systems and their interactions. Line mechanics have to deal with a different problem, often on a different type of aircraft, each time they are called to meet an incoming flight. (p. 161)

2.4 Line Maintenance Functions

As noted earlier, the function of line maintenance is unique in that both scheduled and unscheduled maintenance is undertaken. Ideally, the work conducted on the line is any maintenance that can be performed on aircraft which are in service without disrupting the flight schedule. While the specific work tasks will vary somewhat according to an airline's individual maintenance programme, scheduled line functions typically include 'A' checks, daily/48-hour inspections, and transit checks. An 'A' check is the first of the most commonly known type of aircraft inspection (Rhoades, Reynolds, Waguespack & Williams, 2005). An aircraft's letter checks (A-D) are both progressively more comprehensive and less frequent, thus while an 'A' check might take place every one or two months, the interval between a 'D' check could be 5 years. Daily/48-hour inspections are just that, and will be normally be performed overnight while the aircraft is not being utilised. This check typically consists of a visual inspection of the aircraft exterior, brake and tyre checks, oil replenishment when required and an operational check of systems within the flight deck. The third scheduled inspection which is undertaken by line maintenance is the transit check. This takes place in between flights while the aircraft is being prepared to operate for the next sector. An example of the items which are inspected during a transit check is provided in Section 2.5.1, below.

In addition to scheduled maintenance, aircraft engineers working on the line must attend to those aircraft which arrive at the gate carrying defects. Depending on the nature of the defect, when an aircraft presents with a defective system or component it must either be fixed prior to the aircraft's next sector or deferred to be fixed at a later time (Figure 2.1). The deferral process is described in Section 2.7. In order to optimise the short amount of time an aircraft has at the gate, line maintenance would ideally receive prior notification should an inbound aircraft be carrying a defect. On those occasions when the flight crew pass this information on, this process is co-ordinated through an airline's Maintenance Control centre.

2.4.1 The Role of Maintenance Control

The role of Maintenance Control is to oversee all aircraft which are operating in service. By keeping track of the fleet's maintenance status, Maintenance Control can co-ordinate any non-scheduled maintenance needs which arise. An airline's maintenance control centre is

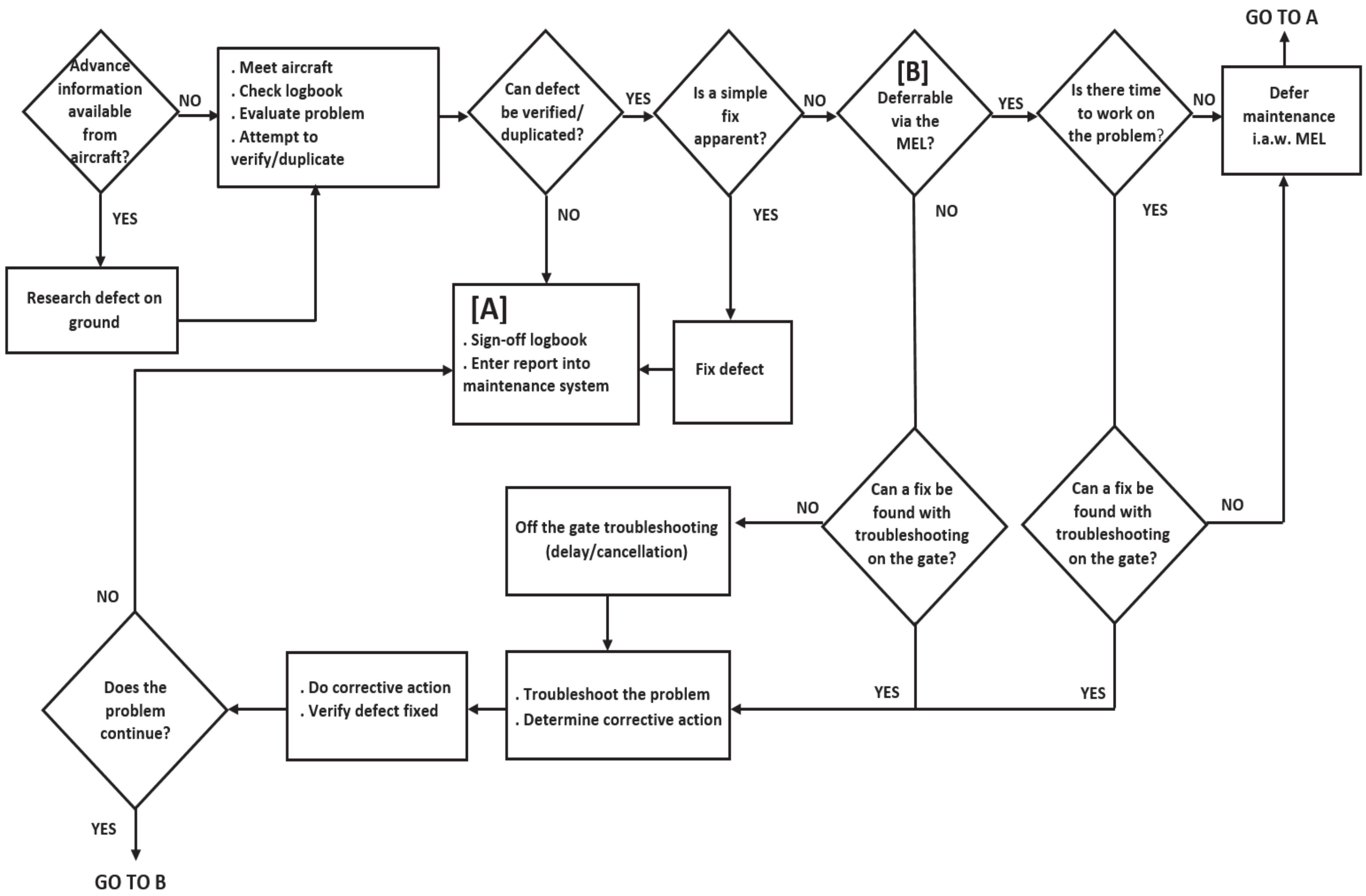


Figure 2.1 Line maintenance deferral process. Adapted from Aeroplane System Design for Maintenance (source: http://elektroarsenal.net/category/aerospace-expert-systems/page/36)

described by Kinnison and Siddiqui (2013) as ‘the heart of line maintenance’ and functions include:

- Tracking all aircraft during flight to determine their location, maintenance requirements and status.
- Co-ordination of maintenance at out-stations and with third-party contractors.
- Co-ordination with Flight Operations regarding flight delays and cancellations whenever the schedule may be impacted by maintenance.
- Co-ordination with other maintenance departments such as materials, engineering, planning for assistance in resolving unscheduled maintenance.
- Provide direction to line maintenance regarding decisions on rectification or deferral of a defect depending upon schedule requirements.
- Give guidance and technical support to flight crew regarding defects which arise in flight.

In order to provide these services, Maintenance Control must have appropriate communication facilities, including those required to contact aircraft during flight. Depending on an airline’s resource, specialised software can provide real-time monitoring of aircraft systems to facilitate troubleshooting and tracking of maintenance status. Access to the organisation’s technical library including all aircraft maintenance manuals and other engineering documentation is essential. The physical location of an airline’s maintenance control centre varies. Despite managing all of their activities, being co-located with line maintenance is not necessary provided communication requirements are satisfactory. Given the close co-ordination required with Flight Operations, some airlines prefer to have their Maintenance Control within the same facility as their ‘day-of-ops’ section i.e. operations control, flight despatch, load control.

2.5 Aircraft Turnarounds

A flight is deemed to have terminated once an aircraft comes to rest at the end of the flight (CAANZ, 2015a) which, for an airline, will be arrival at the terminal gate. From this point on, provided the aircraft is to be utilised on another flight, the process of readying the aircraft for the next sector begins. The turn-around process includes a number of planned activities undertaken by various operational groups. Figure 2.2 depicts the typical passenger handling and aircraft servicing activities which must be accomplished, often within a short space of time.

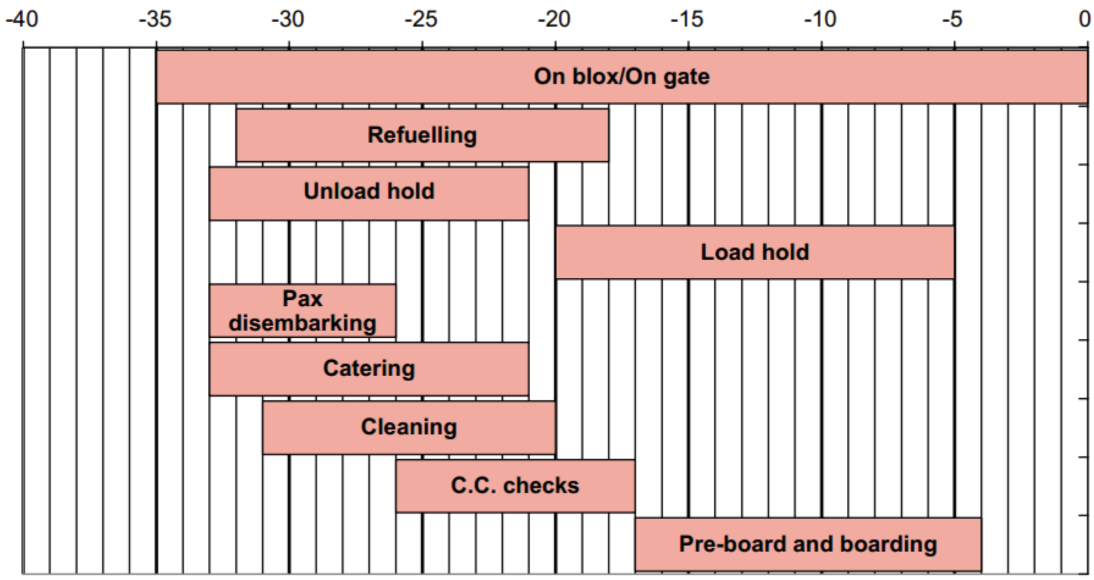


Figure 2.2 Passenger handling and aircraft servicing activities for a 35 minute turnaround on a domestically operated B737 (source: Wu, 2008). *Note: C.C. checks refers to cabin crew checks of the aircraft cabin.*

Within the turnaround time, certain maintenance activities are also undertaken. Line maintenance personnel[11] will enter the cockpit and check the aircraft technical log (see 2.6, below) for any defects written up by the inbound flight crew. It is at this point that the aircraft engineer may have an opportunity to speak with the pilots about any maintenance issues concerning the aircraft. Whether this occurs, however, is dependent upon the movements of the flight crew who may have vacated the cockpit prior to the aircraft engineer arriving. This is by no mean an unusual occurrence for several reasons:

- The turn-around process may involve a scheduled crew swap whereby the flight crew must change aircraft for their next sector. The crew may have to travel some distance to get themselves to another gate in a short space of time.

- The sector may have been the last rostered flight for the crew that day. Crew transport schedules, post flight administration and fatigue following a long duty may induce pilots to vacate the aircraft expeditiously.

- Mid-duty respite. Depending on the length of time the aircraft is scheduled to be at the gate, the crew may utilise the opportunity a turnaround provides for bathroom and refreshment breaks.

[11] The number of engineers will vary between airlines although typically only one licenced engineer would be assigned to an aircraft turn-around. Engineers may also have to cover a number of gates during their shift (Munro, et al., 2008).

- Flight crew turnaround duties. Specific turnaround activities, such as performing an aircraft pre-flight inspection (see 2.5.2) may take the crew away from the flight deck.

Aside from an aircraft engineer being alerted to a maintenance issue either by a review of the technical log or by the pilots themselves, there are two other opportunities which allow for the discovery of any maintenance issues prior to the aircraft's next flight. Before it departs on its next sector, the aircraft is subject to two inspections; one conducted by an aircraft engineer and the other by a member of the flight crew.

2.5.1 A Typical Transit Check

Even a short turnaround time affords an opportunity for the aircraft to be checked prior to its next flight. While the aircraft is parked at the gate, a line maintenance engineer will conduct an external examination of certain flight safety-critical systems and components. This is known as a transit check. While the actual items will vary somewhat, the typical elements are those which are easily accessible to the engineer in the time available (Figure 2.3). Should a defect be discovered during the line maintenance transit check, the aircraft engineer will liaise with the Maintenance Control centre as to what course of action will be taken. Whether an effort is made to repair the defect while the aircraft is at the gate depends upon the airline's flight schedule as well as the nature of the defect itself.

- Service engine oil if required
- Check ram air inlet/exhaust doors and cabin outflow valve for condition and obstructions
- Check positive pressure relief valves for indication that valves have opened
- Check moveable flight control surfaces for condition, obstructions, and locks
- Make sure that the fuelling station door is closed
- Check nose and main landing gear tyres and wheels for obvious damage
- Check navigation and communication antennas for condition
- Check static ports, TAT probe, pitot static probes, and AOA vanes for condition
- Check crew oxygen discharge disc
- Check drain mast areas and drains for leakage of fuel and/or hydraulic fluid
- Check vertical fin and rudder, horizontal stabilisers and elevators for damage, evidence of fuel leaks
- Check for missing or damaged static dischargers
- Check lower wing surfaces and wing tips for damage and fuel leakage
- Check engine cowlings for obvious damage, check blowout door in not open and latches are secure
- Check inlet cowl, fan rotor spinner, and fan rotor blades on both engines

Figure 2.3 Typical transit check for a twin engine jet (source Kinnison & Siddiqui, 2013)

2.5.2 Flight Crew Walk-Around Check

In addition to the inspection undertaken by line maintenance, the crew who will operate the aircraft on its next sector must also conduct their own check. CAR Part 91.201 *Safety of Aircraft* states that prior to operating, the pilot-in-command of an aircraft must be satisfied that the aircraft has been inspected and that it is in an airworthy and safe condition for flight (CAANZ, 2015b). The particulars of what a pilot must check for during his/her inspection are specific to the type of aircraft which is operated. The details are published by the aircraft manufacturer and are contained in the aircraft's operating manual. However, many of the items checked will be the same as those inspected during the line maintenance transit check. An airline's operating procedures will specify whether the pre-flight inspection is undertaken by the captain or the first/second officer or whether it is a function which is attached to a particular role i.e. Pilot Flying (PF) or Pilot Monitoring (PM). A typical pre-flight inspection is carried out by walking around the aircraft in a systematic manner whilst visually checking the integrity of the specified aircraft components (Figure 2.4).

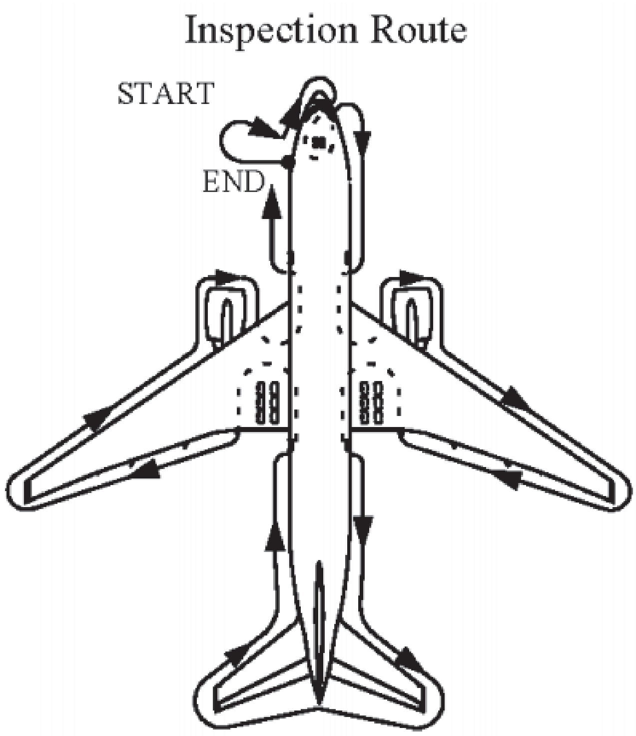


Figure 2.4 Pre-flight inspection walk-around flow

If a defect is discovered by a pilot during the walk-around check, consultation with a line maintenance engineer will be required. If an engineer cannot be located at the aircraft, the crew will use the applicable radio communication channel to request that an engineer attend the aircraft. The pilot(s) and engineer(s) will then discuss the defect, the associated impact it could have on the operation of the aircraft and the appropriate entry to be made into the aircraft's logbook.

2.6 The Aircraft Technical Log

The aircraft technical log is used to record any maintenance discrepancies which occur while an aircraft is in service. The technical log, commonly referred to as the 'logbook', is required to be carried on board the aircraft when the aircraft is operating in service (CAANZ, 2015b). Aside from providing a historic record of an aircraft's maintenance status for legal purposes, one of the primary functions of the technical log, is to provide a communication channel between flight crew and aircraft engineers (Munro et al., 2008). Line maintenance personnel are dependent on the descriptions provided by pilots in order to be able to locate and repair defects efficiently (CASA, 2007). Failures or malfunctions of equipment which are encountered during flight or noted during a pilot's pre-flight inspection are required to be entered into the technical log by the pilot-in-command (CAANZ, 2015b). Once an entry regarding an aircraft defect has been made by a pilot, details of the associated rectification, or deferral must be entered by an appropriately authorised engineer as prescribed by CAR 43.69 thus completing the legal record of the aircraft's current maintenance status (CAANZ, 2015c).

The layout of the technical log will vary between airlines, but a typical format is in a ledger-type style with multiple carbon copies between each new log (Figure 2.5). The description a pilot gives about a defect is entirely discretionary and little formal training, if any, is given to pilots on how to describe maintenance discrepancies (Munro, et al., 2008). While airlines may provide assistance to their pilots with regard to describing aircraft defects, this is typically limited to broad guidelines contained within their operating manuals (Munro, Kanki & Jordan, 2004). Similarly, CAR Part 43.69 *Maintenance Records* merely states that a record of the completion of the maintenance is made in the technical log; how much detail the certifying engineer writes within the free-text space is their choice.

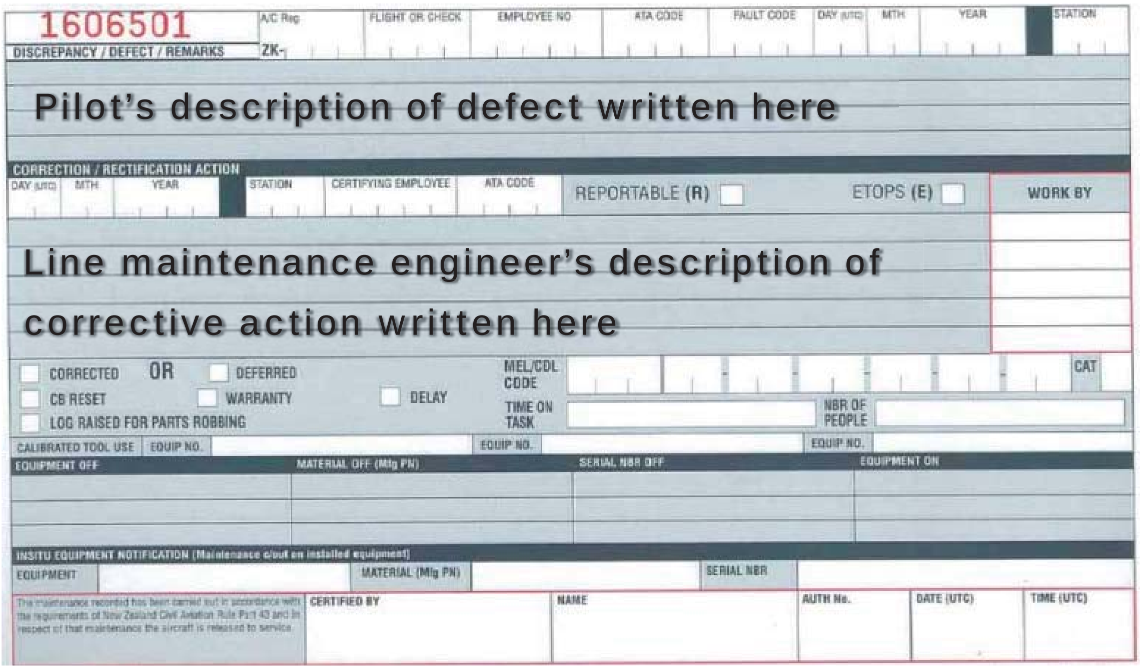

1606501
DISCREPANCY / DEFECT / REMARKS
A/C Reg
ZK-
FLIGHT OR CHECK
EMPLOYEE NO
ATA CODE
FAULT CODE
DAY (UTC)
MTH
YEAR
STATION
Pilot's description of defect written here
CORRECTION / RECTIFICATION ACTION
DAY (UTC)
MTH
YEAR
STATION
CERTIFYING EMPLOYEE
ATA CODE
REPORTABLE (R)
ETOPS (E)
WORK BY
Line maintenance engineer's description of corrective action written here
CORRECTED
OR
DEFERRED
CB RESET
WARRANTY
DELAY
LOG RAISED FOR PARTS ROBBING
MEL/CDL CODE
CAT
TIME ON TASK
NBR OF PEOPLE
CALIBRATED TOOL USE
EQUIP NO.
EQUIP NO.
EQUIP NO.
EQUIPMENT OFF
MATERIAL OFF (Mfg PN)
SERIAL NBR OFF
EQUIPMENT ON
INSITU EQUIPMENT NOTIFICATION (Maintenance c/out on installed equipment)
EQUIPMENT
MATERIAL (Mfg PN)
SERIAL NBR
The maintenance recorded has been carried out in accordance with the requirements of New Zealand Civil Aviation Rule Part 43 and in respect of that maintenance the aircraft is released to service.
CERTIFIED BY
NAME
AUTH No.
DATE (UTC)
TIME (UTC)

Figure 2.5 An aircraft technical log. *Note: not to actual size*

2.7 The Deferral Process

One maintenance-related matter which affects aircraft turnarounds, and contributes significantly to flight delays (Hobbs & Kanki, 2008a), is the issue of aircraft defects. While the reliability of aircraft technology has improved markedly over recent years, to the point that aviation is now considered to be an ultra-safe system[12] aircraft components and systems still malfunction during flight. How promptly these are repaired is determined, in part, by the impact an inoperable piece of equipment has on the related aircraft system. Aircraft are designed with a large amount of system redundancy such that the failure of one system or

[12] Ultra-safe systems are those considered to have less than a 5 x 10^{-7} chance of a disastrous accident (Amalberti, 2001).

component does not necessarily result in an unsafe state of operation. Thus, should a defect occur during an aircraft's scheduled operation, a certain degree of latitude is offered to the airline to allow rectification to take place within a more convenient time frame. As well as reducing the number of schedule disruptions, this also avoids the need to contract a third party to undertake potentially costly repair work if the defect occurs away from the airline's main maintenance base.

The period in which repairs must be undertaken varies depending on the nature of the defect. While failures of components which are critical to the safe operation of the aircraft are generally required to be repaired prior to fare-paying passengers being carried, components associated with higher levels of system redundancy are often able to remain inoperable for a number of sectors prior to having to be fixed. On those occasions when rectification of an aircraft maintenace is postphoned, the defect is said to be 'deferred'. The document which specifies the time frame within which repairs must be made is called the Minimum Equipment List (MEL). Deferral of an aircraft defect is therefore legal, provided that the conditions specified within the applicable MEL are adhered to by the airline (CAANZ, 2015b).

2.7.1 The Minimum Equipment List

Operation of an aircraft which is carrying a defect is governed under CAR Part 91.537 which specifies the requirements of a Minimum Equipment List (CAANZ, 2015b). For a particular aircraft, the MEL details which equipment is allowed to be inoperable during flight. With regard to any particular system component, a MEL will typically specify how many components are installed, how many are required for flight and the allowable timeframe within which the inoperable part must be fixed. The MEL also indicates whether special procedures are required to be complied with in order to safely operate with the defective part. Figure 2.6 shows an example of a MEL pertaining to the wing anti-ice system on a large twin-engine jet aircraft.

30-11-01 Wing Anti-Ice Systems

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

a. Associated valve is locked closed.
b. Wing anti-ice control switch remains OFF.
c. Airplane is not operated in known or forecast icing conditions.

PLACARD

As appropriate.

MAINTENANCE (M)

Lock the associated Wing Anti-Ice (WAI) valve(s) in the closed position (AMM 30-00-00/901).

1. Open P210 panel WAI CTRL circuit breaker.
2. Deactivate the leading edge slats (AMM 27-81-00).
3. Gain access to the appropriate WAI valve:
   A. For left WAI valve, open Access Panel 521AB.
   B. For right WAI valve, open Access Panel 621AB.
4. Lock the WAI valve in the closed position:
   A. Remove the locking screw from the normal position.
   B. Set the crank to the locked (CL) position.
   C. Install the locking screw through the crank into the locked position.
      NOTE: The usual running torque for the locking screw is 10-15 pound-inches (1.1-1.7 newton-meters).
5. Close the opened Access Panel(s).
6. Activate the leading edge slats (AMM 27-81-00).
7. Position the ANTI-ICE Panel (P5) Wing Anti-Ice selector OFF.
8. Close P210 panel WAI CTRL circuit breaker.

Advise Flight Planning.

Figure 2.6 Example of a MEL for an aircraft's wing anti-icing system

The example shows that while there are two wing anti-ice systems installed on the aircraft, none are actually required for flight provided conditions a) through c) are complied with. Should either of the two anti-ice systems become defective, the repair interval is indicated as 'C' which equates to (in this particular case) a period of no more than 10 consecutive calendar days before the malfunctioning must be fixed. The procedure box, in which (M) is denoted, indicates that there are maintenance procedures (listed as 1 through 8 in Figure 2.6) which the aircraft engineer must carry out prior to the aircraft departing with the inoperative system.

While the MEL provides invaluable relief for an airline when defects arise at inopportune times, the purpose of the system is not to encourage flight with inoperative equipment or avoid rectifying defects for lengthy periods. Indeed, often the operating restrictions and penalties associated with using the MEL are such that it can be more beneficial to fix the discepancy as soon as it occurs. While a MEL might technically make a defective aeroplane airworthy, the captain of an aircraft has the authority to refuse to fly an aircraft should he or she believe that operating under the deferral is not safe. MELs associated with pressurisation, air conditioning and braking systems are common examples of when a captain may exercise this right (Kinnison & Siddiqui, 2013).

2.8 Aircraft Release and Acceptance to Service

Any time work is performed on an aircraft or an aircraft is subject to an engineering inspection, that aircraft must officially be ‘released to service’ prior to it being operated by the airline (CAANZ, 2015b). In essence this means that an aircraft engineer who is appropriately qualified under CAR Part 66, signs documentation authorising the aircraft to be flown. In doing so, he or she is legally certifying that the aircraft is airworthy in accordance with CAR Part 43. Release to service is also required should an engineer defer a defect and authorise an aircraft to operate under the provisions of the MEL (CAANZ, 2015b). Notwithstanding the legal documentation which certifies an aircraft’s status of being airworthy, legislation places the final decision of whether an aircraft is acceptable for flight with the captain. Before operating an aircraft, CAR Part 91.201 states that a pilot-in-command of an aircraft must be satisfied that the aircraft is airworthy and in a condition for safe flight (CAANZ, 2015b).

Between the release to service and acceptance of an aircraft for flight, both a pilot and the certifying aircraft engineer share a legal responsibility for the safety of the aircraft. Accordingly, it is possible for situations to arise whereby the two parties disagree as to whether an aircraft is fit for flight. Repeatedly applying a MEL on a reoccurring defect is one example that could result in a captain refusing to accept the aircraft when it is technically airworthy (Kinnison and Siddiqui, 2013).

2.9 The Participant Airline

The organisation where two of the three studies for this thesis research were undertaken was a large New Zealand airline, referred to from this point onward as ‘Airline ABC’. Airline ABC is certified by the Civil Aviation Authority of New Zealand to operate aircraft with a passenger configuration of more than 30 seats or a payload capacity of more than 3410kg (CAANZ, 2016d). Airline ABC is approved to perform maintenance on its aircraft and is also an approved aviation training organisation (CAANZ, 2016e). The training Airline ABC conducts includes human factors and CRM training for airline pilots and human factors training for aircraft maintenance engineers.

During the time the studies took place, Airline ABC operated a fleet of approximately 50 jet-engine aircraft, the size of the fleet fluctuating as aircraft entered and exited the airline’s service. The fleet itself consists of a mix of narrow- and wide-body aircraft manufactured by

Boeing and Airbus. Approximately 800 pilots are employees as captains, first officers and second officers at Airline ABC.

Within New Zealand, Airline ABC has one main operating base with two smaller hubs located in other parts of the country. The airline conducts the majority of its heavy maintenance at its main base, however, line maintenance facilities are located at all three hubs as well as selected other locations on the network. Across the airline's three bases, line maintenance facilities are located either within the terminal gate infrastructure, or situated in hangar facilities a short distance drive from the gates. VHF radio provides direct communication between the individual line maintenance facilities and company aircraft within the vicinity of the airport. Approximately 350 aircraft engineers are employed to work within the line maintenance division of the airline. At ports where Airline ABC maintenance personnel are not stationed, third-party contracts are held with other airlines.

Within Airline ABC responsibility for maintenance control is assigned to the Maintenance Operations Centre (MOC). The MOC is situated away from the airline's main base line maintenance facility and is located within an open-plan office together with Flight Operations Control and Flight Despatch. Approximately 30 aircraft engineers are employed to staff the MOC. The MOC is a 24-hour operation with work undertaken in teams of shifts of 12-hour duties. Communication resources include telephone, VHF radio, telephone, satellite communication phones and ACARS technology[13] to enable contact between the MOC, line maintenance bases and aircraft during flight.

Aircraft turnarounds are conducted in much the same manner as described previously in Section 2.1. Should they become aware of a defect during flight, crew are encouraged to provide advance notification of the aircraft maintenance status. Depending on the whereabouts of the aircraft's location at the time, contact can be made either with the appropriate line maintenance facility via VHF radio, or with the MOC via VHF radio, satellite phone or ACARS. Flight crew must enter defects into the aircraft's logbook, however, there is no requirement for either party to communicate in person with the other. Other than the times when they interact at work, flight crew and line maintenance personnel have no formal contact within the organisation and all technical and non-technical training-related activities are undertaken separately.

[13] Aircraft Communications Addressing and Reporting System (ACARS) is a digital datalink system allowing short text-type transmissions to be exchanged either automatically or manually between the aircraft and ground station via VHF or satellite.

CHAPTER THREE

Literature Review

This chapter presents a review of the literature which provides the framework for the studies that follow. The chapter is organised into five sections. Part I provides an overview of communication within aviation, including the importance of effective communication for flight safety. The communication training which is provided to airline pilots and line maintenance personnel is outlined, including the proposed benefits that a specialised joint-training programme could have. In Part II, the literature review moves to explore the requirement for teamwork within the line maintenance environment. The implications of poor coordination and communication are discussed with regard to both operational efficiencies and flight safety. Part III presents a critical review of the previous research relating to the relationship between pilots and aircraft engineers. The limited number of studies within this field are considered with a view to identify those areas where the current body of knowledge may be advanced. Part IV introduces the concept that flight crew and line maintenance engineers view themselves as separate units within a greater organisation which is the airline. In doing so, they are subject to the numerous socio-psychological biases which influence intergroup behaviours and affect communication. Part IV also examines the relevant intergroup and organisational communication theories which underpin the way individuals relate when interacting with those they consider not to share their own group identity. The literature review chapter concludes with a summary, and the questions to be addressed by the current research are identified.

Part I. Communication in Aviation

3.1 Flight Crew Communication Training

The importance of effective communication within the aviation domain should not be underestimated and this comes as no surprise to practitioners within an industry where poor communication has long been recognised as threat to flight safety. A NASA-conducted analysis of jet aircraft accidents and incidents between 1968 and 1976 showed that pilot error in the form of team communication and co-ordination failures were more prevalent than technical deficiencies (Cooper, White & Lauber, 1980), and data between 1976 and 2000 showed that more than 1100 passengers have died in accidents where communication has been cited as a contributory factor (Flight Safety Foundation, 2006). An early analysis of incidents contained in the NASA-administered ASRS database by Billings and Cheaney (1981) found that over 70% of 28,000 reports submitted by pilots and air traffic controllers between 1976 and 1981 involved information transfer problems, with the authors commenting that: “The most common findings showed that information was not transferred because (1) the person who had the information did not think it was necessary to transfer it, or (2) that the information was transferred, but inaccurately.” (p. 2).

However, the importance of communication in aviation goes beyond merely transferring information. Effective communication is cited as being critical in order to allow flight crew to share a common understanding or ‘mental model’ of events which take place during flight (Sexton & Helmreich, 2000). According to Kanki (2010), in addition to the role it plays in information transfer, communication affects crew performance in the following, more indirect ways:

1. Communication establishes interpersonal and team relationships.
2. Communication establishes predictable behaviour and expectations.
3. Communication maintains attention to task and situational awareness.
4. Communication is a management tool.

Subtle yet significant, these communication functions act to establish an environment which can be either conducive or detrimental to effective crew decision-making. Given the inextricable link between effective decision-making and successful flight outcomes (Oranasu & Martin, 1998; Oranasu, Martin, & Davison, 2001; Batt, 2005; Shappell, & Wiegmann, 2012; Mosier et al., 2012) the influence these communication functions have on flight crew performance is considerable. For this reason, communication is now an important component of flight crew training.

Within the wider aviation domain, which includes general aviation, military and space operations, communication training falls within the broader field of human performance, commonly referred to as 'human factors' (HF). The Civil Aviation Authority of New Zealand (CAANZ) defines the term human factors as a:

> Multi-disciplinary science focusing on systematic and comprehensive assessment and improvement of human performance. Human factors involve the study of the human's capabilities, limitations, and behaviours, and the integration of that knowledge into the design of systems to reduce error, enhance safety and improve efficiency. (CAANZ, 2013, p.5)

Human factors as an aviation discipline can be traced back to the Second World War (Kern, 2001) and while the focus traditionally held a strong association with the study of ergonomics, primarily centred on cockpit design and the limitations of the pilot operator (Salas, Maurino & Curtis, 2010), human factors now encompasses many more areas of research. Advances in aircraft technology, developments in the understanding of human performance, and research into the way organisational failings contribute to aircraft accidents mean that the topics typically classified under the broad title of human factors are numerous. While communication can theoretically be considered a human factors subject in its own right, communication training for commercial flight crew is typically conducted as part of an overarching programme known as Crew Resource Management (CRM). CRM can be described as being:

> ...concerned not so much with the technical knowledge and skills required to fly and operate an aircraft but rather with the cognitive and interpersonal skills needed to manage the flight within an organised aviation system. In this context, interpersonal skills are regarded as communications and a range of behavioural activities associated with teamwork.
>
> (Civil Aviation Authority (UK), 2006, 1-1)

Like so many initiatives in aviation however, the development of CRM and the advancement in safety that it brings, was paid for by the many lives lost along the way. It was an accident, almost four decades ago, that highlighted one of the major barriers to effective cockpit communication between pilots and provided the impetus for improved flight crew communication training.

At 6.15pm on 28 December 1978, United Airlines Flight 173 crashed into a wooded area of Oregon some six nautical miles short of its destination at Portland. The DC-8 aircraft cut a 40m-wide swathe through the trees, striking powerlines and two houses before it finally came to rest. Of the 181 passengers and 8 crew members on board, 8 passengers, the flight engineer, and a flight attendant were killed. A further 21 passengers and 2 crew members were seriously injured (Job, 1996). The following investigation, which was conducted by the National Transportation Safety Board (NTSB), identified an extraordinary communication exchange which had taken place in the flight deck only minutes before the aircraft struck the ground:

> At 1806:46, the first officer told the captain, "We're going to lose an engine…" The captain replied, "Why?" At 1806:49, the first officer again stated, "We're losing an engine." Again the captain asked, "Why?" The first officer responded, "Fuel." (NTSB, 1979, p.7)

The fact that the captain's situational awareness of the fuel state was apparently non-existent seemed to be surpassed only in significance by the ostensible lack of tenacity by the other crew members to draw attention to it. While the NTSB determined that the probable cause of the accident was a failure by the captain to adequately monitor the aircraft's fuel state, the report also cited a failure by the other two flight crew in the cockpit to "either fully comprehend the criticality of the fuel state or to successfully communicate their concern to the captain" (NTSB, 1979, p.29). Indeed, while the first officer had made several subtle comments about the low fuel state leading up to the accident, only after all four engines had flamed out did he direct the captain with frustration to "Get this [expletive] on the ground!" (Job, 1996, p.39)

The United Flight 173 accident investigation report is notable in that it was the first issued by the NTSB to advocate the merits of what is now known as Crew Resource Management.

Recognising that the breakdown in communication between the flight crew of Flight 173 bore similarities to both the Eastern Airlines L-1011 accident[14] and the Tenerife disaster[15], the NTSB published the following recommendation:

> Issue an operations bulletin to all air carrier operations inspectors directing them to urge their assigned operators to ensure that their flight crews are indoctrinated in principles of flight deck resource management, with particular emphasis on the merits of participative management for captains and assertiveness training for other cockpit crewmembers.
>
> (NTSB, 1979, p.30)

This recommendation for airlines to provide specialised training to address teamwork and communication in the cockpit was not insignificant. Ineffective communication between pilots had been identified as contributing factors in numerous accidents preceding United Flight 173, with the term ‘trans-cockpit authority gradient’ (TAG) being coined in 1975 to describe the so-called balance of power between flight crew members during decision-making activities (Helmreich & Foushee, 2010). Only two months before the United Airlines accident, the official investigation report on the runway collision at Tenerife had been released, commenting on the potential reluctance of KLM’s first officer to question his captain’s decision to take off due to an overly-steep cockpit authority gradient:

> Authority in the cockpit: Although nothing abnormal can be deduced from the CVR, the fact exists that a co-pilot not very experienced was flying with one of the pilots of greatest prestige in the company who was, moreover, KLM’s

[14] On 29 December 1972, Eastern Airlines Flight 401 crashed into the Florida Everglades killing 99 of the 176 occupants following the inadvertent engagement of the autopilot. Distracted by an indication that the aircraft’s landing gear was not down for landing, the flight crew lost situational awareness of the aircraft’s trajectory, allowing the autopilot to descent the aircraft into the ground (Job, 1994).

[15] A KLM B747 taking off in fog at Los Rodeos Airport on 27 March 1977 collided with a Pan American B747 which was backtracking along the runway. Simultaneous radio transmissions and ambiguous phraseology used during ATC communications contributed to uncertainty and confusion in both flight decks (Spanish Ministry of Transport and Communications, 1978).

> Chief Flying Instructor and who had certified him fit to be a crew member for this type of plane. In case of doubt, these circumstances could have induced the co-pilot not to ask any questions, assuming this captain was always right.
> (Spanish Ministry of Transport and Communications, 1978, p.38)

Research at the time of these events (Cooper et al., 1980; Murphy, 1980) indicated that the primary cause of the oft-cited ‘pilot error’ (responsible for approximately 70% of worldwide commercial jet hull losses[16]) were due to failures of communication and co-ordination between flight crew (Helmreich & Foushee, 2010). These statistics, together with the recommendation made by the NTSB in response to the Portland accident, subsequently became the focus of a NASA-sponsored workshop entitled Resource Management on the Flightdeck held in 1979 and it was this forum which heralded the beginnings of a new flight training philosophy (Helmreich, Merritt & Wilhelm, 1999). Originally branded as ‘Cockpit Resource Management’, CRM was defined as using all available resources – information, equipment and people – to achieve safe and efficient flight operations (Lauber, 1984). Emphasising what were deemed to be ‘non-technical skills’ (NTS), early CRM curricula included communication as one of several stand-alone subjects to be taught to pilots in the classroom along with other non-technical skills such as decision making, judgement, leadership, teamwork, and situational awareness (Kanki, 2010). In the decades which have passed, CRM has developed through several distinct generations[17] of research and practical

[16] The figure of 70% has long been the estimate at which industry analysts place the contribution of human error to both commercial and military aviation accidents. While improvements in technology have reduced the role mechanical and/or system failures play in aircraft accidents, the prevalence of human error in accidents is still deemed to be in the magnitude of 70% (AGCS, 2014).

[17]The evolution of CRM is traditionally referenced to the five distinctive teaching focuses since its inception. The first generation of CRM consisted of lecture-style seminars in which pilots were taught basic psychological principles related to crew interaction on the flight deck. Second generation CRM recognised the impact of cultural influences on communication and interaction as well introducing concepts such as team-building, crew briefings and situational awareness. Increased awareness of these factors led to a broadening of scope so that the third generation of CRM highlighted the importance of other roles such (cont. next page)

application (Helmreich, et al., 1999). Two of the more noteworthy developments were the title change from 'Cockpit Resource Management' to 'Crew Resource Management' in the late 1980s to reflect the importance in utilising resources outside of the flight deck (see 3.2. below), and the 1990s movement towards amalgamation of technical and non-technical piloting skills in both training and assessment. Contextually, therefore, CRM can be viewed as specialised training which provides pilots with the skills required to effectively utilise those non-technical skills which directly influence crew dynamics on the flight deck (Figure 3.1).

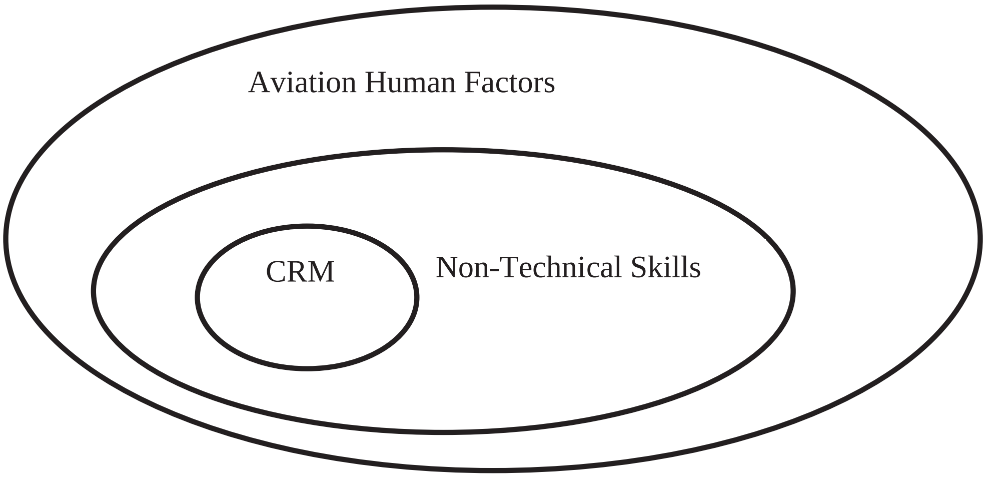


Figure 3.1. Crew Resource Management: a dedicated subset of Non-Technical Skills focusing on the interpersonal techniques required to promote an effective flight deck dynamic

The fourth generation of CRM changed the way non-technical skills such as communication were viewed, trained and even assessed. Initiatives such as the introduction of the Advanced Qualification Program (AQP) by the FAA marked a complete reform on the values placed on non-technical skills (Weitzel & Lehrer, 1992; Velazquez & Bier, 2015). The problems

as cabin crew and flight despatchers can contribute to flight safety. Fourth generation CRM acknowledged the integration of human factors and technical flying skills and the recognition that CRM skills were inextricably linked to piloting performance. The fifth generation of CRM incorporates more proactive human factors training centred on the concept of threat and error management (Valezquez & Bier, 2015).

associated with limiting training of skills such as communication to the classroom were beginning to be recognised (Kanki & Smith, 2001), and the difficulties associated with attempting to uncouple technical performance in the simulator with more intangible proficiencies such as team-work and decision-making were also beginning to become apparent. Recognition of these issues was due in part to a momentum of research focusing on flight deck dynamics including the important role communication plays[18]. These research efforts facilitated an acknowledgement by the industry that non-technical skill sets were just as worthy of regulatory assessment as the more traditional ‘stick and rudder’ technical skills, and empirical measures were subsequently developed in order for such assessments to take place[19].

In New Zealand, CRM programmes are mandated for Part 121 airlines (CAANZ, 2016c). The importance of communication and teamwork for flight crew is reflected by the inclusion of behavioural-based markers during simulator training and examinations, thus surpassing the requirement for a pilot to simply learn about these skills by having to demonstrate an adequate level of proficiency in them (CAANZ, 2013). The fact that CRM skills are regarded as being intricately linked to the technical aspects of aircraft operations now means that simply learning about subjects such as communication in a classroom environment is no

[18] Some 25 years ago, flight crews were already being cited as being the most intently studied teams of professionals (Prince, Chidester, Bowers & Cannon-Bowers, 1992), so it is not surprising that an extensive body of literature has since accumulated regarding the way pilots communicate. These include, for example, how the following factors can affect communication on the flight deck: personality (e.g. Kanki, Palmer & Veinott, 1991), gender (e.g. Archer, 2015), national culture (e.g. Sherman, Helmreich & Merritt, 1997), organisational cultures (e.g. MjØs, 2004), emotional dynamics (e.g. Brown & Moren, 2003), status (e.g. Fischer & Orasanu, 1999), workload (e.g. Sexton, Thomas, & Helmreich, 2000) and automation (e.g. Bowers, Deaton, Oser, Prince & Kolb, 1995).

[19] see Flin et al. (2003), for an overview of the development of non-technical skills NOTECHS performance indicators.

longer deemed satisfactory as illustrated here by the New Zealand regulator when discussing the methodology and assessment criteria for human factors (HF) and CRM training:

> Technical and HF/CRM skills are strongly related, and greatly influence each other. The technical and HF/CRM sides of flight operations are like two sides of a coin, and it would be artificial to consider and assess them separately. Therefore, the first rule of this principle is that technical and HF/CRM skills must be considered together. Another basic rule under this principle is that HF/CRM skills must be assessed in a flight operational context that permits the integration of the HF/CRM and technical skills assessment in a realistic setting. Therefore, by definition, the "total assessment" of a crew member's performance combines technical and HF/CRM skills in the flight-operational context. (CAANZ, 2013, AC 121-4, p.7)

3.2 From 'Cockpit' to 'Crew': The Expansion of CRM

Despite the many different personnel involved with the operation of an aircraft, for the greater part of its history human factors research remained focused almost exclusively on the flight deck and accordingly, human factors training was, for many years, limited to flight crew, specifically the pilot group (ICAO, 1998; Wenner & Drury, 2000; Hobbs, 2008). Thus, while the presence of human factors research and training within aviation has certainly provided benefits in terms of improved flight safety and efficiency (CAA, 2002), the cockpit-centric nature of the focus meant that other groups – flight attendants, maintenance personnel, air traffic controllers – were excluded from this discipline for many years.

While the significance of intra-professional communication between captains and first officers had come to light in the late 1970s, it was not until the early 1990s that the focus was broadened to inter-professional communication in order to accommodate flight crew interaction with those working outside the cockpit. The NTSB had recommended joint training for cabin crew and pilots on at least two occasions following serious in-flight events in the 1980s. However, the airlines involved rejected this suggestion as ‘impractical’ (Kayten, 1993). It was two high-profile accidents in 1989, a British Midlands’ B737 at Kegworth (Air Accidents Investigation Branch, 1990) and an Air Ontario Fokker F28 at Dryden (Moshansky, 1992) which proved to be the catalyst for more resolute attention to be drawn to the ineffective communication which had been exposed between pilots and cabin crew. In both of these accidents, flight attendants were in possession of valuable information which may well have prevented the accidents from occurring had they conveyed that information to the flight deck[20].

The following exert from the British Midlands accident report illustrates not only the seriousness of the particular communication deficiency in question, but also that this shortcoming was reflective of the lack of training within the industry at the time:

> There can thus be seen at these times a firm division between flight deck and cabin, and it is notable in this context that in this accident the flight service manager made no initial attempt to approach the flight deck until he was called. However, it must be stated that had some initiative been taken by one or more of the cabin crew who had seen the distress of the left engine, this accident could have been prevented. It must be emphasised, nonetheless, that present patterns of airline training do not provide specifically for the exercise of co-ordination between cabin and flight crew in such circumstances.
>
> (Air Accidents Investigation Branch, 1990, p. 87)

[20] In the case of the British Midlands’ accident, the flight crew misidentified an engine fire and shut down the operable engine; flight attendants could see the left-hand engine was on fire from the cabin yet did not question the captain who announced he was shutting down the right-hand engine. The accident at Dryden took place when the F28 attempted to take off with snow and ice accretion on the jet’s wings; the flight attendant elected not to express her concerns to the captain due to being told on a similar occasion to ‘take her seat’.

Given that some twenty five years have passed since the communication issues between pilots and flight attendants were formally identified, there is surprisingly little in the way of academic research regarding the particular difficulties across these two professions (Brown & Rantz, 2010). However, that which has been conducted is enlightening, revealing the existence of two, very separate cultures with numerous barriers to effective communication.

One of the early discoveries by those airlines conducting joint cabin and flight deck training, was that there was a significant lack of understanding and awareness on the part of both pilots and flight attendants with regard to each other's jobs. When describing the 'Aircrew Team Dynamics' training programme on behalf of America West Airlines, Vandermark (1991) acknowledged that flight crew and cabin crew were unclear on each other's functions, to the point that their perceptions of what the other group did were distorted. As a result, one of the main objectives of the America West training programme was to facilitate open discussion of these misperceptions. Chute and Weiner (1994) also attribute a lack of awareness by flight crew and cabin crew about each other's' responsibilities for causing misperceptions about the functions of each group:

> Lack of awareness can result in unrealistic expectations in the performance of duties by the other crew. A flight attendant for example may believe that the pilots are just sitting idly in the cruise, when they are in fact scanning the instruments, monitoring the radio, or preparing for the approach. (p.3)

A lack of understanding between the two groups was also identified by Brown & Rantz (2010) who found that 68% of (an international sample of 224) flight attendants thought that allowing them to ride in the jump-seat would be 'very helpful' in improving their understanding of piloting tasks. The implications of a lack of appreciation are significant;

41% of pilots in the same study reported that they had experienced a situation where they were not informed of a problem because cabin crew assumed they would already have known about it. While the lack of job awareness is a considerable issue, it has only become more difficult to manage following the increased cockpit security post the September 11 terrorist attacks, an event which Chute (2002) stated would only further isolate the two work groups. Evidence of this occurring was provided by Ford (2011) who found that both flight attendants and pilots viewed the flight deck door as a major barrier to communication as it not only removes the ability to communicate face-to-face but also the ability for cabin crew to be cognisant of high workload conditions in the flight deck.

The first research to formally explore communication barriers between pilots and cabin crew took place in the mid-1990s. A 1995 paper by Chute and Wiener was aptly named *Cockpit/Cabin Communication: a tale of two cultures*. In it, the authors suggest five specific issues which they believe have led to "misunderstandings, problematic attitudes, and suboptimal interactions between the cockpit and cabin crews" (p. 257). This concept is often referred to as the 'Five-Factor Model of Communication Barriers' (see Table 3.1) and is referenced by later researchers, both within the cabin-cockpit domain (e.g. Kirvonos, 2005; 2007; Ford, 2011) and also as a proposal of the communication barriers which may affect pilots and aircraft engineers (e.g. Mattson et al., 1999). Broadly, the barriers relate to the following issues: psychosocial differences between pilots and flight attendants, influences stemming from dissimilar historical backgrounds, organisational segregation of the two groups within the airline environment, regulatory differences (which ultimately leads to variances in levels of training and licensing requirements), and physical separation within the place of work i.e. the aircraft. Chute and her colleagues (see Chute & Wiener, 1994; 1995; 1996; Chute, Wiener, Dunbar & Hoang, 1995) propose that it is a culmination of these five factors which contribute to communication and co-ordination deficiencies between pilots and flight attendants to the extent that flight safety can be jeopardised.

Table 3.1 *Five-Factor Model of Communication Barriers (Chute & Wiener, 1994)*

Barrier	**Explanation**
Physical	Encourages territorial attitudes: You take care of your part of the airplane, I'll take care of mine
Organisational	Contractual differences (such as hotels, limo pick-ups and crew meals) engender resentment and intergroup conflict
Psychosocial	The pilot profession is male dominated and considered a highly skilled profession while the ranks of flight attendants are female dominated and theirs is considered a service industry
Historical	An independent spirit is still prized among pilots and a gracious demeanour is well regarded in flight attendants
Regulatory	The sterile cockpit rule has left flight attendants in fear of violations and has demanded judgements beyond their training and abilities

Fifteen years on, Brown and Rantz (2010) reported these barriers were not only still present, but affecting communication and co-ordination to such an extent that the authors stated the need for improvement was 'dire'. While their international survey found that organisational issues were rated by pilots and flight attendants as the number one barrier, Krivonos (2005; 2007) maintains that psychosocial factors are particularly influential with regard to how the two groups communicate, specifically in relation to the transfer of information and suggests that establishing a rapport between the two crews is essential as trust is the factor most influential on message distortion. With rapport taking an average of four minutes to establish

(Zunin & Zunin, 1974) this is no easy feat within an operational environment such as an airline. In recognition of the challenges that time limitations impose in an operational environment, the FAA has suggested that mutual, courteous introductions can act to establish a positive working environment between cabin crew and flight crew (FAA, 1988). The lack of time available for the two groups to meet and establish rapport has also been cited as a factor by Ford (2011) who identified that even a short briefing between the captain and all the cabin crew on board prior to flight would aid in creating a positive atmosphere between the two groups.

The recognition that communication training needed to extend to encompass those working in the cabin was reflected in the third generation of CRM when the name changed from 'cockpit resource management' to 'crew resource management' (Helmreich et al., 1999). While the inclusion of flight attendants in CRM programmes has presented some challenges along the way (Salas, Burke, Bowers, & Wilson, 2001), cabin crew are now also required to have CRM training prior to operating within a Part 121 airline organisation (CAANZ, 2016c). Thanks in part to the research exploring the efficacy of cabin crew CRM training (e.g. Ford, 2011), industry regulators have acknowledged the benefits of encompassing flight attendants into the human factors fold as exemplified here by the Civil Aviation Authority of New Zealand in the prelude to AC 121-4 *The Training and Assessment of Human Factors and Crew Resource Management:*

> The principal objective of the human factors/crew resource management (HF/CRM) training discussed in this document is to enhance the HF/CRM skills of flight and cabin crew in the New Zealand aviation industry in order to reduce the risk of accidents and to optimise safety performance. This training is intended to reduce the occurrence of breakdowns in CRM, to enhance teamwork and other CRM processes, to improve their HF/CRM

> knowledge, skills and behaviour, and to outline the need for a full integration of this non-technical training with existing technical training.
>
> (CAANZ, 2013, p. 4)

Given the requirement for both flight and cabin crew groups to receive CRM training, some airlines will combine a portion of teaching and deliver it to a combined class of pilots and flight attendants. This is often referred to as 'joint-CRM training' and has been proven to have positive safety outcomes. Ford (2011) undertook a series of studies exploring the effectiveness of joint-CRM training on intergroup teamwork and communication between pilots and cabin crew to which she concluded:

> These data showed that joint CRM training is valued by both flight attendants and pilots, especially when joint training sessions enabled both groups to meet and hence break down barriers to communication; a major aim of CRM programmes. (p. iii)

3.3 Communication Training for Aircraft Maintenance Engineers

Unlike pilots who have long benefitted from the communication training that human factors programmes offer, it was only in the early 1990s that the human factors spotlight turned toward maintenance personnel. This is generally attributed to a spate of high-profile accidents[21] the origins of which led investigators not to the flight crew but back to the hangar (Gramopadhye & Drury, 2000; Patankar & Taylor, 2008; Kanki, 2010). This resulted in the FAA calling for a systematic review of human factors in aviation maintenance, a challenge which saw joint working agreements between two other aviation regulators, the UK CAA

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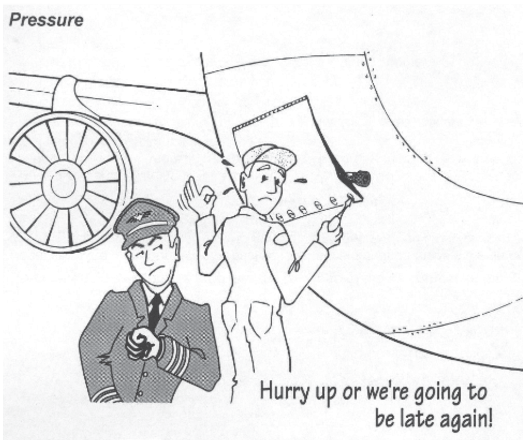
[21] JAL Boeing 747 Bulkhead Structural Failure, 1985 (Japan Air Accident Investigation Commission, 1987), Aloha Airlines B737 Cabin Structural Failure, 1988 (NTSB, 1989), British Airways BAC-111 Flightdeck Windshield Failure, 1990 (AAIB, 1992).

and Transport Canada (Kanki, 2010). The collaboration effort was two-pronged, seeking not only to identify the issues behind maintenance error, but also to promote human factors awareness within the industry. Although the comparative late introduction of human factors for maintenance personnel has been acknowledged as a serious oversight (ICAO, 1998), an unfortunate, yet inevitable result of this exclusion is that a disparity in both human factors research and training exists between the various sectors of the aviation industry.

One of the early outputs from the collaboration between the US, UK and Canada to promote human factors for maintenance personnel, was a list of the threats which face aircraft engineers while they are working. These threats were succinctly summarised in DuPont's (1997) 'Dirty Dozen' posters which have subsequently adorned many an aviation organisation, including those in New Zealand. The 'Dirty Dozen' are:

1. Lack of Communication
2. Complacency
3. Lack of Knowledge
4. Distraction
5. Lack of Teamwork
6. Fatigue
7. Lack of Resources
8. Pressure
9. Lack of Assertiveness
10. Stress
11. Lack of Awareness
12. "Destructive" Workplace Norms



In an attempt to address training the non-technical skills associated with human factors, direction was, inevitably, taken from the piloting world and Maintenance Resource Management (MRM) was born. MRM has been formally defined as:

> a general process for improving communication, effectiveness, and safety in aviation maintenance operations. Effectiveness is measured through the reduction of maintenance errors, and improved individual and unit coordination and performance. (Sian, Robertson & Watson, 1998, p.10)

Given that maintenance human factors research lagged behind flight crew research, it is not surprising that MRM programmes were modelled off early CRM training courses (Taylor & Patankar, 2001), a move which in hindsight was unwise considering the time it took for flight crew CRM to mature through its own distinct generations to become such a highly efficient and successful training tool. The perils of the MRM movement simply attempting to replicate CRM were noted by Lofaro (1997). At the Eleventh Meeting on Human Factors Issues in Aviation Maintenance and Inspection he remarked that MRM had taken some of the worst of early and middle CRM before going on to predict that airlines would not be as patient with their training investments in maintenance personnel as they were with their flight crew:

> CRM training is neither an effective nor an appropriate paradigm for use in developing MRM training…aircarrier crew usually have a fairly uniform level of college education, often have military training and flying experience; they have a highly prized licence, the ATPL…they are a group which has a pride of accomplishment in what they are and what they do; see themselves as very special, highly trained and highly professional. And the pilot group is 'closed' to non-pilots…
>
> …we must be aware that Flight Ops and flight crew get the lion's share of 'attention' – be that attention in the form of visibility, training, money or just

> recognition from their company. CRM could afford to make the mistakes it did and to take 8-10 years to coalesce because CRM was for the flight crew. MRM will not have this extended grace period. MRM will not have the luxury of feeling its way, of having growing pains, of being allowed years to form up, of making mistakes along the way. MRM training may well have one shot; at most two, before it is asked to prove its value or disappear. (pp.58 & 62)

These somewhat bitter predictions transpired. MRM limped along, managing to transform through at least 4 distinct generations (Taylor & Patankar, 2001) before appearing to stall. In terms of success, NASA funded several longitudinal research studies to monitor the effectiveness of various MRM courses. However, despite finding that MRM programmes were generally effective at raising awareness about human performance limitations which have been correlated with reductions in ground damage, Lost Time Injuries and logbook errors (Patankar & Taylor, 2008), there has been little appetite by industry regulators to mandate MRM training programmes and MRM is not required for aircraft engineers operating in a Part 121 airline as it for flight and cabin crew (CAANZ, 2016d). Indeed, the FAA Human Factors in Aviation Maintenance Operators Handbook implies that MRM is now a defunct term, stating that the MRM paradigm has simply evolved to 'Maintenance Human Factors Training' (FAA, 2014), and the UK CAA guidance material on maintenance human factors warns that:

> There are good lessons to be learned from CRM, and some areas which apply both to the flight deck and hangar floor, but the differences between the two contexts should not be under-estimated. (CAA, 2003, Chapter 8, p.2)

In absence of a dedicated subspecialty, communication training for maintenance personnel takes place as a standalone subject under the umbrella of the human factors syllabus

(CAANZ, 2015c) and is not required to be integrated with, or assessed as part of the technical training which engineers receive. Relegating NTS topics to simply be taught as classroom modules undermines the research which cautions against attempting to separate non-technical skills from technical activities, as noted by Kanki and Smith (2001): “When trainers isolate communications as a stand-alone ‘soft’ CRM skill, they overlook the limitless potential of communication – the mechanism for achieving proficiency in technical, procedural and CRM skills” (p. 110). Given the specialised demands that accompany the diversity within the engineering profession, such advice should perhaps be heeded.

Communication has been recognised as a particular weakness for aircraft engineers, former NTSB Board Member John Goglia – himself a former LAME – stating:

> A desirable trait in the past, individualism can be a problem in the current safety environment. Those involved in aviation safety must learn to work as teams, and they must reform their linear communication style. This is an especially difficult barrier for maintenance employees. With their engineering focus, maintenance managers and technicians possess highly technical skills, but sometimes lack the communication skills necessary to ensure safety in today’s complex operations. What is needed is a better balance of technical skills and social skills. Workplace communication must be improved if the job is to be done right. Supervisors, leads, and staff must continually strive for excellence in communication. Furthermore, new programs must be designed to accommodate worker needs and play to their strengths.
>
> (ICAO, 2003, p.3-5)

However, while communication is acknowledged as being an important component of their work (ICAO, 2003; CAA, 2002b; 2003, CASA, 2013), current maintenance human factors training remains technically orientated and tends to focuses issues such as error detection (CAA, 2014). Research to date has focused on communication only between maintenance personnel such as occurs during shift-handover (e.g. Parke & Kanki, 2008). This focus is reasonable given the negative repercussions which can result from poor communication between aircraft engineers at shift handover[22] and, as a result, it is understandable that the training syllabi with regard to communication tend to focus exclusively within the maintenance organisation itself. When communication skills are taught to aircraft engineers, it is communication to be used between engineers and other maintenance personnel as the following example illustrates:

CAA (2002b), CAP 715: An Introduction to Aircraft Maintenance Engineering Human Factors for JAR 66

> On Communication: As noted in previous chapters, aircraft maintenance engineers often work as teams. Individuals within teams exchange information and need to receive instructions, Guidance, etc. Moreover, one team will have to pass on tasks to another team at shift handover. An engineer needs a good understanding of the various processes of communication, as without this, it is impossible to appreciate how communication can go wrong (Ch. 7, p.1)
>
> On Communication between teams: Communication between teams is critical in aircraft maintenance engineering. It is the means by which one team passes on tasks to another team. This usually occurs at shift handover. (Ch.7, p.3)
>
> On teamwork: Maintenance operations are characterised by large teams working on disjointed tasks, spread out over a hangar. In addition, a maintenance task may require multiple teams (hangar, planning department, technical library, management) each with their own responsibilities. (Ch. 3, p. 19)

Within New Zealand, the AMEL Human Factors syllabus concerning communication between teams is also limited to teams made up of other maintenance personnel:

> Describe the importance of effective communications between teams in a maintenance organisation.

[22] The structural breakup of a Continental Express Embraer 120 aircraft in 1991 is one example of fatalities resulting from inefficient communication during a shift-handover when 47 screws were removed and not replaced on the left horizontal stabilizer (NTSB, 1992).

> Outline the information that would normally be passed on to another team at shift changeover/handover.
> Describe the place of written reports and spoken details at shift changeover.
> Describe the importance of traceability and continuity of information, at shift changeover.
> Describe the key processes of listening in terms of hearing, interpreting, evaluating and responding.
> Describe the practice of reflective listening and give examples of when it may be used
>
> (CAANZ, 2015d, p. 27-28)

It may be due in part to the relative infancy of maintenance human factors programmes, that little consideration has been given to the unique environments between hangar and line maintenance and this appears to be reflected in the lack of tailored training for the different maintenance work environments. The fact that engineers employed in line maintenance are required to interact with airline pilots means they are essentially communicating across a professional boundary. As demonstrated by the difficulties flight attendants can have when attempting to communicate with pilots, the ability for workers to interact effectively with those of a different professions can present challenges. With regard to the pilot-maintenance interface, this concept appears to be recognised by the UK Civil Aviation Authority who suggest that:

> Most line engineers appear to have a good understanding of how human factors affect them in their everyday work. Where they have less understanding is with regard to what the pilot is thinking. The reverse is also true; pilots currently appear to have a poor understanding of the engineer's perspective. (CAA, 2014, p. 162)

Cross professional communication problems are not limited to aviation. An appraisal of the medical literature concerning team co-ordination for example, reveals numerous difficulties that arise when employees from different specialist backgrounds are required to communicate effectively with each other, many of which could feasibly apply to pilots and engineers[23]. These include: lack of familiarity with team members due to shift work (Bergs, Rutten, Tandros, Krijnen, & Schipper, 2005); concurrent task-demands (Salas, Rosen & King, 2007); time and resource constraints (Lingard, Reznick, Espin, Regehr, & DeVito, 2002a; Riley, Manias, & Polgase, 2006); assumptions of others' motivation (Lingard et al., 2002a; Lingard, Reznick, DeVito, Espin, 2002b); personality differences (Fagin, 1992; Kosnick, 2002); and lack of joint communication training between disciplines (Baggs & Schmitt, 1988; Fagin, 1992; Lingard et al. 2002a; 2002b; Leonard, Graham, & Bonacum, 2004).

A more specific communication challenge for line maintenance personnel is highlighted by former NTSB Board Member, John Goglia above, with his comment that maintenance personnel are known to be individualistic. Individualism is also a noted trait of flight crew, particularly in Anglo-Saxon countries (Merritt & Helmreich, 1996; Merritt, 2000) where pilots have been assessed as being more individualistic than surgeons (Helmreich & Merritt, 2001). It is worthy of note then that research has also reported that maintenance engineers are more individualistic than pilots (Taylor & Patankar, 1999). As individualism traditionally

[23] Considering communication within a medical context was deemed relevant; parallels between aviation and medicine are frequently discussed, perhaps no more so than with regard to human error and the associated impact on safety (for examples see Helmreich, 2000; 2001; Rivers, Swain & Nixon, 2003; Sexton, et al., 2000). Surgeons and pilots have been compared for their individualistic personality traits (Helmreich & Merritt, 2001) and the field of anaesthesiology also shares particular similarities with flight crew training; pilot and anaesthetist workload profiles are comparable (Flin & Maran, 2004) and the development of non-technical behavioural markers for anaesthetists is modelled on that which is used to assess piloting skills (Fletcher, Flin, McGeorge, Glavin, Maran & Patey, 2003). Perhaps the greatest point of likeness, however, is that both hospitals and airlines are heavily reliant on teams of differing professions who are required to interface seamlessly within a high-pressure environment.

tends to be associated with competitive as opposed to co-operative attitudes (Wagner, 1995) and is reported to be negatively correlated with a desire for teamwork and an ability to trust co-workers (Kiffin-Petersen & Cordery, 2003) this could potentially pose additional difficulties for this particular cross-professional communication environment.

With the challenges associated with cross-professional communication in mind, it appears reasonable to advance the notion that the broad-styled classroom-based human factors training for maintenance personnel which is currently practiced by airlines may not provide line maintenance engineers with an entirely suitable communication skill set. The ICAO Human Factors Guidelines for Aircraft Maintenance manual published in 2003 provides guidance for the material to be included in human factors training and the following objective is listed under the subject of teamwork: "[A belief] that maintenance personnel, flight crew, cabin crew, operations personnel, planners, etc. should work together as effectively as possible" (ICAO, 2003, p. 5-B-6).

However, there appears to be little, if any guidance about how an airline might consider achieving this objective. The development of a joint-CRM training programme for flight crew and line maintenance engineers could be one method of achieving this with the twofold objective of improved communication between the groups and a greater awareness of each profession's roles and responsibilities. This concept has been advocated before. Following their investigation into collaboration between pilots and maintenance personnel, Mattson et al., (1999) stated:

> Through interdepartmental training programs that recognise the cultural perceptions of the other held by these groups and work to overcome their

> socialised aversion to working together face-to-face, the common goal of increased airplane safety and productivity can be achieved. (p.747)

In a follow up survey study (Mattson et al., 2001) maintain the need for joint-training:

> The primary aviation industry goals of safety and on-time flights are team goals not individual or department-specific goals. Clearly, training that addresses these objectives needs to be sufficiently integrated across departments and career fields to be maximally effective. (p.48)

These views are also shared more recently by Munro et al., (2008):

> As is done with flight attendants, the [CRM communication] module should include line mechanics as part of the session and require the two groups to work through scenarios based on real in-house events. The structured review of [logbook] entries could also occur here with mechanics providing feedback that allows pilots to understand what mechanics need to know about certain types of faults. (p.102)

and Ford (2011):

> This research has shown that joint emergency procedures for flight attendants and pilots have been highly rated as a way of getting to know each other and understand each other's job roles and responsibilities. This training should be continued and extended to other groups. For instance, it would be useful to enhance wider team coordination by including maintenance in such emergency drills in the mock-up aircraft. (p.391)

There is, however, no mandatory requirement for airlines to facilitate such a venture. Despite recognising that joint-CRM training between pilots and engineers could be both “desirable” and “beneficial”, the UK Civil Aviation Authority predicts this is unlikely to occur on a widespread basis given the logistical challenges of bringing both groups together (CAA, 2014, p.162). In addition to difficulties associated with employees who may be contracted to different companies, developing and administering training programmes is a costly investment for organisations and typically one needs to present strong evidence over and above the face-value benefits for personnel by way of an economic return on investment. Airlines are no different, although evidence in the form of increased safety benefits or - perhaps more cynically - the cost associated with adverse safety outcomes such as accidents are another form of persuasion. The possibility is presented, therefore, that despite the promotion of joint-CRM training programme for maintenance personnel and flight crew, there is simply not enough objective evidence to support a strong case for such an endeavour.

3.4 Summary

The importance of effective communication in aviation with regard to both the direct and indirect effect it can have on flight safety has long been recognised. However, due to fact that the majority of human factors research over the decades has been concentrated on the flight deck, a disparity exists in the way in which communication is both taught and assessed. While pilots must demonstrate proficiency in their communication skills within an operational environment in order to satisfy regulatory requirements, communication training for aircraft maintenance engineers is limited to classroom-style learning and does not recognise the unique challenges imposed when communicating in the line maintenance environment. Additionally, while arguments have been made to extend joint-CRM training to incorporate maintenance personnel, there is currently no regulatory requirement to do so despite the success this initiative had with the inclusion of cabin crew. The fact that little is known about the specific challenges that arise when communicating in the line maintenance environment, or the potential implications of poor communication between pilots and engineers, could well be preventing such an undertaking. The following section of the literature review explores these matters.

Part II. Teamwork in the Line Maintenance Environment

Part II of the literature review explores the complexities associated with teamwork within the line maintenance environment. Difficulties peculiar to the communication processes which pilots and engineers use to communicate are discussed and attention is drawn to the fact that the logbook in particular could be considered an especially ill-suited medium through which to communicate. The review then considers the potential implications of poor communication between flight crew and maintenance personnel with respect to both the operational demands of the airline and flight safety.

3.5 Communication Media

When considering the way in which individuals communicate with each other, many models have been proposed over the years. One of the earliest models of communication was that produced by Shannon & Weaver in 1949 (see Huseman, Lahiff & Hatfield, 1976). The source (sender) encodes and transmits a signal (message) which is received and decoded at the destination by the receiver. The message which was sent may or may not be received in the same way it was intended due to interference in the way of noise (anything that distorts the signal being transmitted). The main criticisms of early models such as that described, however, is that they depict the process of communication to be linear and only one way; no account is taken of the way in which the receiver responds.

Transmission models of communication, whilst influential (Eunson, 2008), were soon expanded to incorporate the role of the receiver and also the environment and experiences of each of the communicators. These transactional models are concerned with how meaning is developed and, according to Baker, Barrett and Roberts (2002), meaning is only shared when participants have enough common experiences to make sense of the message. Fisher's (1993) model for example, depicts the influences the characteristics that the task at hand, the group and the organisation itself have on the communication behaviour between individuals (Figure 3.2). As each element is affecting and being affected by the other, this expands the transactional communication model into a 'system model' whereby communication is not considered as simply a free-flowing conduit. Instead, the ways in which meanings are transmitted from one person to another are hampered by psychological, social and structural barriers all of which act to distort the intended message.

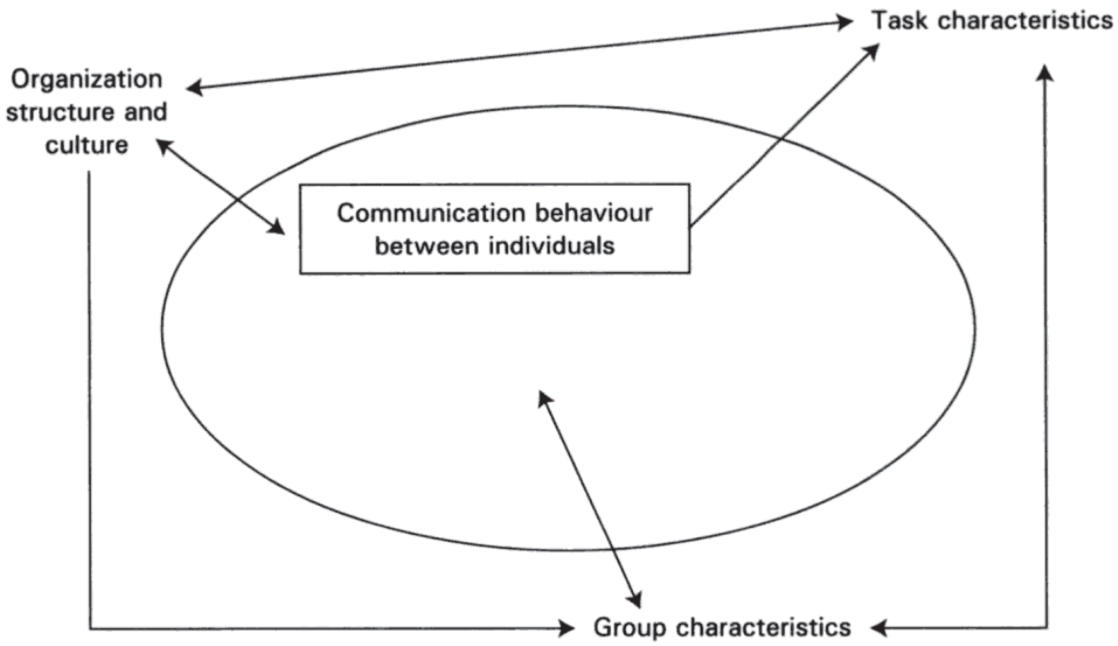


Figure 3.2 Communication can be distorted by social influences (Source: D. Fisher, 1993)

In addition to the effects the environmental and organisational system have on communication, the medium used will influence the efficiency of communication. The importance of non-verbal cues in the form of body language is well-recognised in terms of communication effectiveness. From Dwyer (2012):

> The non-verbal aspects of communication are so closely intermingled that it is difficult to separate them. People receiving verbal and non-verbal messages interpret them within the context of the communication and derive the 'total message' (p.28)

Non-verbal cues perform numerous communication functions including framing, contradicting, substituting, accenting and regulating (Andrews & Baird, 2005). Further, the use of body language is an important means of validating communication and, according to Becker and Wortmann (2009), without validation there is no trust between the transmitter and receiver.

Given the important role that non-verbal cues have, it stands to reason that the communication medium will have a close association with the effectiveness of message transmission and receipt. The Information Richness Theory as described by Mohan, McGregor, Saunders and Archee (1997), considers the amount of sensory information which can be transmitted using different types of medium. Media are described as being 'rich' when they have a broad range of data-carrying capacity. For example, face-to-face communication allows for visual, auditory and other sensory information to be gleaned hence it is the richest 'modality' in terms of information. Media which are 'lean' do not have the capacity for additional information such as verbal and non-verbal clues to aid communication. According to McShane and Von Glinow (2009), the richness of the media also takes into account the ability for the receiver to provide timely feedback and for the sender to customize the message specifically for the receiver. The theory posits that when communication is non-routine and potentially ambiguous, rich media are better suited. Conversely, lean media (such as data only reports) are best suited when the sender and the receiver have a common expectation and shared mental models as can be seen in Figure 3.3.

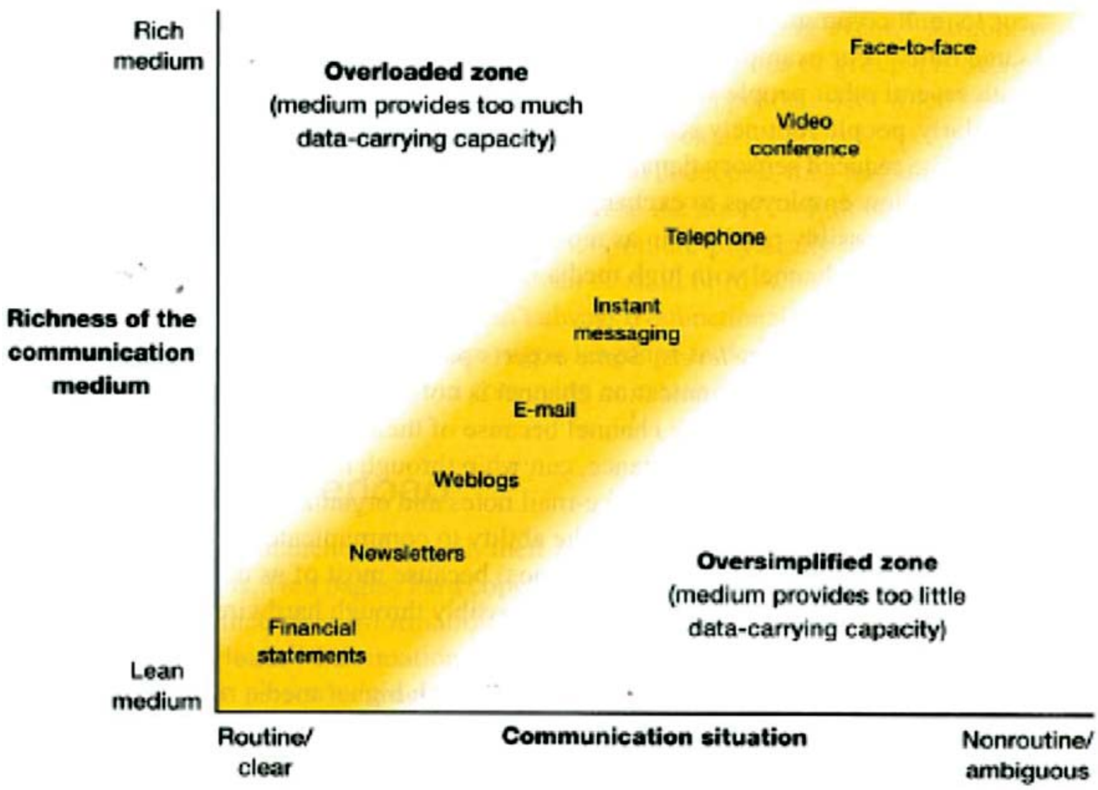


Figure 3.3 Media Richness Hierarchy (source: McShane & Von Glinow, 2009)

3.5.1 The Technical Log

The primary medium through which pilots and engineers communicate is the technical log, otherwise known as the aircraft logbook. The logbook allows for one-way, space-limited written communication with no opportunity for feedback from the receiver to the sender.

With reference to the Media Richness Hierarchy (Figure 3.3), the logbook would therefore appear between newsletters and financial statements i.e. media 'lean'. Given the ambiguous nature of many aircraft defects, pilots may have difficulty choosing an appropriate description which, once he or she has left the aircraft, then becomes the only source of information available to maintenance personnel. Moreover, the fact that terminology may be different between the two groups (as discussed in Section IV, below) would suggest the logbook is a less than satisfactory match for the communication situation, a concept supported by the studies which have investigated logbook communication between pilots and engineers.

Research published by the Australian Bureau of Air Safety Investigations revealed that half (54%) of maintenance engineers surveyed at regional airlines found pilot entries in a logbook 'somewhat' helpful in identifying defects (BASI, 1999). Studies undertaken in the US have reported similar results. An experiment conducted by Lapacek, Mattson, Lopp and Eiff (1997) compared fault-finding efficacy between engineers who spoke to pilots and those who only had access to the associated logbook write-up. The reported findings showed that engineers using the logbook as a sole reference had more difficulty troubleshooting the maintenance discrepancies and took longer to rectify the defect than those who were able to discuss the issue with the flight crew. According to Mattson et al., (2001) the most common problems engineers cited with the logbook were a lack of sufficient detail and missing entries. Their findings were supported by Munro et al., (2004; 2008) who found that both pilots and engineers reported that the technical log frequently contained only the bare minimum of information with regard to the maintenance status of the aircraft. In their 2004 survey of 147 airline maintenance personnel, nearly all (97%) indicated they wanted more information from pilots at least half of the time. Investigation of the difficulties the logbook presents as a communication medium identified that the layout of the logbook contributed to this as the majority of pilots and engineers indicated that they never provided more information than could be contained in the space available (see Fig. 2.5) despite the fact that entries can be continued onto subsequent pages. The fact that the vast majority (76%) of pilots surveyed indicated that they spent less than five minutes filling out the logbook lead the authors to comment:

> The space provided for pilot entries is quite limited and comprises a small portion of a total logbook page, which might create the impression that entries are expected to be brief. This could be exacerbated by the very short turn-around times airlines schedule between flights. Filling out the logbook is one of the last administrative chores a pilot (the captain) must complete before he or she can leave the aircraft and prepare for the next flight. All these factors would appear to encourage quick, terse entries. (Munro et al., 2008, p.100)

3.5.2 Voice-Only Channels

The radio and telephone are richer media than the logbook for communication as they allow for information to be exchanged in real-time, thus providing the receiver with an opportunity to give feedback to the sender as necessary. The ability to talk directly therefore facilitates effective problem solving as it allows an engineer to clarify information with the pilot and ask any relevant questions about a defect (Munro et al., 2008). However, while the radio and telephone have been noted to be an effective means of communication by both pilots and engineers (Mattson, et al., 1999), these media are not without fault as the absence of body language can impede the ability to communicate effectively (Dwyer, 2012; Andrews & Baird, 2005; Becker & Wortmann, 2009). As they do not allow for body language as part of the transmission and exchange process, other communication markers such as paralanguage[24] and verbal listening techniques such as back-channel responses become important for the co-ordination within the conversation (Duncan, 1972; Berko, Wolvin & Wolvin, 1995; Ward & Tsukahara, 1999).

In addition to not being as 'rich' as face-to-face communication, voice-only media can also be problematic in other ways such as occasions where the quality of the channel is poor. In an exploration of communication barriers between pilots and flight attendants, Ford (2011) identified the interphone posed challenges when background noise levels were high often making communication difficult. Pilots also reported that etiquette associated with the interphone - such as informing the other party who they were speaking with – was often not followed which also contributed to the problems associated with this particular medium.

3.5.3 Face-to-Face Communication

As Figure 3.2 shows, face-to-face communication is considered the richest medium, and has been found to improve interaction, particularly in those environments desiring collaboration across skilled groups of workers (Daft & Lengel, 1986). As well as the addition of body language, within a line maintenance environment, engaging in face-to-face communication allows a pilot to demonstrate how a system or component has malfunctioned. Accordingly, while face-to-face communication cannot be the sole medium given the legal requirement for

[24] Paralanguage refers to those features of voice communication which support and convey meaning such as tone, intonation, volume and prosody (patterns of rhythm and stress).

the logbook, face-to-face can provide an effective supplementary means to exchange information.

Interestingly, however, despite the fact that engineers have reported dissatisfaction with the logbook, and the ability to discuss a maintenance discrepancy with the flight crew aids defect rectification, some research indicates that face-to-face communication between these two groups also appears problematic. A survey undertaken by Mattson et al., (1999) identified that both pilots and engineers did not rate face-to-face communication as an effective communication medium. A subsequent survey (Mattson et al., 2001) distributed across 55 organisations, asked pilots and maintenance personnel to comment on which aspects of defect reporting in their company did not work well. While almost half (46.3%) indicated that the logbook was not effective, a third (31.6%) of the 136 respondents stated that face-to-face communication was problematic. Eiff et al. (1997), also noted difficulties with (what should be) the most appropriate medium for information exchange in the line maintenance environment. Here they provide a striking illustration:

> Observations found that technicians most often avoided contact with flight crews. In fact, it was not uncommon for technicians meeting arriving flights to stand at the bottom of the stairs to the aircraft and wait until the flight crews had left the aircraft. When technicians did meet and debrief the flight crews, the interface was often marked by tension and communication was often kept to a bare minimum. (p. 8)

It would seem therefore, that despite the face-to-face medium affording the opportunity for the most effective communication between pilots and maintenance engineers, previous research would suggest this method of communicating is not always utilised.

3.6 Implications of Ineffective Line Maintenance Communication

With the difficulties associated with communication in the line maintenance environment in mind, the potential implications of poor communication between pilots and aircraft engineers are now considered.

3.6.1 Aircraft Defect Rectification

Perhaps the most obvious repercussion of poor communication in the line maintenance environment is the impact on an engineer's ability to resolve the maintenance discrepancy. A pilot's description of the fault including details of when it occurred and how it was detected can impact the particular direction an engineer takes to determine why the event happened and subsequent assessment of how to rectify it (Munro et al., 2008). Survey results from 147 maintenance personnel across two different US airlines found that poor logbook descriptions from pilots impacted on the ability of engineers to troubleshoot. Almost half (48%) of engineers stated that a poor description impacted on their ability to repair or troubleshoot a defect 'somewhat', while a further 41% said it impacted on them either 'considerably' or 'completely' (Munro et al., 2004).

If an engineer cannot replicate the maintenance discrepancy, there is often little choice but to note in the technical log that an attempt has been made to troubleshoot but that nothing could be found. This is obviously not a desirable outcome and it is one which can be a source of frustration for pilots should there be a reoccurrence of the particular discrepancy. Supporting the notion that ineffective communication hinders defect rectification is a comment from Eiff et al. (1997) who, in contrast to their observation that the majority of face-to-face communication with pilots was poor (see 3.5.3, above) noted some exceptions:

> Several technicians were observed who had a history of conflict free interactions with flight crews. These technicians made it a point to establish good lines of communication with the flight crew immediately upon arrival and maintained contact with them throughout the ground operation. These technicians were observed to have fewer ‘could not duplicate’ and ‘no fault found’ results when evaluating maintenance discrepancies and had a lower rate of deferred items and despatch delays. (p. 8)

The impact of poor communication on defect rectification can potentially have safety-related implications. In the case of a maintenance discrepancy not being able to be rectified, there is a possibility that a future flight may experience a more significant problem relating to the original defect which puts the safety of the flight at risk. However, given the extent to which system redundancies are designed into modern aircraft, an inability to rectify an aircraft defect is probably more likely to impact on an airline’s schedule by manifesting as a reoccurring defect. When the source of the maintenance discrepancy is not correctly identified in the initial instance, further troubleshooting measures will then be required, thus the primary impact will most likely be operationally-related.

3.6.2 Despatch and On-Time Performance

The study from Munro et al., (2004) found that poor logbook descriptions increased the time required for engineers to troubleshoot a defect which is an undesirable outcome when considering the importance of despatching on time. In the competitive global economy in which they operate, a significant concern for airlines is the operational efficiency of their aircraft. Aircraft which are not flying are not making money and in fact they are costing money. According to 2014 figures[25] the cost of a delay is approximately $80 per minute of aircraft block time. Consequently, aircraft turnarounds have a significant economic impact on an airline's operating cost as they directly affect the utilisation of the aircraft (Alamdari & Fagan, 2005). A study undertaken by Boeing determined that even a 10-minute reduction in turnaround times could increase aircraft utilisation by 8% (Mirza, 2008). The financial driver is such that turnaround efficacy is now being mathematically modelled (Fricke & Schultz, 2009; Wu, 2008; Sohoni, Lee & Klabjan, 2011) with many carriers implementing turnaround times of only 30 to 40 minutes. However, the challenge for optimal efficiency is twofold; regardless of the turn schedule an airline decides on, the aircraft must still depart on time in order to achieve its target utilisation. Delays during the turnaround process due to ineffective troubleshooting not only mean an aircraft which should be earning revenue in the air is sitting at the gate, but also the airline's On-Time Performance (OTP) is threatened. Any delays to an aircraft's pushback are coded according to the cause with no fewer than 99 delay codes now standardised globally (IATA, 2016). As OTP metrics are now used to compare and rank the schedule reliability of airline operators (Sohoni et al., 2011), inefficient turnarounds resulting in departure delays are particularly undesirable given that schedule reliability is frequently used as a measure to gauge customer perception of, satisfaction with, and loyalty to an airline (Tiernan, Rhoades &Waguespack, 2008).

Given the importance of OTP, it is not surprising that aircraft turnarounds are tightly co-ordinated by airlines to be as efficient as possible within the scheduled time the aircraft is at

[25] This data is provided by Airlines for America and calculates the per-minute cost of delays for passenger airlines within the US. In 2014, the cost of aircraft block time for U.S. passenger airlines was $81.18 per minute, giving total delay costs for 2014 at US$9,149 million. http://airlines.org/data/per-minute-cost-of-delays-to-u-s-airlines/ retrieved 1 December, 2015.

the gate. Aircraft turnaround activities and work flow processes which are undertaken by different operating teams require good co-ordination and communication (Wu, 2008). The introduction by some airlines of a ‘turn co-ordinator’, whose role is to supervise the co-ordination of turnaround activities reflects economic impact related to this phase of the operation. Yet co-ordinating the multiple functions which are conducted by independent groups of employees is not an easy feat. Research on airline departure coordination (Gitell, 2000; 2001; 2006) found that while coordination is critical for highly interdependent work processes, it can be problematic for airlines due to differences in status and expertise causing a divisiveness at the boundaries which separate the functions. During observational studies at one US airline where status barriers were particularly problematic, Gitell (2006) noted the presence of a mutually reinforcing cycle whereby perceived lack of respect between work groups discouraged open communication and reduced the willingness of employees to coordinate with other work groups. Invariably, this caused delays which then led to ‘finger-pointing’ as to which group was ultimately responsible and therefore should be allocated the delay code.

As communication is a critical function of co-ordination (Tolbert & Hall, 2015), effective communication between airline employees is essential should airlines wish to reduce their aircraft turnaround times and improve their on-time departures (Gittell, 2000; 2006). As mentioned in the introduction to this thesis, one would imagine that delays due to communication breakdowns and conflicting opinions between flight crew and line maintenance personnel would be disadvantageous for an airline. In the context of this research, Suzuki, von Thaden and Geibel (2008), found some evidence of interdepartmental co-ordination failures between flight crew and aircraft maintenance engineers -

misapplication of the MEL being the predominant issue, but there was no indication of how this affected OTP.

3.6.3 Accidents, Incidents and Safety Implications

Aircraft accidents are the result of a complex interaction of latent conditions, active failures and unsuccessful defences or controls (Reason, 1990; 1997; 2000; 2005; Wiegmann & Shappell, 2001; Dekker, 2006; ATSB 2008). In the same nature as accidents unfold within complex socio-technological systems, aircraft accidents begin with the negative consequences of processes (often shaped by economic, political and regulatory constraints) stemming from the organisational level of the system. These negative consequences are transmitted down through the organisation and, if unstopped by the various risk-controls or 'defences' in place at various levels within the organisation, reach the workplace. At this point, the combination of local conditions and human fallibility produces an environment favourable for errors (or violations of rules) to be made and, in the absence of any final layers of defence which may break the accident sequence, an adverse outcome occurs (Figure 3.4).

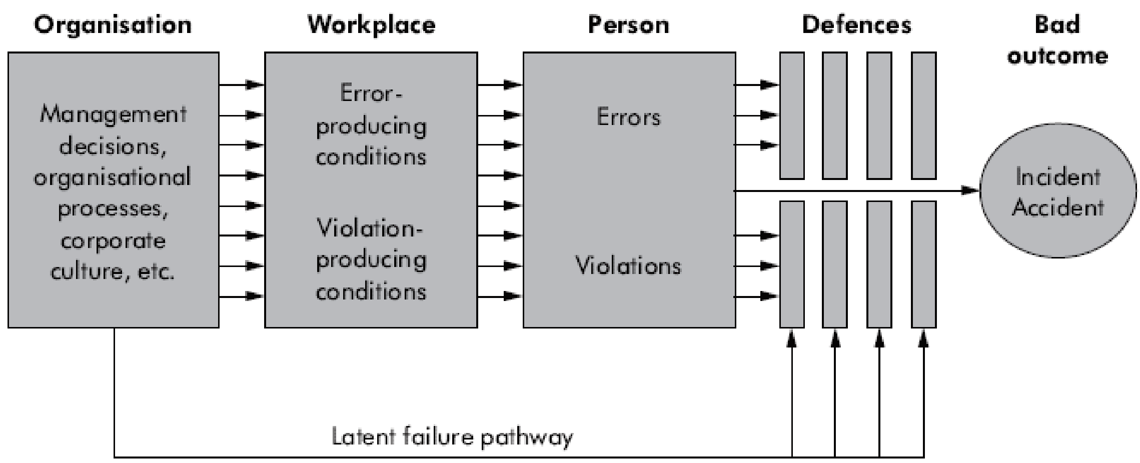


Figure 3.4. Stages of an organisational accident (source: Reason, 2005)

While active failures are defined as the unsafe actions which are made immediately prior to the adverse outcome, latent conditions tend to be insidious, described by Reason as 'resident pathogens' within an organisational system which may lie dormant for many years before a particular active failure triggers an accident opportunity (Reason, 1995). Any strategic decision made by an organisation has the potential to create latent conditions and the adverse effect may be twofold; creating error-provoking conditions within the workplace and creating weaknesses in system defences (Reason, 2000). It is due to this complex interaction of events that while some investigation reports may determine a 'probable cause' of an air accident, numerous contributing factors will also be identified as the following example illustrates.

On 11 July 1991, a Canadian registered McDonnel Douglas DC-8 operating a charter flight for Nigerian Airways as Nationair crashed shortly after takeoff from Jeddah, Saudi Arabia killing all 247 passengers and 14 crew members on board. According to the official investigation report [26] the aircraft suffered a tire failure during the takeoff run and, as the tire remnants on the gear bogie[27] were on fire when the landing gear was retracted, the subsequent fire which developed in the wheel well caused a catastrophic structural failure which ultimately resulted in a loss of control and impact with terrain. The cause of the fire was two underinflated tires which, according to the report, the aircraft engineer was aware of prior to the flight departing. As the aircraft was operating a charter flight, an engineer was deployed with the crew to carry out the maintenance and service checks at Jeddah. Upon discovery that the tires were underinflated, the engineer made an attempt to source nitrogen, however, this

[26] The investigation was conducted by the Saudi Arabian Ministry of Defence and Aviation, however, a review of the report by the National Transport Safety Board resulted in additional recommendations being made (Flight Safety Foundation, 1993).
[27] This is the term for the multi-wheel truck attached to the gear strut.

was unsuccessful due, in part, to schedule pressure and the aircraft subsequently departed with the flight crew unaware of the tire status (Flight Safety Foundation, 1993). The fact that the aircraft engineer seemingly had plenty of opportunity to inform the crew of the tire status (he was travelling in the cockpit jump-seat during takeoff) has been noted as a contributing factor to the accident. While the recommendations made by the NTSB were primarily concerned with the errors that the flight crew made following the tire failure, the accident occurred due to a combination of latent failures which influenced the way in which the local conditions facilitated the active errors and violations which were made. Foyle and Dupont (1995) examined how the engineer's role in in the accident contributed. As highlighted in Table 3.2, three of the factors they identified are particularly relevant to this research, being directly related to the pilot-maintenance interface.

Considering the nature in which aircraft accidents and incidents transpire, in the context of this research it would seem that poor communication and co-ordination between airline pilots and line maintenance engineers does have the potential to contribute to an adverse safety outcome. Indeed this was suggested by Matteson et al. (2001) who warned that: "during maintenance discrepancy reporting the potential for latent safety errors exists because pilots and maintenance technicians do not effectively interact with one another about maintenance problems on the aircraft" (p.46). The relationship between safety and the flight crew-maintenance interface was also highlighted following the inflight break-up of a Continental Airlines Embraer 120 aircraft in 1991. While the accident occurred primarily as a result of poor communication and coordination between engineering teams during an overnight shift hand-over, the NTSB investigation report commented that had the flight crew been informed of the overnight maintenance activity which had taken place, they may have elected to inspect the work which had been conducted[28] thus providing an additional layer of defence against the forthcoming accident (NTSB, 1992).

Table 3.2 *Maintenance errors associated with the loss of Nationair DC-8 (Foyle & Dupont, 1995)*

Lack of communication	**The AMT did not inform the pilot that tire pressures were low, even after the pilot stated "we got a flat tire, you figure?" on the final takeoff roll**
Complacency	The tires had low pressure for several days without attention
Lack of knowledge	Ignorance of the manufacturer's specifications for tire pressure
Distraction	(any distraction to the AMT is unknown)
Lack of teamwork	**The AMT and the cockpit crew were flying together, yet did not appear to know the maintenance status of the aircraft**
Fatigue	AMT did not go to sleep until at least 11pm and was called up at 3am. He had also been travelling with the aircraft and working on it during down time
Lack of resources	Nitrogen to inflate the tires was not readily available
Pressure	The AMT was apparently under much personal pressure to keep the aircraft flying for job security reasons
Lack of assertiveness	The base manager, who had no authority over the ATM, told him to "forget it" when it appeared that the aircraft would be delayed 30min if the ATM inflated the low tires
Stress	The AMT was counting on the success of this deployment to enable him to advance with the company and settle in Canada
Lack of awareness	**The AMT was unaware that tire pressure was critical to the aircraft's safety**
Norms	Company procedures allowed the AMT to make errors an acceptable practice

[28] The maintenance activity had been conducted on the top surface of the horizontal stabilizer which, due to its height off the ground was not normally visible to pilots during their pre-flight inspection and because of this 47 missing screws were not observed. It is not known in this case whether the flight crew would have chosen to inspect the surface panels in question had they known that the de-icing boots had been replaced. Nevertheless, it was proposed by the NTSB that giving crew visibility of significant maintenance work recently undertaken provides an element of redundancy in the system.

In addition to the negative safety outcomes associated with a lack of communication, safety can also be compromised by interpersonal conflict. In their study on coordination and safety behaviours in commercial aircraft maintenance, Suzuki et al. (2008) suggest that coordination problems — be they intra- or inter-departmental — as well as conflict can weaken safety procedures and cause undesirable outcomes. Their research, which examined ASRS database reports for co-ordination failures between maintenance personnel, found examples of poor conflict management between flight crew and engineers. Both 'competing' and 'accommodating' conflict solution styles were evident, neither of which is compatible with safety; 'competing' being defined as "convincing others that their [own] conclusion is correct, seeking one's own interest regardless of others" and 'accommodating' being defined as "allowing the goals of the other party to take precedent while sacrificing one's own goal" (p.90). The authors suggest that a competing style of conflict resolution may weaken levels of safety and a more cooperative style such as 'collaborating' (*clarifying differences, cooperating and searching for a mutually beneficial outcome*) should be promoted.

While conflict itself is unavoidable (Buchanan & Huczynski, 2010), there is certainly little place for 'competing' styles or argumentative behaviours within a line maintenance environment. The fact that competitive styles of conflict resolution are often marked by acts of aggression can cause conflict that results in disputes with a destructive orientation (Berko et al., 1995). The anger which ensues from such arguments can result in diminished cognitive functioning (Berko et al., 1995) which is highly undesirable for both flight crew and maintenance personnel given the potential safety implications. The stress that a pre-flight argument can cause has been linked to the loss of at least one airliner, the captain of a BEA

Trident collapsing at the controls following a heated verbal altercation with colleagues in the crew room over union negotiations (Job, 1994).

3.7 Summary

The methods used by pilots and maintenance personnel to exchange information appear to pose a challenge in terms of suitability for maintenance-related communication. The primary means by which the two groups communicate and are indeed reliant on for critical information pertaining to the maintenance status of the aircraft – that is the logbook - appears to be unsuitable in terms of data-carrying capacity. Additionally, pilots and engineers appear averse to using the medium which theoretically should be the most effective (face-to-face), suggesting that there are difficulties beyond those purely associated with information transfer. It is proposed that the implications of poor communication are potentially significant both in terms of cost to the airline and safety of the flight, contributing to the argument that research relating to flight crew-maintenance communication is warranted. It is thus timely to now consider the previous research which has been conducted in this field of study in order to determine the extent to which these matters have been examined.

Part III. Critical Review of Previous Research

As discussed in Chapter One, the selection of this subject for research was, in part, due to the fact that little attention seems to have been given to the relationship between pilots and maintenance engineers. In terms of academic research, a review of the previous literature available confirms this as there are only a handful of studies in which these two groups, together, are the primary focus of investigation. In order to gain an appreciation of the previous research, and to determine the extent of what remains to be explored, these studies are reviewed below.

3.8 Overview of the Literature relating to Pilot-Maintenance Communication

An examination of the literature[29] specifically relating to flight crew-maintenance communication reveals six studies of significance published from 1997 to 2008 (Table 3.3).

3.8.1 The Purdue 'Pilot' Studies: Hints of a Problematic Interface

The first dedicated research to examine communication between pilots and engineers took place at Purdue University (Lapacek, Mattson, Lopp, & Eiff, 1997). Primarily exploratory in nature, the researchers undertook a pilot study of inter-professional communication between flight crew and line maintenance personnel at the university flight training school. The study utilised students (who were either in the process of qualifying for their pilot or engineering licences) as well as instructors (who were qualified pilots or engineers). Investigation of the

[29] Electronic article databases were used to search peer-reviewed journals. Key-word searches [Flight crew AND Maintenance AND Technician AND Communication] were conducted with no timeframe exclusions. The studies selected for review were restricted to those having a specific research focus on flight crew and line maintenance personnel communication

Table 3.3 *Studies pertaining to pilot-maintenance communication*

Year	Title	Authors	Setting	Methodology	Focus
1997	*Maintenance Discrepancy Reporting: Human Factors Issues*	Lapacek, M. Mattson, M. Lopp, D. Eiff, G.	Department of Aviation Technology, Purdue University	'Pilot' study: survey and experiment	Logbook write-ups
1997	*Practical Considerations of Maintenance Human Factors for Line Operations*	Eiff, G. Lopp, D. Abdul, Z. Lapacek, M. Ropp, T.	Four US air carriers	Observational ('pilot') Field Study	Human factors issues for line maintenance personnel
1999	*Communication Discrepancies between Pilots and Maintenance Technicians in the Reporting of Maintenance Issues: The Impact of Organisational Socialization*	Mattson, M. Crider, J. Whittington, J.	55 US aviation organisations (major, regional, corporate and general)	Survey 222 responses	Perceptions and willingness for pilots and engineers to collaborate, communication media preferences
2001	*Integrating Safety in the Aviation System: Interdepartmental training for pilots and maintenance technicians*	Mattson, M. Petrin, D. Young, J.	As above	As above	Perceived effectiveness of communication between pilots and engineers, perceived benefits of interdepartmental communication training
2004	*Reporting Discrepancies: An assessment of the informational needs of airline pilots and mechanics*	Munro, P. Kanki, B. Jordan, K.	2 US airlines	Survey 319 responses	Logbook write-ups
2008	*Beyond 'Inop': Logbook Communication between Airline Mechanics and Pilots*	Munro, P. Kanki, B. Jordan, K.	As above	As above	Logbook write-ups

quality of pilot logbook write-ups (as judged by maintenance faculty staff who rated both the content and legibility of student pilot logbook entries), found that pilot descriptions of defects which were written up for the purpose of rectification by engineering were rated poorly by maintenance personnel. A quarter of the 203 logbook entries which were examined required clarification because the handwriting was poor, and 21% of defects which were written up were unable to be duplicated by engineering indicating that the descriptions of the problem were not detailed enough (or possibly were of an intermittent nature). With a view to exploring these claims further, a B727 simulator was rigged with a defect. The researchers subsequently found that defect rectification was timelier when pilots and engineers communicated face-to-face due to the difficulties maintenance experienced interpreting pilot write-ups in the aircraft logbook. In conclusion, Lapacek et al. (1997) stated that communication difficulties result in 'frustration', 'excessive downtime', and 'reoccurrence of the problem' which, in turn, could lead to schedule disruptions affecting both passengers and flight crew.

In addition to their findings regarding the logbook, Lapacek et al. (1997) made two observations of interest concerning the relationship between the pilots and maintenance personnel in their study. The authors stated that communication difficulties resulted in pilots and engineers fostering "unhealthy (and inaccurate) stereotypical notions about the overall competence of each group" (p.1), however, there was no evidence presented in the study to illustrate how this conclusion was drawn. Likewise, their comment that: "an overriding theme in all the research was that attitudes and stereotypes of each other's profession many times foster breakdowns in communication" (p.4), provides no elaboration on what these stereotypes are, nor what the attitudes are based on. Similarly, despite hinting at a causal relationship, there was no mention in the study as to how these factors were facilitating a breakdown in communication, nor is there any description of what a ‘breakdown’ is, or indeed how one might be recognised.

In 1997, a second ‘pilot study’ from Purdue University was published (Eiff, Lopp, Abdul & Ropp, 1997). The aim of the research was to explore human factors issues that specifically impacted on line maintenance. Acknowledging that there had been little recognition of the different specialities within the aviation maintenance profession (i.e., line maintenance vs. heavy maintenance), the study was designed to collect qualitative data consisting of observations of line maintenance personnel at work at a US airline. Interestingly, during their time in the field, the observers noted several occurrences of conflict between engineers and pilots. According to the researchers, not only were engineers troubled by thoughts that their profession was both undervalued and underappreciated by the general public, they also identified that engineers “seemed to unanimously agree that they were not afforded the respect or considerations which pilots receive” (p.7). While the authors acknowledged this may have simply been a reflection of what was an unhappy workforce, they were disinclined to attribute these perceptions solely to that possibility. Interestingly, the study suggested that the way in which line maintenance personnel perceive themselves in comparison to the pilot group impacts on communication but how or why exactly this occurs was not explored.

This study by Eiff et al. (1997) also noted that disagreements arose between pilots and engineers regarding the airworthiness of aircraft, whether a particular rectification was appropriate and whose legal authority the aircraft was under at specific points in time. How often these disagreements took place and what the resultant outcome was, was not however, reported. Additionally, the observers stated – somewhat cryptically – that only some of the conflicts related to ‘real issues’. While the authors commented that poor communication was a barrier to effective teamwork which, in turn can cause errors and affect safety, this particular study was not designed to test this relationship empirically. What the researchers did observe, however, was that those maintenance engineers who displayed good interpersonal skills when interacting with flight crew, tended to have greater success in rectifying defects. What the authors deem to be ‘good’ interpersonal skills was not explained. Eiff et al. (1997) conclude that while the observations made in their study were ‘enlightening’, they were simply observations. Additionally, as the focus of the research concerned only line maintenance engineers the views of pilots were not covered.

3.8.2 The Purdue Industry Survey: An Insight into Perceptions

Two further studies were published by researchers at Purdue University. In 1999, the first of these studies reporting the results of a survey designed to explore the perceptions flight crew and maintenance personnel held with regard to the way they communicated was published. Mattson, Crider and Whittington (1999) sought to determine whether each group’s perceptions of the other promoted collaboration. The survey was distributed to a range of major and regional US airlines as well as corporate and training organisations and 129 pilots and 92 maintenance personnel across 55 organisations responded. With regard to perceptions of technical competency and mental capability, each group rated themselves slightly higher than the other; however, each group also perceived that the other group rated them significantly lower than what they scored themselves. In other words, both pilots and engineers perceived that the other group thought significantly less of them than they thought of themselves. Interestingly, while a comparison with the actual ratings each group gave the other indicated that these perceptions were ill-founded, it remains unclear on what basis these perceptions were formed. Another finding of interest was that both pilots and engineers rated face-to-face communication as the least effective medium by which to report maintenance discrepancies. Surprised by this finding, the researchers concluded that the reasoning behind it was most probably "complex and disparate" (p. 747).

In the framework for their study, Mattson et al. (1999) promoted Chute and Weiner's (1995) 'Five-Factor Model of Communication Barriers' (see Table 3.1) contending that the barriers between pilots and engineers will be similar to those between pilots and flight attendants. However, while some of these arguments appear logical (such as separate cultures developing as a result of segregation within an organisation), other factors which are proposed as communication barriers are more difficult to understand. For example, under the banner of a 'Regulatory Barrier', the existence of separate licensing requirements for engineers and pilots is offered as a contributing factor, specifically the fact that pilots have no time limit imposed on their licence applications[30]. While the licensing requirements are somewhat different in that regard, whether this would create significant levels of animosity between the two groups might be questioned. Further, despite the survey demonstrating that each group held erroneous perceptions of the other, the experiences of the participants themselves were not examined in order to determine what particular issues were driving such beliefs. Interestingly, Lapacek et al., (1997), also refer to Chute and Weiner's (1995) model with

[30] The authors state that (in the US) while both pilots and engineers have similar licencing requirements with regard to medical testing and oral, written and practical exams, engineers must complete all their requirements within a two-year period, however, pilots do not have this stipulation.

regard to the attitudes and personality differences which were found in their own study, however, while they too purported the pilot-flight attendant barriers would hold true for pilots and engineers, no evidence was provided to explain how this conclusion was drawn.

The second paper from Purdue University industry survey focused on the desirability for interdepartmental training for pilots and maintenance engineers (Mattson et al., 2001). Both pilots and engineers reported that their training in relation to maintenance discrepancy reporting had been only 'somewhat adequate' and that a supplement to logbook communication, such as an accompanying briefing would potentially minimise miscommunication which occurred between the two groups. Findings also indicated that the majority (82.9% of those surveyed) felt that some form of integrated communication/CRM training would be beneficial to their work. Interestingly, with regard to the reasons why respondents felt joint-training would be of benefit, the study notes that: "The need to "break down the wall of mistrust/conflict/close-mindedness" between the professions was reported by the pilots and maintenance technicians" (p.47). Being outside the scope of the study, there was, however, no indication as to why the groups happened to feel this way about each other.

Of the survey itself, the authors note that it was designed by a group of students as part of a separate experiment the researchers were involved with at the time and stated that the way in which the survey was designed and distributed "may have skewed responses in a particular direction or discouraged recipients from filling out the survey" (Mattson et al., 2001, p. 48) leading to reliability and validity concerns. Furthermore, despite the survey being distributed to a wide variety of different aviation organisations (e.g., military, general aviation, airlines), analysis of the responses did not differentiate between the settings making it difficult to draw conclusions with regard to generalisability.

3.8.3 Munro and Colleagues: Investigation of the Logbook

The most recent studies dedicated to communication between flight crew and maintenance engineers were published in 2004 and 2008. Joint research from San Jose State University and the NASA-AMES Research Centre (Munro, Kanki & Jordan, 2004; 2008) involved the distribution of another industry survey investigating the difficulties associated with logbook communication. The survey was distributed to pilots and line maintenance personnel at two US airlines and sought to determine the degree to which pilots and mechanics found logbook entries helpful with regard to defects. From the 319 responses, the researchers established that there were differences not only in the level of detail each group reported wanting from the logbook, but also the perceptions regarding the level of detail that each group was providing. For example, pilots were queried as to how often they would only describe a maintenance discrepancy as ‘inop’(as in ‘system xyz is inop’). The frequency which pilots reported making such entries was statistically significantly different to the frequency which engineers reported receiving these entries. Similarly, when engineers were queried how often they would describe a system repair only with reference to their maintenance manual (to which pilots do not have access), the frequency they reported doing so was significantly different to the frequency pilots reported receiving such entries. Additionally, while the majority of engineers indicated that pilot entries lacking sufficient detail were the norm rather than the exception, the majority of pilots disagreed, indicating a disparity in perceptions.

A second paper (Munro et al., 2008) presented additional results from the industry survey. In order to explore the reasons behind the differences in the way that pilots and engineers utilise the aircraft logbook, the researchers queried both pilots and maintenance personnel on who they believed their primary audience was when they wrote in the logbook. Results from the survey indicated that each group was essentially writing their description for a different audience with maintenance personnel making their entries primarily with the FAA in mind and the pilots describing defects for engineers specifically. Other results also revealed factors that influenced logbook write-ups with the amount of detail written varying between pilots and engineers depending upon what factors each group perceived as being most important (e.g. whether the defect was new or had happened previously, whether the defect impacted the airworthiness of the aircraft etc.). Pilots also reported having less time to fill out the logbook and neither group tended to write more information than the logbook form provided space for. The authors concluded by determining that the two groups had different goals with regard to logbook communication and it would be beneficial to give each group structured training and feedback on their entries; joint-CRM training was suggested for this purpose.

3.9 Summary

Due to the limited amount of research which has examined the interaction between flight crew and aircraft maintenance engineers, it is not surprising that the range of methods used is comparatively narrow. Pilot studies (Lapacek et al., 1997; Eiff et al., 1997) identified potential areas of further investigation, yet subsequent research has been restricted to the use of self-completion questionnaire surveys (Mattson et al., 1999, 2001; Munro et al., 2004, 2008). Hence, the potential to extend the research by making use of a wider range of methods is evident.

Previous literature has identified that the relationship between pilots and engineers is subject to a certain amount of conflict. However, there is little understanding as to why these feelings prevail. In the absence of any dedicated exploration into communication barriers between pilots and engineers, it is perhaps to be expected that comparisons have been made with the relationship between flight crew and flight attendants. However, while the flight crew-cabin crew model may be the most compelling comparison to use for pilots and engineers, there is, to date, no objective confirmation that the same barriers exist between these groups.

In light of the paucity of research into the interaction between flight crew and line maintenance engineers, it is to be expected that numerous questions remain unanswered. The findings from previous studies are either restricted due to methodological limitations or remain, at least to a certain degree, unexplained. While it might be accepted that conflict exists between pilots and engineers, the reason for the phenomenon has not been fully explored. Additionally, while there are assumptions that conflict between flight crew and line maintenance personnel will affect communication, there is no quantifiable evidence that this is occurring. To summarise, the repercussions of intergroup conflict and the effects of poor communication between the two groups are yet to be investigated in an objective and rigorous manner. With this in mind, Part IV of the literature review is now presented where the wider social psychology literature is used to provide a theoretical framework in which to consider both the previous body of work and to identify the questions to guide the current research.

Part IV. A Social Identity Perspective

This section of the literature review sets forth the case that identification with their individual occupations leads to a series of intergroup biases which influence the relationship between pilots and aircraft engineers, in turn resulting in conflict between the two groups. The nature of intergroup conflict within organisational settings is discussed along with the effects that poor intergroup relationships can have on communication.

3.10 Social Identity Theory and Social Categorisation of Organisational Groups

Group research is an extensive body of work within the field of social psychology and there are numerous theories on which to support an argument. Indeed, Berdahl and Henry (2005) lament the need for a more integrative approach, naming no fewer than eleven theoretical perspectives in what they call ‘a conceptually fragmented’ state of group research. Notwithstanding, the majority of these theories are built upon the foundations laid by the seminal work of Henri Tajfel and his colleagues[31] in developing Social Identity Theory. Social Identity Theory (SIT) has since become, as expressed by Hogg (2006), “a familiar part of the landscape of social psychology – one that continues to develop conceptually and spawn a huge literature” (p. 133). In addition to being one of the few ‘grand theories’ within the realm of social psychology (Haslam, van Kippenberg, Platow, & Ellemers, 2014), SIT provides a comprehensive explanation of the typical behaviours which are observed between groups of people. It is upon the underlying principle of SIT, for example, that the process of stereotyping can be explained including the effects that this often subconscious cognitive

[31] see Tajfel, 1981; 1982; Tajfel, Billig, Bundy & Flament, 1971; Tajfel & Turner, 1979; Turner, 1984.

process can have on intergroup relations. Despite an absence of reasoning as to what might be motivating such behaviour, previous research has acknowledged the existence of stereotypes between pilots and engineers (Lapacek et al., 1997) and intimated the presence of intergroup biases (Mattson, et al., 1999) and it is for this reason that SIT will be used to provide an explanatory framework for the current research.

Prior to the ensuing discussion, it is necessary to clarify what is meant by the term 'group', for as illustrated by Forsyth (2014), there are not only numerous definitions of the word but also many ways in which groups may be classified. Given that the primary focus of this research is to examine the way in which two professions engage and communicate with each other, it follows that a definition which is central to the concept of interaction is used as well as one which is compatible with the fundamental principles of SIT. With this is mind, Johnson's (1995) definition of a group is presented:

> A group is a social system involving regular interaction among members and a common group identity. This means that groups have a sense of 'we-ness' that enables members to identify themselves as belonging to a distinct entity. (p.125)

With regard to the way in which groups engage with each other, it is considered fitting to use a definition provided by one of the pioneers[32] of intergroup research. Therefore from Sherif (1966):

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[32] Sherif (1951) and colleagues (Harvey, White, Hood & Sherif, 1961) ran a series of studies including the 'Robber's Cave' experiments exploring *Realistic Conflict Theory*. Their findings, which have since been replicated in numerous different contexts, including organisations (e.g. Brief, Umphress, Dietz, Burrows, Butz, Scholten, 2005), determined that intergroup competition for limited resource can not only reduce co-operation and collaboration between groups, but increase hostility between group members.

> Whenever individuals belonging to one group interact collectively or individually with another group or its members in terms of their group identifications, we have an instance of intergroup behaviour. (p.12)

When considering the organisational literature, a pluralist frame of reference with regard to industrial relations is adopted. According to Buchanan and Huczynski (2010) this can be defined as:

> a perspective that views organisations as consisting of different, natural interest groups, each with their own potentially constructive, legitimate interests which makes conflict between them inevitable. (p. 663)

With this framework in mind, it is acknowledged that conflict is unavoidable and therefore the need to facilitate effective interaction and communication between individual groups of workers is essential. It is with reference to these definitions that the discussion on intergroup behaviour from the perspective of Social Identity Theory is presented.

3.10.1 Social Identity Theory and Social Categorisation

A succinct description of the basic principles of SIT is provided by Anastasio, Bachman, Gaertner and Dovidio (1997). According to the theory, humans divide the world into social categories, separating themselves from others in order to make sense of their social context. In this manner, a person’s identity is, in part, determined by the social categories – or groups – to which he or she is a member. Using this logic it is argued that an intrinsic motivator for positive self-esteem leads people to view themselves (the ‘in-group’) as superior to others (the ‘out-group’), and indeed in-group favouritism is a practiced means of enhancing one’s own social identity (Haslam et al., 2014). To facilitate this, individuals must feel that their in-group is <u>at least</u> [emphasis in original] slightly more superior to the referenced out-group. Accordingly, central to SIT is the notion that an in-group will attempt to bolster collective self-esteem by increasing the perceived differences between themselves and the out-group.

A major tenet of SIT therefore is that group members will perceive the group they are part of as being different from the groups to which they do not belong thus resulting in a <u>perception</u> [emphasis in original] that there is more disagreement between the two groups than actually exists (Chambers & Melnyk, 2006; Abrams & Hogg, 2006). While they do not explore their findings in relation to intergroup cognitive bias, survey results from a study which investigated perceptions of pilots and engineers (Mattson et al., 1999) found that pilot and engineer respondents viewed their own profession as being slightly more mentally and technically capable than the other. Furthermore, each profession also perceived that that the other profession would rate them significantly lower in capability than what that profession would rate themselves technically and mentally. In other words, both pilots and engineers perceived that the other group thought significantly less of them than they thought of themselves. Interestingly, however, a comparison of the ratings provided by the survey respondents indicated that these perceptions were actually ill-founded, a finding central to SIT and one which may indicate that the existence of psycho-sociological influences.

A closely related theory to SIT is that of social categorisation; that is, how individuals consider their group identity. The discovery of what is now known as the Minimal Group Paradigm (Tajfel et al., 1971; Turner, 1984) presented a significant insight to the way in which individuals view groups. According to this theory, which has been well-replicated in the decades since its conception, merely being told one has been categorized into a group –

no matter how insignificant the defining features of that group are – is enough to spur intergroup competition. Indeed, it has been demonstrated that competition does not even need to exist for intergroup conflict to arise (Ferguson & Kelley, 1964). In the context of this research, the difference between pilots and engineers in terms of group salience is fairly substantial. In addition to the natural divisiveness surrounding differing work functions and perceived status differences in airline workers as observed by Gittell (2000; 2006), both professions have distinct uniforms which reflect the nature of their work; corporate-styled attire for flight crew and overalls for maintenance personnel. It might therefore be expected that, primed largely by their appearance, pilots and engineers experience a heightened sense of identity with their respective groups, thus increasing the likelihood that intergroup competition and conflict could arise. Interestingly, one of the cognitive processes associated with social categorisation is out-group homogeneity bias, whereby individuals have a tendency to assume that members of their own group are more heterogeneous compared to those of the out-group (Forsyth, 2014). According to Hogg (2006), this is caused by a process of 'depersonalisation', whereby people perceive groups prototypically as opposed to considering the interpersonal relationships or various idiosyncrasies of individuals in the groups. Given that one of the primary functions of a uniform is to signify group membership and lessen individuality, it is conceivable that the wearing of uniforms by flight crew and maintenance personnel is further encouraging this bias.

It is perhaps not surprising that these comparative processes and judgments of relative worth that are inherent in SIT and social categorisation have consequences for social behaviour in the form of cognitive generalisations about the qualities and characteristics of particular groups, namely stereotypes. Given the categorisation processes that underpin SIT, it is understandable that subscribers to SIT argue that stereotyping is not merely a ‘perceptual error’ or an unavoidable cognitive by-product of information processing, but a functional means by which humans make sense of the work around them (Anastasio et al., 1997). Indeed, the whole notion of social identity is the perception of self in terms of stereotypical attributes of one’s in-group (Abrams & Hogg, 2006). While stereotypes can be viewed in a relatively neutral sense (Forsyth, 2014), in-group members will tend to use positive labels when describing a trait processed by the in-group and negative labels when describing traits of the out-group (Stephan & Stephan, 1996). As SIT posits that in-group members tend to view themselves more positively than members of the out-group, an in-group/out-group bias[33] can develop. Evidence of stereotyping between pilots and maintenance engineers was found by Lapacek et al. (1997) during their pilot study which explored logbook communication between student pilots and maintenance personnel at a flight training school. While their study noted that “An overriding theme in all the research was that attitudes and stereotypes of each others’ profession many times foster breakdowns in communication” (p.4), no information was provided on what may have been generating these behaviours, nor was there elaboration regarding what the particular nature of the stereotypes mentioned.

In addition to stereotyping and biases, trust between groups is also affected by social categorisation. For example, Brewer (2009) discusses how in-group favouritism affects

[33] An example of this is Pettigrew’s (1979) ‘ultimate attribution error’ (UAE). UAE or ‘attribution bias’, offers an explanation to the way in which individuals explain behavior. Whilst in-group negative behaviours are likely to be blamed on situational factors, poor behaviour from the out-group is viewed as being a result of personality factors. However, where success is concerned, the bias works the other way, with in-group members attributing good performance from out-group members as merely a result of situational factors, or luck.

intergroup relations. While individuals appear willing to trust a stranger when told they are a member of their in-group, trust levels drop appreciably when the stranger is labelled a member of the outgroup. While this does not mean intergroup relations are automatically characterised by an active *distrust*, empirical evidence demonstrates a significant degree of uncertainty or a lack of trust across groups (Yuki, Maddux, Brewer & Takemura, 2005). In their survey which sought the opinions of pilots and engineers regarding the effectiveness of their communication, Mattson, et al. (2001) reported evidence of mistrust: “the need to ‘breakdown the wall of mistrust/conflict/close-mindedness’ between the professions was reported by pilots and technicians” (p.47). However, no elaboration of this particular conclusion was provided.

3.10.2 Social Categorisation between Work Groups

While much of the early work developing SIT was experimental, the growth of organisational psychology has seen an extension of this research into field-settings, including the workplace (Haslam et al., 2014). The fact that organisations are made up of groups means that SIT is well-suited as a tool to analyse organisational behaviours (Hogg & Terry, 2014). As social categorisation processes take place even between minimally distinctive groups, the influence of social identity within an organisation where divisions among employee groups can be particularly distinct will be appreciated. Different job functions, salaries, work locations and uniforms all contribute to both an employee’s sense of belonging to their own work group and their segregation from another. Indeed, organisational research has shown that work-related identities can be more important to individuals than their identity with their race, ethnicity or gender (Hogg & Terry, 2014). Moreover, those employed within specialised professions often identify more strongly with their profession than they do with the organisation in which they work (Ashforth & Johnson, 2014; Johnson, Morgeson, Ilgen, Meyer & Lloyd; 2006). Given the link between occupation and social identity, it follows that social categorisation processes will inevitably influence intergroup relationships within the workplace.

R. Fisher (1993) argued that the presence of different professional specialties reduces the extent to which members of an organisation share common interests. If workers perceive they have little in common with employees in a different group, there may well be a reluctance to mix between groups. Evidence of this phenomenon may well have been captured during a naturalistic observation study of line maintenance personnel at work (Eiff, et al., 1997). Here the authors observe what seems to be a distinct unwillingness for line maintenance engineers and other ramp employees to interact in their shared workplace facility:

> It was interesting to note that members of these two professional populations elected to congregate in homogenous groups and seemed to avoid inter-group interactions. Despite the fact that no facility layout feature segregated the two groups, the combined employees at the station naturally polarized into groups of similar profession. This resulted in a division of the ready room with ramp personnel on one side and what few maintenance technicians were present on the other. (p.5)

What the field researchers were witnessing appears to be the tangible manifestation of the socio-psychological influences on group behaviour. The illustration is particularly apt because it demonstrates that even groups of employees who share workplace facilities - and probably a similar work attire – can be susceptible to these barriers across professions. It would seem plausible therefore that more distinct work groups such as pilots and engineers might also have a natural reluctance to interact with each other, raising the question of how such intergroup behaviours might affect their ability to communication.

3.10.3 The Influence of Social Identity on Communication

The importance of communication within workplace settings is such that organisational communication research is now an established discipline in its own right (Jablin & Putnam, 2001). Communication is central to the performance of an organisation and nearly everything significant that happens in a workplace involves some degree of communication (Buchanan & Huczynski, 2010). Communication within organisations tends to be considered in terms of the direction of hierarchical flow; downward (the flow of information from superiors to subordinates), upward (the flow of information from subordinates to superiors) and lateral (horizontal communication among peers and/or across workgroups without distinct reporting relationships with each other). According to D. Fisher (1993), downward communication ‘instructs’, upward coordination ‘informs’ and lateral communication ‘co-ordinates’. For the purposes of this research, lateral communication is of interest as, despite any perceptions held by the two groups, neither pilots nor line maintenance engineers are subordinate or superior to one another within a commercial airline organisation.

Communication barriers are factors that either block or significantly distort successful communication (Nelson & Quick, 2013). Within an organisational context, one of the main barriers to effective lateral communication is increased specialisation. According to Growler and Legg (1981), different technical and professional training and socialisation gives specialist groups not only differing views of the world, but different languages as well due to specialised terminology. This is due to the substantial influence communication has on social identity, in fact communication has been argued to be a key factor in determining the salience of social identities (Postmes, 2003). Differences in terminology can create a salient division between groups when different professions use specialised language. The use of jargon and sublanguages can act to alienate individuals of the out-group, the exclusion often leading to suspicion and apprehension of those who witness it (Huseman et al., 1976) and thus becomes a major barrier to communication (Eunson, 2008; Nelson & Quick, 2013). Pilots and aircraft engineers are trained separately and even when they begin working in an operational environment, they interact with the aircraft in different ways and under different circumstances (Munro et al., 2008). It is not difficult to appreciate that the differences in their use of aircraft technical language will also contribute to their professional group salience.

Organisations such as airlines consist of remote work groups and are reliant on effective communication taking place between employees who may be physically separated. In addition to the logistical challenges posed when remote work groups communicate, within an organisational context, physical separation has been identified as a communication barrier which also affects intergroup relations (Papa, Daniels & Spiker, 2008). An undesirable characteristic associated with the communication barriers generated by salient group identities (such as described above) is a perpetuating cycle whereby physical separation acts to reinforce any perceived group differences. R. Fisher (1993) explains how physical separation and a mutual mistrust between workers illustrates the interdependent nature of communication barriers: being physically separated reduces the likelihood that trust will be built and the lack of trust acts as a disincentive to want to spend time together so the two barriers effectively sustain and reinforce one another. Further, perceptual distortion and hostility increase with decreased communication and the likelihood of conflict becomes a reality. This aligns with SIT theory which has demonstrated that poor intergroup attitudes have a negative impact on effective intergroup communication (Gudykunst, 1986; Papa et al., 2008). As discussed previously, flight crew and maintenance engineers are reliant on the logbook for communication as they may not see each other during the course of an aircraft turnaround. This situation may well be exacerbated in the future. The Royal Aeronautical Society predicts that while there is currently little contact between pilots and engineers, this will only continue to reduce as new aircraft are designed to require less engineering input during the turnaround (CAA, 2014). In the absence of any dedicated time together away from the aircraft (e.g. classroom training) the two professions are conceivably vulnerable to the impact that physical separation may have on their intergroup relationship.

Given the close link between social identity, occupation and communication, the accompanying biases and lack of trust between employee groups can become problematic within a workplace setting, R. Fisher (1993) warning that when left unchecked, these can lead to conflict between groups and cause serious problems within organisations. In the aviation maintenance environment, such a concept has been demonstrated by research from Eiff and Suckow (2008), who support the concept of a vicious cycle whereby communication difficulties lead to conflict which, in turn, leads to further communication difficulties. The authors assert that a failure to recognise how the performance of one group may impact on the performance of another "…can often lead to strong animosities between career fields" (p.44). The Eiff and Suckow (2008) study referred specifically to maintenance personnel located in separate divisions within an engineering organisation. While it is potentially applicable to even less homogeneous groups such as pilots and engineers, there is no research to date investigating the presence of this phenomenon between these two groups.

3.11 Intergroup Relations and Work Performance

There are many potential sources of conflict within an organisation such as differing goals, means of evaluation, task interdependency, competition for resource and overlapping authorities, job specialization, status inconsistencies, personality clashes, perceptual differences, differing skills and abilities and communication barriers (Buchanan & Huczynski, 2010; Nelson & Quick, 2013). As intergroup conflict tends to increase with organisational size (Growler & Legg, 1981; Papa et al., 2008), it is not surprising that workplace diversity has also been recognised as a major challenge for organisations and diversity management is one of the fastest growing areas of group process/group relations research (Christian, Porter, & Moffitt, 2006).

Conflict within organisations is traditionally classified two ways; conflict which is related to the job at hand or conflict between the employees themselves. Multiple terms in which to describe these two types of conflict are found within the large body of literature on organisational and group research. Conflict surrounding work or specific task matters can be known as ‘substantive’ (Forsyth, 2014), ‘cognitive’ (Priem & Price, 1991), ‘goal-orientated’ (Coser, 1956) and ‘constructive’ (McShane & Von Glinow, 2009) while conflict which is of a more personal nature is referred to as ‘affective’ (Guetzkow & Gyr, 1954), ‘social-emotional’ (Priem & Price, 1991), ‘emotional’(Coser, 1956), ‘relationship’ (McShane & Von Glinow, 2009) and ‘personal’(Forsyth, 2006). For the purposes of this discussion, the somewhat less ambiguous terms used in Jehn’s (1994, 1995; 1997) work on organisational group conflict will be used. Jehn (1995), defines ‘task-related conflict’ as disagreements “about the content of the tasks being performed including differences in viewpoints, ideas and opinions" (p. 258) and 'interpersonal conflict' as interpersonal incompatibilities typically including "tension, animosity and annoyance" (p. 258).

Issues associated with an aircraft's dispatch have been highlighted as a source of task-related conflict between flight crew and line maintenance engineers. In their study of maintenance co-ordination failures, Suzuki et al., (2008) examined reports from the NASA-administered ASRS database and identified that the majority of conflict between pilots and aircraft engineers was task-related, specifically disagreement over the MEL. Reithmaier (2001), also examined reports selected from the ASRS database and found that interpretation of the MEL often resulted in a disagreement between pilots and maintenance personnel. In his appraisal of 79 reports concerning maintenance-associated errors which pilots have made, Reithmaier (2001) notes that not only were problems with the MEL frequent, pressure for an on-time departure was always present as a contributing factor. Whilst insightful, these ASRS report accounts contain only the perspective of the reporter and although testimonies from pilots might suggest the existence of task-related conflict, neither the MEL nor OTP pressures have been the subject of a dedicated academic study[34]. Thus, whilst reports such as the one above might indicate the presence of task-related conflict, the research required to underpin any specific themes is lacking.

Researchers' views regarding the effects of conflict within organisations have fluctuated over the years. Traditionally, conflict in general was seen as being detrimental to team performance and acted to reduce group member satisfaction (e.g. March & Simon, 1958;

[34] Pattersen & Aase (2008) identified that both the MEL and on-time-performance were concerns for line maintenance engineers, but this was in reference to organisational demands as opposed to interaction with flight crew.

Pondy, 1967; Brown, 1983). However, studies within the field of group research have since had mixed results. For example, empirical evidence has been found to suggest that in some situations the presence of task-related conflict can be beneficial to stimulate improved performance from a team (e.g. Pelled, Eisenhardt & Xin, 1999; Shah & Jehn, 1993; Jehn, 1995). However, the impact of interpersonal conflict is widely agreed to be negative with links to decreased performance, increased work stress and lower levels of decision making quality (Pelled, 1996; De Dreu & Van Vianen, 2001; Jehn & Mannix, 2001). The result of differentiating between the types of conflict has, according to De Dreu and Weingart (2003), led to somewhat of a general consensus that task-conflict can be viewed as productive in some cases whereas interpersonal-conflict is only ever dysfunctional. For example, McShane and Von Glinow (2009) state that while interpersonal-conflict causes aggressiveness, which in turn leads to a decreased motivation to communicate, distorted perceptions and stereotyping, task-conflict is considered constructive because discussion remains focused on the issue at hand allowing for ideas to be generated and challenged without triggering defensiveness and negative emotions.

More recently, however, these ideas have been challenged for while there are clear theoretical distinctions between relationship conflict and interpersonal conflict, realistically, the presence of one appears to be accompanied by the other as discovered by Pelled et al. (1999), "Task conflicts may be taken personally by group members and generate emotional conflict, or emotional conflict may prompt group members to criticise each other's ideas, thereby fostering task conflict" (p.23).

Support of this notion came via a meta-analysis conducted by De Dreu and Weingart (2003) who demonstrated that while task-related conflict may be associated with positive consequences, this was limited to highly specific circumstances and the authors cautioned against the blanket argument that all task-related conflict is beneficial. Results from their review of the literature revealed that conflict of any type interferes with an individual's ability to process information and will therefore impede task performance, particularly when tasks are complex and demand high levels of cognitive activity. Further, task-related conflict was only determined to have positive effects on performance when there were high levels of trust, openness and perceived cooperation as opposed to competitive goal interdependence between individuals. Given that communication barriers do not facilitate trust, openness and perceptions of cooperation, it is not surprising that a lack of awareness of the tasks other people perform can lead to conflict for those in highly specialised jobs (Nelson & Quick, 2013).

3.11.1 Effects of Conflict on Highly Specialised Teams

As literature regarding the effects of conflict between flight crew and line maintenance engineers is limited, the following explores a field where there has been more substantial research of the effect conflict has on the ability for professional teams to communicate and co-ordinate effectively. The medical industry was selected for this purpose; not only is there an ample amount of literature to draw upon, but the parallels between aviation and medicine are frequently discussed, perhaps no more so than with regard to human behaviour and the associated impact on safety[35].

[35] See footnote 24 (page 61)

One does not need to search far in the medical literature to find reference to poor inter-professional communication, or the adverse effects which are attributed. Data from the period 2004 to 2015 indicate that communication failure is a leading cause of inadvertent patient harm in the United States[36] with some crediting ineffective communication as being responsible for 60% of medical error (Lingard, et al., 2004). Others ascribe an even higher rate; Leonard, Graham and Bonacum, (2004) stating that 70% of 2455 medical 'events' which had an adverse outcome were due to communication failure and in 75% of those cases the adverse outcome was death of the patient[37]. Conflict stemming from poor communication and teamwork between teams in the operating room also has a more indirect effect with disruptive behaviour such as yelling, abusive language and condescension by physicians impacting on hospital retention rates of nursing staff (Rosenstein, 2002),

When considering the interface between airline pilots and line maintenance engineers, many of the factors which have been identified as having as causing conflict between surgical teams in the operating theatre appear relevant to this research, namely: a lack of familiarity with team members due to shift work (Bergs, et al.; 2005); concurrent task-demands (Salas, et al., 2007); time and resource constraints (Lingard et al., 2002b; Riley et al., 2006); assumptions of others' motivation (Lingard et al., 2002a; 2002b), personality differences (Fagin, 1992;

[36] Joint Commission Sentinel Event Statistics, 2004-2015 Root Causes by Event Type. http://www.jointcommission.org/assets/1/18/Root_Causes_by_Event_Type_2004-2015.pdf accessed on 3/4/2016.

[37] Interestingly, and in a similar vein to the context of this research, while there is general agreement that poor communication or poor collaboration between surgical teams leads to some form of negative effect (e.g. Undre, Sevdalis, Healey, Darzi & Vincent, 2006; Bergs, Rutten, Tandros, Krijnen & Skipper, 2005; Kosnik, 2002; Riley, Manias & Polgase, 2006), there is acknowledgement that much of this consensus is driven by anecdotal evidence rather than academic research (Kennedy & Garvin, 1988; Lingard, Reznick, Espin, Regehr & DeVito, 2002a; Nestel & Kidd, 2006). With this in mind, researchers acknowledge the need to collect empirical data in order to support or reject the less-substantiated reports.

Kosnick, 2002), and lack of joint communication training between disciplines (Baggs & Schmitt, 1988; Fagin, 1992; Lingard et al. 2002; Leonard et al., 2004).

Appraisal of the medical literature, however, identifies that one particular issue appears widespread. Perceptions – or misperceptions – of other job functions appears to be a common source of conflict for the various medical professions who must interact. Fagin (1992) for example, found that doctors perceived nurses to have less authority than nurses themselves believed they had. Kosnick's (2002) appraisal of the stalled collaboration between medical professions reflected a similar view with nurses expecting to use their own knowledge when caring for patients while doctors perceived them as simply 'physician – extenders'. These findings were supported by Nestel and Kidd (2006) who highlighted that confused and conflicting role perceptions were both a source of frustration for nurses and also had an impact on communication. A series of focus groups (Lingard, et al., 2002a) found that of the 40 different references nurses made when describing the role of a surgeon, only one of those references was consistent with how surgeons perceived their role leading the authors to note: "Subjects' constructions of other professions, particularly their values and motivations, were often dissonant or harshly/negatively inconsistent with those professions' constructions of themselves" (p. 730). In their follow-on study comprising of observation of 35 surgical operations (Lingard et al., 2002b), the observers linked sources of tension in the operating theatre specifically to matters surrounding individual roles and responsibilities.

A lack of understanding of what other personnel in the operating team are required to do appears to be closely interwoven with the problem of erroneous perceptions, resulting in somewhat of a vicious circle from which conflict stems. The nurses in Nestel and Kidd's

(2006) study, for example, reported frustration that doctors did not understand nurses' roles, often expecting them to do particular tasks in theatre that the surgeons themselves should be doing and neither appreciating nor respecting the boundaries of a nurse's role. Lingard et al. (2002a) attribute the fact that surgical team members are often trained in isolation and, as such, it would be expected that not only would personnel have 'distorted' and 'narrow' understandings of each other's roles but the resultant 'silo effect' can lead to ineffective team collaboration, and possibly accidents. Studies have also identified that discrepancies exist between surgical team members' perceptions of teamwork. Sexton et al. (2000), found that 77% of physicians reported high levels of teamwork with nurses in intensive care, yet only 40% of nurses shared this view. Similarly, while surgeons stated that their teamwork with anaesthetists was good, this was not reciprocated to a high degree. Insight as to the cause of these differences merely demonstrates the depth of the problem. In their study of teamwork in the operating theatre, Undre et al. (2006) discovered that nurses perceived the operating team to be a single entity working toward a common goal. However, both surgeons and anaesthetists strongly disagreed; their perception was that the operating team consisted of highly-specialised sub-groups who were required to work together.

With uncertainty surrounding such fundamental issues such as role functions and teamwork in the operating room, it is perhaps not surprising that hierarchical issues between doctors and nurses have also been identified as a point of conflict. Riley, et al. (2006), for example, determined that the instrument count at the end of surgery (which is directly related to patient safety) was often not completed because nurses felt unable to exert authority over surgeons and demand that the count be done. Nestel and Kidd (2006) cite both power and hierarchy as a source of frustration for nurses, who reported that anaesthetists were 'more approachable' than surgeons, a finding which echoed an observation made by Baggs and Schmitt (1988) that nurses felt discriminated in the doctor-nurse relationship and that doctors did not value their communication. Thomas, Sexton and Helmreich (2003) also found that nurses found it difficult to speak up within the intensive care unit and that, compared to physicians, nurses believed their input was not well-received. Interestingly, and consistent with SIT, such perceptions of disrespect might well be misguided, Rosenstein (2002) finding statistically significant differences when nurses and physicians each rated the value and respect the latter had with regard to nurse input and collaboration.

3.12 Improving Intergroup Relations

Given the problems which can arise, it is little wonder that there are many proposed theories on how to reduce intergroup conflict. Three of the more widely acknowledged methods include reorganisation of the groups in question, increased contact between groups and the introduction of superordinate goals.

3.12.1 Common Identity Model

Reorganisation of groups is based on the premise that intergroup conflict is higher in ideographic organisations where employees identify more with their divisions or sub-groups than in holographic organisations where employees identify more with the organisation as a whole (Hennessy & West, 1999). A concept suggested by Gaertner and colleagues (Gaertner, Mann, Murrell & Dovidio, 1989; Gaertner, Mann, Dovidio, Murrell & Pomare, 1990) involves re-categorising the two groups into one common or ‘superordinate’ group. This is often referred to as the Common Identity Model. An example of this is provided by Ford (2011) who investigated the influence of SIT on cabin crew and found evidence that flight attendants who had been ‘primed’ for an organisational social identity were more likely to engage in effective co-ordination and teamwork compared to flight attendants whose personal identity had been primed. Based on these findings, Ford (2011) suggests that priming a salient ‘organisational identity’ for cabin crew and pilots would increase the effectiveness of CRM training for the two groups. However, whilst utilisation of the Common Identity Model can reduce intergroup conflict, there can be practical problems associated. Schneider (2004) warns that the salience of original group identity on a day-to-day basis can be problematic. Within an airline context group identity is primed by the presence of uniforms, heightening the salience of occupational groups and reducing the salience of the organisation itself.

3.12.2 Contact Hypothesis

The Contact Hypothesis (Allport, 1954) theorises that increased contact between dissimilar groups in a non-competitive environment will provide opportunity for any stereotyping to be diminished. While there are differing thoughts as to whether contact is best to take place at an interpersonal level (Brewer & Miller, 1984) or between groups (Hewstone & Brown, 1986), there is agreement that contact should be prolonged and involve co-operative activity between groups of more-or-less equal social status. Additionally, integration of dissimilar groups should take place with appropriate institutional support for the activity and include common goals for the groups to work toward. Research utilising the Contact Hypothesis has, over the years, produced what Vaughan and Hogg (2005) describe as “a complex picture”, something they put down to a prevalence of uncontrolled field studies along with various modifications of Allport’s original conditions under which contact should take place. Further, there are numerous confounding variables all of which influence outcomes to such a degree that the complexity of the theory may well be affecting its usefulness (Stephan & Stephan, 1996). Nevertheless, it is generally agreed that at least *some* interaction between groups is helpful as a lack of contact only serves to reduce the opportunities for groups to correct their perceptual distortions (R. Fisher, 1993). With regard to organisational settings, Pettigrew and Tropp (2000) found that compared with other populations, contact between employees within the workplace had the most influence on conflict resolution. The fact that many airlines conduct joint-CRM between pilots and cabin crew and have found such programmes beneficial (e.g. Ford, 2011) supports the concept of the Contact Hypothesis.

3.12.3 Superordinate Goals

Superordinate goals refer to those which are achievable only by having both groups work together. The model works on the premise that an emphasis on those goals which transcend the individual interests of the conflicting groups will encourage co-operation and lower antagonism between group members (Schneider, 2004). According to Schneider, research regarding the importance of cooperative behaviour is consistent in that findings support the reduction of stereotypes when groups work together collaboratively. Hennessy and West (1999) who specifically tested SIT within an organisational setting found that it was possible to have professionals who identified strongly with their work group yet did not engage in in-group favouritism when it came to allocation of resource. Given that the resources in question were medical supplies, the researchers suggested their (unexpected) finding may have been contextual as the clinicians in the study probably held a strong ideology that their patients had a right to good health care and discrimination between work groups might be inappropriate. Whether such an ideology in the form of passenger safety might overcome any intergroup conflict between pilots and line maintenance engineers is yet to be discovered.

An important stipulation of the superordinate goal theory as noted by Hartley (1996), is that one goal is not enough; there must be a series of interdependent tasks in order to de-escalate intergroup conflict. There is, however, an important provision with the superordinate goal concept, that being that the goal must be attainable in the first instance and then subsequently attained (Carr, 2003). Vaughan and Hogg (2005) warn of the consequences when groups fail to achieve the said goal; unless there is a compelling external justification for the failure, non-achievement of a superordinate goal will result (rightly or wrongly) in blame of the out-group. Similarly, Growler and Legg (1981) state that conflict is likely to be exacerbated if groups with divergent interests are faced with a success criteria that has a differential impact on each group i.e. rewarding one group at the expense of another. Moreover, R. Fisher (1993), states that while conflicting groups within an organisation can generally agree upon the overarching mission to be achieved, there is often disagreement concerning more specific goals required to reach the objective.

3.13 Summary

Upon review of the social psychology literature, the following points are apparent. Given the socio-psychological influences on intergroup behaviour which are associated with SIT, it is likely that a degree of intergroup conflict exists between pilots and maintenance engineers. Reviewing the barriers other professions experience when attempting to communicate and co-ordinate as teams, one would expect similar impediments to mark the interface between pilots and engineers. Those barriers can be grouped into two main themes; conflicts that are primarily related to the task at hand, and conflicts that appear to be predominantly driven by the relationships of those involved. This not only appears to affect communication, but also creates a vicious circle whereby poor communication impacts adversely on the intergroup relationship. With communication being a vital component with regard to aircraft safety, the importance of facilitating teamwork in the line maintenance environment is evident. The chapter now concludes with Part V, a summary of the literature review.

Part V. Conclusion

3.14 Summary of the Literature Review

A need for improvement in the way flight crew and line maintenance engineers interact was first identified almost twenty years ago. However, in the decades since it appears that the anecdotal evidence and reported concerns that these two groups are experiencing continue to grow. The fact that there has been little interest in developing specific guidance to assist pilots and engineers with inter-professional communication, may be due, in part, to a lack of objective evidence that their relationship is indeed problematic. Examination of the literature provides a potential insight into the relationship between pilots and engineers and the difficulties they face when they are required to interact. Given the characteristics of the two groups, Social Identity Theory appears relevant and would suggest that the intergroup relationship between pilots and line maintenance engineers is predisposed to the various psychosocial influences associated with SIT. As demonstrated by the difficulties other interdependent teams face when interacting, issues such as specialised language and a lack of understanding of the out-group's role might well contribute to a problematic interface between pilots and maintenance personnel also.

It appears that communication and conflict are closely related, implying that any conflict between the two groups may possibly impact on their ability to communicate. Of the three strategies designed to improve intergroup relations, the highly salient nature of two groups effectively thwarts at least one (Common Identity Model), and joint-CRM training (essentially supporting the Contact Hypothesis) is not a regulatory requirement for the airlines. The two groups do share a superordinate goal by way of a successful aircraft turnaround and departure, but anecdotal evidence would suggest this actually appears to be the source of task-related conflict such as differing opinions over the MEL or airworthiness of the aircraft. In light of the potential conflict which is present, the importance of good communication in the line maintenance environment would appear even more desirable given the potential impact poor communication could have on operational efficiencies and the safety of the flight. Previous research indicates that the logbook presents difficulties for both pilots and maintenance personnel, although other media, such as the radio and face-to-face communication give the impression they may be problematic also.

Whilst the previous studies undertaken in this field clearly hint that there are relationship difficulties between these two groups, the source of these issues remains largely unexplored. Similarly, while there is evidence that the logbook creates communication problems for pilots and aircraft engineers, other communication mediums have not been examined. Finally, the way in which a problematic interface between flight crew and maintenance personnel might manifest has not been objectively demonstrated.

3.15 Identification of Research Questions

The research aims to extend the studies which have previously been undertaken and explore three of the fundamental questions to which the literature is suggestive. Upon reflection of both the academic literature and the more subjective evidence such as ASRS reports, the following guiding questions were developed, with the knowledge that results from the first study would inform and shape the scope of these questions.

Study One: The Intergroup Relationship

(1) What do airline pilots and line maintenance engineers identify as impediments to effective communication between their two groups?

(i) Is there evidence that these impediments are reflective of a problematic intergroup relationship?

(ii) Is there evidence that the intergroup relationship between airline pilots and line maintenance engineers is contributing to poor communication?

Study Two: Operational Communication

(2) *How do these impediments affect the way in which pilots and engineers communicate in an operational environment?*

Study Three: Manifestations

(3) *How do the impediments which were identified by airline pilots and line maintenance engineers affect airline operations and flight safety?*

(i) Can impediments relating to the interface between flight crew and maintenance personnel be associated with events which negatively impact on airline operations?

(ii) Can impediments related to the interface between flight crew and maintenance personnel be associated with events which negatively impact on aircraft safety?

CHAPTER FOUR

Impediments to Effective Communication between Airline Pilots and Line Maintenance Engineers

This chapter details the first of the three studies exploring the interaction between flight crew and line maintenance engineers. The aim of this study was to investigate the intergroup relationship between pilots and engineers in order to identify the issues which may be contributing to communication difficulties. The study was designed to allow both groups to express their views on what they felt were impediments to effective communication between their two professions. Affording both pilots and engineers the opportunity to voice the issues which were of concern to them would provide an insight to the intergroup relationship. This meant that the communication barriers could be explored in depth and any impediments which were suggestive of a problematic relationship could be examined in order to determine what role these played in contributing to the overall difficulties experienced by the two groups.

This study aimed to address the following questions:

(1) What do airline pilots and line maintenance engineers identify as impediments to effective communication between their two groups?

> *(i) Is there evidence that these impediments are reflective of a problematic intergroup relationship?*

(ii) Is there evidence that the intergroup relationship between pilots and engineers is contributing to poor communication?

4.1 Method

Due to the exploratory nature of the research question, a qualitative method was sought in order to provide data that was rich in detail and with sufficient depth to provide insight into what was predicted to be complex social behaviour between the two groups. One-on-one (in-depth) interviewing and focus group sessions were considered to be the two most fitting methods available and, following consideration of the benefits and drawbacks of each, the focus group was chosen as being the most suitable to address the first research question. The reason for this was twofold; the focus group methodology was judged more suited to exploratory work, and also to the particular subject matter of the research, namely, insight into group processes.

The focus group has been recognised as a means of not only understanding how people feel about certain issues, but as a technique which can be used gain insight to their attitudes, values and motivations (Hocking, Stacks & McDermott, 2003; Novak & Buddenbaum, 2001; Kitzinger, 1995). Lewis-Beck, Bryman and Liao (2004) state that focus groups provide not only a means of identifying what prompts particular behaviours, but also for “discovering the barriers that impede certain behaviours” (p.393), in which case the methodology is particularly well-placed for the first research question. Additionally, Bloor (2001) advocates that those with a particular interest in group processes, specifically collective judgments and normative understandings, can benefit from using focus groups as a means of data collection, a notion also supported by Morgan (1997). Meanwhile, Robson (2002) cautions that focus groups should be used only to explore collective phenomena not individual issues. Given the suggestion of interpersonal conflict as an issue between pilots and engineers, the focus group would seem advantageous in that respect, Keyton (2011) promoting the technique as a means of gathering comparative data on ‘complex behaviours’. Further, it has also been suggested that focus groups may have an advantage when participants are questioned about issues that are ‘habit-ridden’ or rarely considered in much detail (Morgan, 1997). Given that pilots and line maintenance engineers interact with each other on a daily basis, it is likely that communication between these two groups would fall into this category. Kitzinger (1995) perhaps summarises best when to choose focus groups as a research method:

> group discussion is particularly appropriate when the interviewer has a series of open ended questions and wishes to encourage research participants to explore the issues of importance to them, in their own vocabulary, generating their own questions and pursuing their own priorities. (p. 299)

A second advantage with regard to the subject matter, is that focus groups are a method particularly suited to communication research within organisations, Hocking et al. (2003) stating that in an organisational context, focus groups can help us to “understand the reasons behind a communication phenomenon” (p. 204). Gomm (2008) also suggests that focus groups are more useful than one-on-one interviews when studying organisational issues as a group setting is more likely to reflect the way in which discussions take place between employees within their work environment. Similarly, Kitzinger (1995) advocates the use of focus groups when researching cultures within the workplace.

Further reasoning for favour of the focus group over one-on-one interviewing centred on the exploratory nature of the research. There is general consensus that a focus group is an efficient means of generating data (Novak & Buddenbaum, 2001; Keyton, 2011; Robson, 2002; Denzin & Lincoln, 2000). In fact, focus groups are most often used for exploratory research, Stewart, Shamdasani and Rook, (2007), stating that they are a particularly useful tool when little is known about the subject of interest. Morgan (1997) also states that focus groups are better suited to exploratory research as it provides the opportunity to turn control over to the group where need be. Engaging in group discussion not only allows participants to bounce off one another's responses providing a greater variety of information to the researcher (Hocking et al., 2003) but it also stimulates responses from participants that might not have been forthcoming otherwise (Henn, Weinstein & Foard, 2005). Interestingly, Kitzinger (1995), advocates that focus groups are particularly beneficial when solutions are being sought to improve situations as the method tends to generate more critical comments from participants than traditional one-on-one interviewing.

4.2 Research Design

4.2.1 Sample

The first step in the research design was identification of the sample frame from which participants were eligible to be selected. The sample frame consisted of all airline pilots employed at Airline ABC at the time of the study ($n = 814$), and all aircraft maintenance engineers employed at Airline ABC who were either working in the line maintenance environment ($n = 377$), or within the Maintenance Operations Centre[38], ($n = 26$) at the time of the study. While there are a variety of non-probability sampling techniques which can be used to select participants for focus groups, convenience sampling is the most common

[38] As noted in Chapter Two, maintenance control is an integral part of line maintenance and the engineers employed in this function frequently communicate with pilots as part of their job is to provide maintenance-related information to flight crew should it be required during flight.

method (Stewart et al., 2007). Whilst planning for the study, it became clear that the best opportunity to speak with groups of pilots and engineers was to conduct the focus groups during work hours. Given the constraints associated with this, it was accepted that convenience sampling was going to be the only feasible means of speaking to the participants in a group setting. In the case of the pilots, the researcher contacted groups who were rostered to have administration days and queried whether they would be interested in participating in a discussion at a suitable break in their scheduled activities. In the case of the engineers, permission from Airline ABC was sought to hold discussions during quiet periods of maintenance downtime and the resultant focus groups took place with agreeable participants during their coffee/meal breaks. It was acknowledged that the practicalities associated with accessing the participants meant that the sample was purposive and, as such, findings would be constrained in terms of generalisation (Robson, 2002).

4.2.2 Group Composition and Number of Sessions

While some consideration was given to having mixed sessions of pilots and engineers, it was decided that the focus group design would be homogenous. Homogenous groups are beneficial for facilitating ideas and experiences as group members feel comfortable with each other (Robson, 2002; Novak & Buddenbaum, 2001; Keyton, 2011) and avoids discussions becoming conflict-ridden (Morgan, 1995), the possibility of which was deemed high given what has been discovered in the previous intergroup communication literature. Comparative to the advice regarding the number of participants per focus group (see below), there is little guidance concerning how many sessions ought to be conducted. The consensus appears to be between three and five groups (Morgan, 1995; Stewart et al., 2007; Keyton, 2011; Lewis-Beck et al., 2004), with a requisite of at least two sessions to ensure the data which is generated is not merely reflective of a particularly unique group dynamic or composition (Morgan, 1995; Stewart et al.; 2007; Hocking et al., 2003). Ideally, sessions should be continued until a theoretical saturation is reached or no new insights are generated. Lewis-Beck et al. (2004) state this usually occurs after three or four focus group sessions. However, it is acknowledged that focus groups are labour intensive and it is advised that sessions be restricted to the minimum number required to satisfy the researcher that coverage has been adequate (Khan et al., 1991; Morgan, 1995; Bloor, 2001).

Given Morgan's (1995) argument that the number of sessions required decreases when

a. the groups are highly homogenous
b. the number of populations being compared is low
c. there is high moderator involvement

it was decided that there would be five focus groups run per sample frame i.e. five groups of engineers and five groups of pilots.

4.2.3 Number of Participants

Because all participants in the sample frame were shift-workers whose rosters are built some two months in advance, it was anticipated that there would be logistical difficulties associated with organising the focus groups; specifically, arranging times that were mutually convenient and within rostered hours of work for all those who wished to participate. There was initial concern that the size of the focus groups might be limited to an extent that group discussion was not conducive, or worse, fell outside what would be deemed acceptable in terms of methodological criteria.

Typically, focus groups are cited as having between six to twelve participants (Morgan, 1997; Bryman, 2004; Gomm, 2008; Novak & Buddenbaum, 2001; Robson, 2002; Stewart et al., 2007; Bloor, 2001). Groups that are too large may be challenging for the moderator to control (Keyton, 2011; Stewart et al., 2007), limit the amount of input from individuals due to time constraints (Novak & Buddenbaum, 2001; Keyton, 2011; Stewart et al., 2007) and be difficult to accurately transcribe for academic research purposes (Morgan, 1997; Bloor, 2001). The main argument against having too few participants tends to be a lack of sustained discussion (Novak & Buddenbaum, 2001; Keyton, 2011) or, perhaps even worse, a 'dull' conversation (Stewart et al., 2007). Nevertheless, there is a relatively strong case for using smaller rather than larger groups when it comes to the topic of the discussion. Morgan (1995; 1997) contends that smaller groups are superior to larger ones when the participants have a high level of personal involvement with the particular issue, are knowledgeable on the subject matter, and when the researcher requires a 'clear' impression of how participants react to the topic. Edmunds (1999) differentiates smaller groups by the term 'mini focus groups' or 'triads' (when there are just three participants), suggesting the latter is particularly beneficial when in-depth probing on discussion topics is required. Bloor (2001) also supports the concept of smaller groups when the topic is complex and the participants are recruited for their expertise. Interestingly, despite the oft-quoted participant numbers of six to twelve, Bryman (2004) notes that published studies using focus groups generally seems to have a lower number of participants, citing an average of 4.4 people per group in the examples he had selected for review. With this in mind, it was determined that small group sizes would not only be acceptable, it would actually be preferred.

4.2.4 Focus Group Guide

It was desired that the focus group sessions were kept to a maximum length of 90 minutes in accordance with what appears to be best practice (Keyton, 2011; Bloor, 2001; Morgan, 1995).With regard to structure, a 'funnel approach', as advocated by Morgan (1995), was chosen as the best way to accommodate both the less-structured approach beneficial for exploratory research and a more-structured approached which allows the researcher to ensure that desired lines of enquiry are covered. Questions were constructed to be open-ended in order to encourage more dialogue and promote discussion as opposed to simply answering the particular query. Probes were noted under each question in order to further guide the direction of enquiry as required. With regard to the number of questions, consideration was given to the nature of the group. Bearing in mind that more homogenous groups will move through questions relatively quickly yet the more involved the participants are, the longer it will take, it was decided to set the number of questions at ten with an introductory exercise to begin with. The focus group guide can be found in Appendix A.

4.3 Procedure

Once the potential participants had been identified, an email outlining what would be involved was sent to them along with the information sheet as approved by the Massey University Ethics Committee (see Appendix B). Contact was made again closer to the proposed date to ensure candidates were still in agreement to participate. Once each focus group session convened, introductions were made and participants were reminded of their rights as outlined in the information sheet. Each focus group was audio taped using a digital recording device. Prior to commencement of the session, participants were given a letter to which they would be referred to during transcription and gave a brief introduction which was recorded for demographic data. Data collection and storage was carried out in accordance with the details submitted in the Massey University Human Ethics Committee (Application number 11-31).

Data collection spanned a period of five months between November 2011 and March 2012. A total of ten focus groups were conducted; five sessions with pilot participants and five sessions with engineer participants. All sessions involving pilot participants were held at Airline ABC's primary base of operations utilising a meeting room in a convenient location at the airport. The focus group session for MOC engineers was also conducted in this location. The remaining four engineering focus groups (conducted with line maintenance personnel) were undertaken on site at their place of work which included two sessions at the primary base of Airline ABC's operations and two sessions at secondary hub airports).

A total of 25 pilots and 24 engineers participated across the ten focus groups. Pilot experience (time working at Airline ABC) ranged from 4 years to 34 years with an average time of employment of 19.64 years. Engineering experience (time working at Airline ABC) ranged from 5 years to 47 years with an average time of employment of 23.17 years. Engineering experience operating in either a line maintenance or MOC environment ranged from 18 months to 34 years. The number of participants in the pilot focus groups ranged from 4 to 6. The number of participants in the engineering focus groups ranged between 3 and 7. Session lengths varied between 39 minutes 54 seconds, and 67 minutes 47 seconds (see Table 4.1).

Table 4.1 *Participant makeup and length of focus group sessions*

Focus Group	*Employment*	*Participants*	*Session Length*
1	Flight Crew	4	42:42
2	Flight Crew	4	53:20
3	Flight Crew	6	57:09
4	Maintenance Control	4	56:52
5	Flight Crew	5	49:34
6	Line Maintenance	4	39:54
7	Flight Crew	6	58:43
8	Line Maintenance	3	39:58
9	Line Maintenance	7	67:47
10	Line Maintenance	6	40:53
TOTALS		*49*	*08:26:52*

4.4 Analysis

Two methods were utilised when the focus group data was analysed. Thematic analysis was performed on the transcribed discourse from the focus group sessions following the principles of Framework Analysis (Ritchie & Spencer, 1994; 2002). Additionally, quantitative analysis was undertaken on a small subset of data from the discourse, specifically the words pilots and engineers used to describe themselves and each other.

4.4.1 Thematic analysis of Focus Group transcripts

The discourse from the focus group sessions was thematically analysed using Framework Analysis, a technique developed by Ritchie and Spencer (1994; 2002). Framework Analysis provides a methodical, rigorous and transparent means of data examination and subsequent transformation into meaningful results (Krueger, 1994; Shrivastava & Thomson, 2009; Furber, 2010). While Framework Analysis can be used for theory generation, it is specifically suited to description, evaluation and interpretation of specific questions. According to Shrivastava and Thomson (2009), Framework Analysis:

> can be said to be quite similar to grounded theory; however, framework analysis differs in that it is better adapted to research that has specific questions, a limited time frame, a pre-designed sample (e.g. professional participants) and a priori issues (e.g. organizational and integration issues) that need to be dealt with. (p. 73)

The five stages of data analysis are described below.

Familiarization

In order to become familiar with the data the researcher undertook the transcription from the audio recordings. This allowed additional time to immerse in the data which aided in beginning the process of abstraction and conceptualisation with regard to data transformation.

Identifying a Thematic Framework

The literature review lead to *a priori* issues being identified and an initial code list was developed. As the data collection and familiarisation were taking place, emergent issues were adopted into the code list. Similarly, codes split or merged as higher level themes began to be interpreted, resulting in a mix of both a deductive and inductive approach to the data analysis. The researcher’s supervisory team were given transcripts of each focus group and prior to any discussion with the researcher, independently noted the themes they felt were present in the data. Reading and re-reading the transcripts alongside the developing thematic framework allowed a process of constant comparison and refining until a master template was finalised. Although the majority of themes were identified (and subsequently coded) at a semantic or descriptive level, the inductive process of refining the initial framework led to identification of certain themes at a latent level, as interpretation of concepts beyond what was articulated by participants took place.

Indexing

The process of indexing involved applying the codes from the thematic framework to the transcripts. Despite only working with ten transcripts, qualitative coding has a propensity to become unwieldy and a decision was made to use a qualitative data analysis computer programme. NVivo was utilised to aid both with the indexing process and the subsequent steps of charting and synthesising the data. For the initial process of indexing the transcripts, codes were applied at the level of the data item meaning that if a theme appeared anywhere in the transcript it was coded. Codes were not mutually exclusive and a section of transcript could be coded multiple times to reflect different themes. The unit of analysis to be coded was not constricted to a number of words, lines or sentences but rather segmentations of meaningful parts at the researcher's discretion. In this way both 'broad-brush' coding and fine-grained coding could be used enhancing the researcher's ability to discriminate, a technique useful in enhancing analytical rigor (Kidd & Parshall, 2000). Finally, memos in the form of short descriptive statements were assigned to the indexed data in preparation for charting.

Charting

Indexed data was ‘lifted’ from its original context within the data corpus by organising the associated memos into a tabular format whereby codes were arranged to allow comparison within and across both the pilot and engineer groups. Charting the data in this manner assisted the search for patterns across and within the data which in turn lead to further refinement of specific codes. By way of interpreting similarities and differences, the process of charting also facilitated the progression from data organisation and the early stages of analysis to the final, high level thematic conceptualisation.

Mapping and Interpretation

Once the core themes had been identified the process of mapping and interpretation began. This procedure involves considering the themes which have emerged from the data in relation to the overarching research objective so that any relationships and associations between the themes can be identified or ‘interpreted’. The search for patterns within the data, along with consideration of the salience and weight of each theme allows for the study findings to take shape in a structured and interpretive form as opposed to merely a list of the themes themselves.

4.4.2 Analysis of Assigned Characteristics and Traits

A separate analysis was conducted on a sub-set of the focus group data, that being the words participants had felt best described the attributes of each of the professions. At the beginning of the focus group session, participants were asked to write down words that came to mind when they thought of their own group (i.e. pilots or engineers) and also words that came to mind when they thought of the other group (i.e. pilots of engineers, engineers of pilots). The participants were briefed that there were no right or wrong answers and that the terms 'characteristic' and 'trait' could be thought of interchangeably. Words that had been written down during this exercise, as well as additional words that were used by participants to describe either of the groups during the discussion itself were collated into four lists:

i) *Words pilots used to describe pilots*

ii) *Words pilots used to describe engineers*

iii) *Words engineers used to describe engineers*

iv) *Words engineers used to describe pilots*

Each list was reviewed with duplicate words being counted then removed. Further refinement was made within lists by combining words considered as synonymous. The researcher then rated each word on a semantic differential scale using the polar adjective pairing 'positive-negative' to measure value dimension (Figure 4.1).

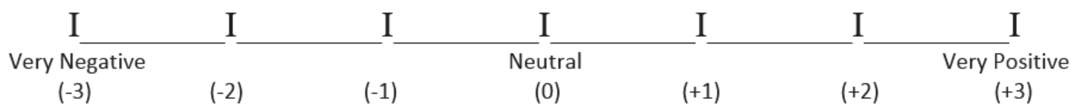


Figure 4.1 Semantic differential scale used to rate attributes of pilots and engineers

Given the subjective nature of the data, lists (i) and (iv) were combined and lists (ii) and (iii) were combined and two individuals not associated with the study were asked to rate the words on one of the lists using the same semantic differential scale. The combined list of (i) and (iv) i.e. words used to describe pilots, was rated by an individual whose occupation is that of an airline pilot and the combined list of (iii) and (iv) i.e. words used to describe engineers, was rated by an individual whose occupation is that of an aircraft maintenance engineer. Each individual was informed that the list they were given contained words which had been used to describe the attributes of people working in their profession. Despite knowing that the list of words had been generated by pilots and engineers, to eliminate bias the source of each description was not revealed.

Reliability between the researcher and the secondary rater's scores on the semantic differential scale was compared. For the purposes of testing inter-rater reliability, *exact agreement* was recorded when the researcher and the secondary rater gave the same rating for an individual attribute (e.g. -2 and -2). If the researcher and secondary rater both deemed an attribute to be either 'positive' or 'negative' but did not assign the same rating (e.g. +1 and +2, or -1 and -3), this was deemed to be *general agreement.* The term *partial agreement* was used when an attribute was deemed to be 'neutral' by one rater and either 'slightly positive' or 'slightly negative' by the other (e.g. 0 and +1, or 0 and -1). *Disagreement* was recorded whenever the researcher and secondary rater assigned an attribute to different sides of the scale (e.g. +2 and -1, or +1 and -1) or whenever a score of 'neutral' was given by one rater together with a score of 'positive' or 'very positive' or 'negative' or 'very negative' from the other rater (e.g. 0 and -2, or 0 and +3). The levels of agreement[39] achieved between the researcher and secondary raters are reported in Tables 4.2 through to 4.5, below.

[39] On the occasions where disagreement was noted, this was discussed with the secondary rater. However, due to the fact that the researcher was present when the participants were explaining their descriptions of each profession in the focus group sessions (and therefore was more cognisant of the context), the disagreements were recorded (as above) and the researcher's ratings were used when reporting the results.

Table 4.2 *Agreement between researcher and rater for 'pilots describing pilots'*

	Attributes (n)
Exact agreement	36
General agreement (both rated ≤ -1 or ≥ +1)	28
Partial agreement (a rating of 0 and a rating of either +1 or -1)	2
Disagreement (a rating of ≤ -1 and ≥ +1) or (a rating of 0 and ≤ -2 or ≥ +2)	8
Total	**74**

Inter-rater reliability was calculated for positive, neutral and negative rating scores. Percentage agreement was 86% and Cohen's Kappa was κ = .61

Table 4.3 *Agreement between researcher and rater for 'engineers describing engineers'*

	Attributes (n)
Exact agreement	40
General agreement (both rated ≤ -1 or ≥ +1)	16
Partial agreement (a rating of 0 and a rating of either +1 or -1)	2
Disagreement (a rating of ≤ -1 and ≥ +1) or (a rating of 0 and ≤ -2 or ≥ +2)	10
Total	**68**

Inter-rater reliability was calculated for positive, neutral and negative rating scores. Percentage agreement was 82% and Cohen's Kappa was κ = .65

Table 4.4 *Agreement between researcher and rater for 'pilots describing engineers'*

	Attributes (n)
Exact agreement	38
General agreement (both rated ≤ -1 or ≥ +1)	20
Partial agreement (a rating of 0 and a rating of either +1 or -1)	6
Disagreement (a rating of ≤ -1 and ≥ +1) or (a rating of 0 and ≤ -2 or ≥ +2)	7
Total	**71**

Inter-rater reliability was calculated for positive, neutral and negative rating scores. Percentage agreement was 82% and Cohen's Kappa was κ = .70

Table 4.5 *Agreement between researcher and rater for 'engineers describing pilots'*

	Words
Exact agreement	30
General agreement (both rated ≤ -1 or ≥ +1)	32
Partial agreement (a rating of 0 and a rating of either +1 or -1)	1
Disagreement (a rating of ≤ -1 and ≥ +1) or (a rating of 0 and ≤ -2 or ≥ +2)	6
Total	**69**

Inter-rater reliability was calculated for positive, neutral and negative rating scores. Percentage agreement was 88% and Cohen's Kappa was κ = .78.

4.5 Results

The outcomes from the focus group sessions are reported in two sections. The first section presents a quantitative analysis of the qualities assigned to pilots and engineers by the participants when describing in-group and out-group attributes. The second section summarises the participant feedback from the focus group discussions; this is organised according to the ten themes which were identified as being central to addressing the research questions.

4.5.1 In-Group and Out-Group Attributes

Across the ten focus group sessions, a total of 484 words were used by participants to describe the attributes of pilots and engineers. Following removal of duplicates and the refinement of words considered synonymous, a total of 282 words describing engineers and pilots remained for analysis. These attributes were then rated by both the researcher and the secondary raters as outlined in Section 4.4.2. Table 4.6 depicts the total number of attributes assigned to pilots and engineers by each group with the figures in brackets indicating the number of attributes which were subsequently rated for analysis following the removal of duplicates and refinement of words.

Table 4.6 *Number of attributes assigned by each group*

	Describing Pilots	Describing Engineers	TOTAL
Pilots	117 (74)	129 (71)	246 (145)
Engineers	124 (69)	114 (68)	238 (137)
TOTAL	241 (143)	243 (139)	484 (282)

4.5.1.1 Descriptions of the In-Group

Pilots describing pilots

The full list of words pilots used to describe themselves together with the ratings which were given on the semantic differential scale can be found in Appendix C. Table 4.7 shows the distribution of attributes used by pilots when describing themselves according to whether they were considered to be positive or negative traits.

Table 4.7 *Nature of attributes used by pilots when describing themselves*

	'Very Negative'	***'Negative'***	***'Somewhat Negative'***	***'Neutral'***	***'Somewhat Positive'***	***'Positive'***	***'Very Positive'***	
n	1	2	6	4	8	44	52	***Total 117***
%	0.9	1.7	5.1	3.4	6.8	37.6	44.4	

When describing themselves, the words most frequently used by pilots were *'professional'* (n = 8), *'SOP-driven / procedural'* (n = 5), '*Trustworthy / Reliable'* (n = 4), '*Conservative'* (n = 4) and '*Structured' /* '*Ordered'* (n = 4).

Engineers describing engineers

The full list of words engineers used to describe themselves together with the ratings which were given on the sematic differential scale can be found in Appendix D. Table 4.8 shows the distribution of attributes used by engineers when describing themselves according to whether they were considered to be positive or negative traits.

Table 4.8 *Nature of attributes used by engineers when describing themselves*

	'Very Negative'	*'Negative'*	*'Somewhat Negative'*	*'Neutral'*	*'Somewhat Positive'*	*'Positive'*	*'Very Positive'*	
n	5	4	6	9	10	26	54	***Total 114***
%	4.4	3.5	5.3	7.9	8.8	22.8	47.4	

When describing themselves, the words most frequently used by engineers were *'professional'* (*n* = 9), *'Humorous* (*n* = 5), *'Honest / Ethical'* (*n* = 4), '*Methodical / Systematic'* (*n* = 4) and '*Pedantic / Look for faults in everything'* (*n* = 4).

4.5.1.2 Descriptions of the Out-Group

Pilots describing engineers

The full list of words pilots used to describe engineers together with the ratings on the sematic differential scale can be found in Appendix E. Table 4.9 shows the distribution of attributes used by pilots when describing themselves according to whether they were considered to be positive or negative traits.

Table 4.9 *Nature of attributes used by pilots when describing engineers*

	'Very Negative'	*'Negative'*	*'Somewhat Negative'*	*'Neutral'*	*'Somewhat Positive'*	*'Positive'*	*'Very Positive'*	
n	15	10	14	9	3	12	66	***Total 129***
%	11.6	7.8	10.9	7.0	2.3	9.3	51.2	

When describing engineers, the words most frequently used by pilots were *'Knowledgeable / Intelligent'* (*n* = 7), *'Technically minded'* (*n* = 6), *'Structured / Logical'* (*n* = 5), *'Hardworking / Dedicated'* (*n* = 5), *'Manual driven / Procedural'* (*n* = 5), *'Practical / Common sense'* (*n* = 5) and *'Professional'* (*n* = 5).

A comparison between how pilots described themselves (the in-group) and how they described engineers (the out-group) can be seen in Figure 4.2. Overall, pilots described their own profession favourably with 88.9% of the total attributes used being rated as either 'somewhat positive', 'positive' or 'very positive' and only 7.7% of the total attributes deemed as either 'somewhat negative', 'negative' or 'very negative'. Comparatively, the pilots described engineers less favourably than themselves using positive traits ('somewhat positive', 'positive' or 'very positive') 62.7% of the time and negative traits ('somewhat negative', 'negative' and very negative') 30.2% of the time.

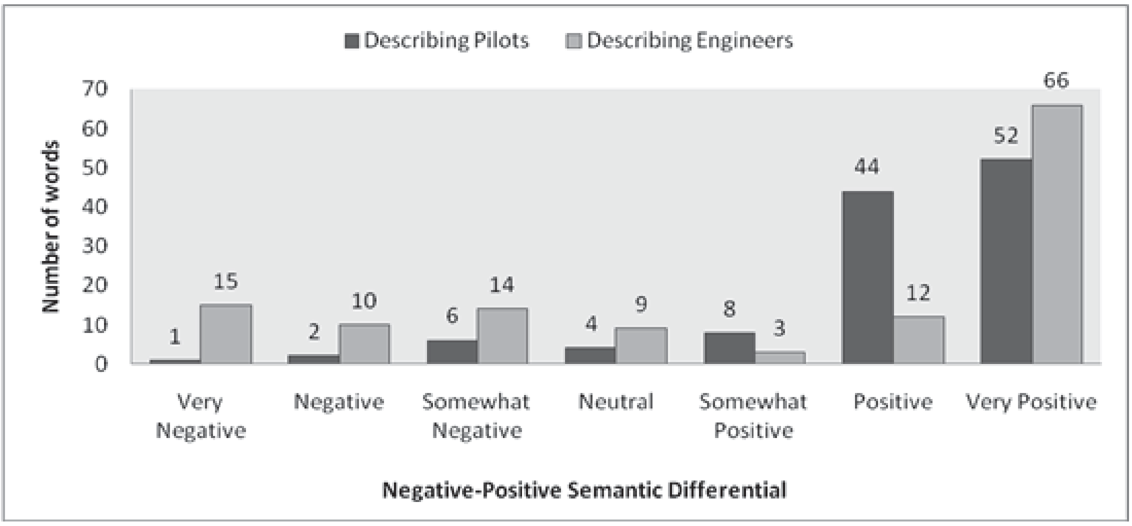


Figure 4.2 Comparison of pilots describing the in-group (pilots) and out-group (engineers)

Engineers describing pilots

The list of words engineers used to describe pilots together with the ratings on the sematic differential scale can be found in Appendix F. Table 4.10 shows the distribution of attributes used by pilots when describing themselves according to whether they were considered to be positive or negative traits.

Table 4.10 *Nature of attributes used by engineers when describing pilots*

	'Very Negative'	***'Negative'***	***'Somewhat Negative'***	***'Neutral'***	***'Somewhat Positive'***	***'Positive'***	***'Very Positive'***	
n	40	18	13	2	10	15	26	***Total 124***
%	32.3	14.5	10.5	1.6	8.1	12.1	21.0	

When describing pilots, the words most frequently used by engineers were *'professional'* (*n* = 9), *'Arrogant'* (*n* = 6), *'Egotistical'* (*n* = 4), *'Methodical'* (*n* = 4) and *'Intelligent / Knowledgeable'* (*n* = 4) and *'Do stuff by the book as opposed to understanding it'* (*n* = 4).

A comparison between how engineers described themselves (the in-group) and how they described pilots (the out-group) can be seen in Figure 4.3. Overall, engineers described their own profession favourably with 78.9 % of the total attributes used being rated as either 'somewhat positive', 'positive' or 'very positive' and 13.2% of the total attributes used being rated as either 'somewhat negative', 'negative' or 'very negative'. Comparatively, the engineers described pilots considerably less favourably than themselves, with less than half (41.1%) of the total attributes deemed positive ('somewhat positive', 'positive' or 'very positive') and over half (57.2%) of the total attributes deemed negative ('somewhat negative', 'negative' and very negative').

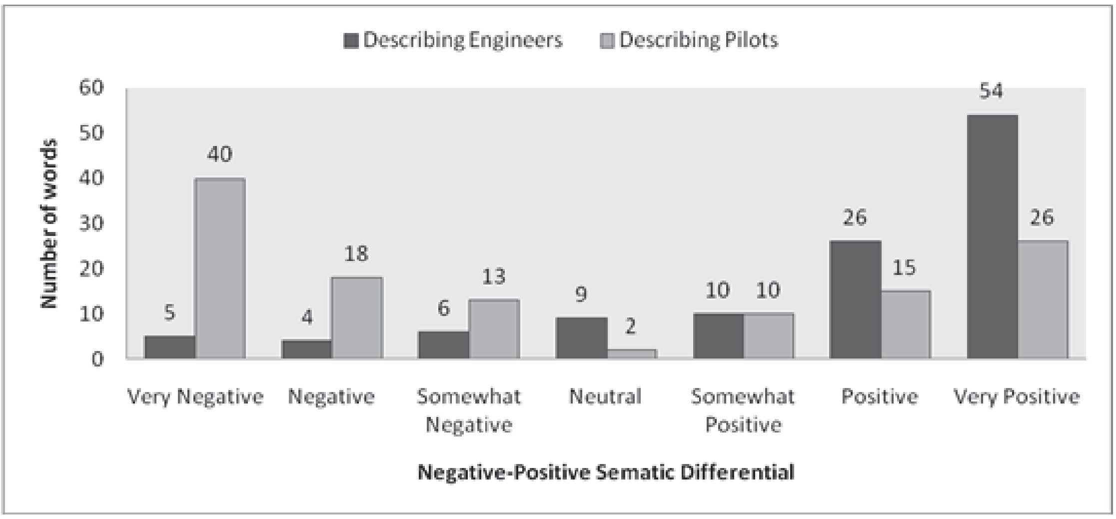


Figure 4.3 Comparison of engineers describing in-group (engineers) and out-group (pilots)

4.5.2 Thematic Analysis of the Focus Group Discussions

The thematic analysis of the focus group transcripts identified two distinct areas of interest. The first concerned those issues directly pertaining to the communication processes between the two groups while the second involved issues influencing the intergroup relationship between pilots and engineers; the results of each are considered separately. This section of the results is descriptive; it endeavours to present a candid reflection of the issues which were established as being the most central to the pilot and engineering groups who were interviewed. Consistent with qualitative data analysis, the voices of the participants are employed extensively in order to facilitate an insight into their reality. Numerous extracts from the focus groups are provided in such a way so as to explore the breadth of each theme whilst providing a narrative in which to illustrate the significance of the themes for each of the professional groups. The separation of the descriptive and interpretive phase of qualitative analysis is important (Patton, 2002) and consequently the views of the researcher are reserved for the analytical interpretation presented in 4.6 Discussion.

4.5.2.1 Communication Issues between Airline Pilots and Line Maintenance Engineers

Discussion relating to communication between pilots and engineers covered an extensive range of issues. However, in the interests of generalisability of the research those aspects peculiar to the research setting itself (such as organisation-specific communication processes and procedures), were not included in the thematic analysis. Instead focus was confined to general issues pertaining to language, communication skill and communication media.

Both pilots and engineers spoke of each profession having its own specialised terminology, the use of which occasionally presents difficulties. Engineers reported problems comprehending pilots when they used vocabulary engineers were not familiar with:

> *"They have a tendency to use jargon, too much jargon and abbreviations, which is fine for the world they live in, they use them every day. But it does make it difficult; you have to decipher what is going on"* [Engineer]

Pilots acknowledged that the way in which they described things, particularly in the logbook, might cause confusion for engineers: *"my write ups may not be as clear as they need to be; an annunciator light, you know, is it a light or is it actually an indicator?"* [Pilot]. Pilots in particular viewed the variations in terminology as significant, extending the notion of each profession actually having their own 'language':

> *"Pilots understand pilot's language...one of the most valuable things for me is to read back [in the logbook] maybe two or three days to read what other pilots have written...and it will make sense to me because that's the way I would have*

> *written it myself. But that's not to say an engineer is going to understand it as well"* [Pilot]

> *"Engineers have got a language to themselves in a sense which, for someone who is not technically orientated, it's very closed"* [Pilot]

Whilst one engineer maintained that they generally *"understand the gist of what pilots are talking about",* the following narrative provided by a participant illustrates the potential implications when the professions utilise different terminology. Here a pilot relates an event he had involvement with whereby the way in which some flight crew were recording engine anomalies in the logbook caused problems for the engineering group:

> *"You get differential acceleration between the two engines – new engine and old engine basically – it's certainly not uncommon on the fleet for one to spool a bit slower than the other and you've got to be very careful. The pilot speak is 'oh, that number one engine is slow to spool', but actually it's within limits and what there is is a differential between the two accelerations. So pilots will call one 'slow to spool' and engineering will then have to go out and do ground runs to see if it's within limits but in actual fact, that's not what the pilot meant. He meant that there was a differential between the two engines"* [Pilot]

A common feature across all of the pilot focus groups and indeed a number of the engineering groups too, was lament for the loss of the flight engineer, a crew position which no longer exists in the modern aircraft types operated by the organisation. Pilots who had experienced working with a flight engineer spoke positively about having a crew member who was able to act as a go-between:

> Pilot 1: *I think it's gone downhill since we got rid of flight engineers. I think we should bring them back!*

> *(laughter)*
>
> Pilot 2: *Absolutely*
>
> Moderator: *I guess that would have been a good intermediate sort of liaison?*
>
> Pilot 1: *Yeah, 'cause you had the pilot there, the flight engineer there, and then the engineer would come in the door so that was like a point of contact...and most of the flight engineers were ex-engineers anyway*
>
> Moderator: *So they could speak the same lingo?*
>
> Pilot 1: *Yeah and they had a place on the flight deck so they had the sort of operational responsibility as well*
>
> Pilot 3: *And the flight engineer could break it down into baby speak for the pilots*
>
> Pilot 2: *Yeah*
>
> Pilot 3: *Can we go or can't we?*
>
> *(laughter)*

Positive comments were also made by pilots about individuals who had previously worked as flight engineers and were now working in line maintenance positions:

> *"The good dealings I've had have been with ex-flight engineers who have sat in a flight deck environment, have operated in a flight deck environment and they actually speak your language...they think your language"* [Pilot]

As well as experiencing difficulty with terminology, both pilots and engineers raised concerns about the other profession's ability to communicate in an effective and cooperative manner. Pilots were critical that the maintenance group had poor communication skills:

> *"I don't always feel that the engineers are great communicators...I don't know what training they have in human factors, but we're encouraged to communicate effectively and I don't know whether that always comes across*

> *with the engineers but I certainly feel as though the communication I get from them is quite lacking at times"* [Pilot]

Engineers also felt that pilots did not communicate effectively with them, complaining that messages were often *"lost in the translation"* and that: *"the information that you get sends you down the wrong track half the time"* [Engineer]. Further comments included:

> *"You never get the full story, you know, like they might radio in and they never...somehow the story gets lost in the translation. It's not until you actually go and look at the defect or the problem that you actually get a proper handle on it"* [Engineer]

> *"Some people tell you what they think you want to be hearing rather than what they're actually seeing...getting over that hurdle sometimes is a bit of a problem"* [Engineer]

With regard to having to interact with each other in order to communicate, there was evidence that both groups may, on occasion, be discouraged from doing so due to the perceived reception from the other party. One engineer spoke of feeling confronted on the flight deck when attempting to communicate with the captain due to the presence of other flight crew:

> *"When we go to the flight deck we're always outnumbered because there's always only one of us and there's two of them -or three or four I guess - and so when a discussion gets going, they're all chipping in. Normally you try just to speak to the captain, he's the man but the others are all trying to impress him so they're all throwing things at you as well and you're trying to say...we're always kind of on the back foot a wee bit"* [Engineer]

Below, another engineer expresses concern regarding messages conveyed by the body language of some pilots, while a pilot describes a feeling of being deterred from questioning maintenance staff due to his lack of technical knowledge:

> *"We do get some pilots who do have that edge of saying, you know, I'm going to put my nose in the air and that's literally how they come across when they're talking to you. They're not physically doing it but they're saying it with their words and their body language is very strong sometimes, 'I'm the pilot here', you know, that sort of thing and there is that arrogance which is there...but you're always going to get the 'them and us' thing aren't you? It's not going to change"* [Engineer]

> *"I might have a really silly question for the engineer and the engineer will deal to me as though I asked a really stupid question. We encourage the flight attendants, no matter how silly a question to come up [and ask us] and I think most crew treat the flight attendants, no matter how stupid the question, that it is positive information and should be encouraged. There isn't that connection with the engineers and us..."* [Pilot]

For their part, the majority of engineers agreed that communication was not a particular strength of their profession. Many admitted to experiencing difficulties when they interacted with pilots who they acknowledged as having superior communication skills. As one engineer attested, *"some do flounder"*. The maintenance groups were, however, very mindful of the fact that their role in line maintenance was reliant on their ability to communicate with flight crew:

> *"I think a lot comes down to the...it is pure communication really. It's how good you are at communication a lot of it really*" [Engineer]

> *"Some engineers aren't the best communicators either. They're a systematic thinker, they know what it is in their head but to verbalise it to a pilot who generally are quite good communicators – they like talking – so they might not get the gist of where the engineer is coming from and then that will create an issue. Some of the guys are fantastic but you do just see other guys struggle a bit to get the point across and then the pilot will think 'oh, hang on…'"* [Engineer]
>
> *"…when things are starting to get a wee bit curly, like curly MELs…[it's the way] you carry yourself and the way you present yourself to them…if they feel that something is not quite right they will just keep on picking and picking and picking and picking until they destroy you…the guys do know what they're talking about…I mean, technically one of the guys was excellent but he could not communicate that to the crew for love or money"* [Engineer]

With regard to methods of communication, all focus group participants were asked which medium they preferred when communicating with each other. While pilots acknowledged that devices such as Satphone made life easier for them: *"that's a huge step forward because you're talking directly to the guy"* [pilot], the preferred method of communicating with engineers was face-to-face: *"face-to-face; it's always better isn't it, in all things"* [Pilot]. Despite this preference, however, face-to-face communication is not always an option:

> *"You may not necessarily be face to face so that always creates problems. If you're talking to MOC it's always on the radio or Satphone or telephone and that creates issues with the transfer of information I guess"* [Pilot]
>
> *"When you're communicating with them it tends to be one way, on the phone and trying to explain what the problem is because the engineer doesn't happen to be nearby so you're not getting a kind of feel for what their body language is,*

> *it's just one way. Not having them there in front of us – I'd say that's one of the biggest barriers"* [Pilot]

Pilots acknowledged the difficulties associated with written communication: *"it's actually sometimes quite hard to put all the detail you want to put in there"* [Pilot]. The maintenance groups concurred with this issue: *"well there's only so much you can put on a piece of paper"* [Engineer].

> Engineer 1: *Often with the flight crew you can only get so much in writing, you can have a conversation on it and discuss it, especially noises, smells, vibrations, those sorts of things are very hard describe*
> Engineer 3: *They are, that's right*
> Engineer 1: *The interpretation of one English word can throw you off track completely you know?*
> Engineer 3: *Yes, quite right*

However, the fact that written communication is a necessary requirement within aviation was acknowledged by both an engineer: *"this is an industry that records everything so it has to go on paper"* [Engineer] and a pilot: *"the very last resort – which is the method we always use – is paper"* [Pilot].

Talk regarding the aircraft logbook was predominately negative with both groups expressing dissatisfaction on how the other group used the document and, more specifically, how that use caused difficulties for their own group. Whilst poor handwriting was a complaint shared by both pilots and engineers: *"the writing is illegible, it doesn't make sense"* [Pilot], *"their handwriting can be pretty tragic"* [Engineer], the main grievance from pilots was that they found it hard to follow the progress of defects through the logbook. This was due to either difficulty with the technical language the engineers used; *"engineers are by definition technically minded and they write in tech speak"* [Pilot], or the fact that engineers make reference to procedures that pilots do not have access to: *"they reference numbers and we don't have access to that information so you do put a lot of faith in the [engineering] system working as it should"* [Pilot]. Other pilots agreed with these thoughts:

> *"You can't read it. If you can read it, it doesn't necessarily make a logical progression through the write-up of what has happened, so you're left...um...none the wiser or clearer and then you're forced to have to seek clarification*" [Pilot]

> Pilot 1: "*Some of those follow-on logs that are written by engineers mean nothing because of the way they are written. They don't paint a picture for a pilot...but then perhaps it's not supposed to"*
> Pilot 2: *"If they've cleared a log then that's not usually a big issue but if there's still something wrong with it then that's often when it's not clear – what the original problem was or what they have or have not done about it or still have to do"*
> Moderator: *"So you can't see that from reading the log?"*
> Pilot 1: *"It's not always that clear"*
> Pilot 2: *"No, especially if it's been deferred 'nil time this overnight', 'nil time this overnight'. If it's one of those ones that they can defer, defer, defer...I mean, it's in the log there, we may as well not read it cause it's in a language that's for engineers not us and equally, I mean probably it's for the engineers but it's good information for us to know, if there's an ongoing issue what work has been done."*

Pilots did, however, admit that their own logbook write-ups could cause problems for maintenance engineers: *"one of the engineers' biggest beefs is that the pilots don't give them enough information in the maintenance logs"* [Pilot], *"I read things where both pilots and engineers have written things where it can be read a number of ways, you know, very ambiguous"* [Pilot]. Pilots spoke of two consequences when they had difficulties understanding the logbook, those being the choice of either causing a delay to seek clarification, or else choosing to depart without having a full appreciation or understanding of the aircraft's defect history:

> *"It's very hard to decipher exactly and you spend quite a bit of time, particularly if there's a lot of items, trying to decipher what it is up to, and including, getting an engineer to come and explain it and often they can't read it or don't know and they have to ring MOC. It's all time wasting when, in terms of getting the job done, when they're already under pressure and you need to get them to explain it and they can't do it so it's got to go off to MOC and they've got to research it on a computer and find out what's going on and then everyone's backs are against the wall for the on-time pressure again..."* [Pilot]

> *"...or you gloss over it, you know, like a lot of it....some fastener or something that's clearly been deferred. You tend to gloss, you know, because domestically, if you tried to understand everything in our log you'd be taking an hour to turn an airplane around. You still have to achieve that in half an hour. Again, it's OTP I know, but to walk on to an airplane and be airborne in half an hour, you cannot fully understand a defect. I just go 'scratched', 'scratched', 'deferred'...if it doesn't say something that I can have any interaction with – if I read 'stabilizer' I'm reading it because I'm interested but if it's 'toilet' or, you know, a crack..."* [Pilot]

Like pilots, engineers had no positive comments about the way in which the other group used the logbook. While there were criticisms of the language that pilots used: *"at least if you've spoken to them you've got a better idea of what they're talking about rather than having to work out their poorly written abbreviation means"* [Engineer], the primary complaint from engineers was the level of detail which was written. Engineers expressed disapproval when pilots did not put enough information in the logbook when they wrote up a defect:

> *"You don't get the full story, you might get a very basic description of the defect and then they assume that you know all the contributing factors when clearly, unless you're involved, you can't know all the contributing factors"* [Engineer]
>
> *"You cannot give us too much information, we need as much as we possibly can and some crew are good and others are just very, very vague. They don't give you the phase of flight, the speed, the engine power setting, all the basic stuff that you need to troubleshoot it"* [Engineer]

The implications for engineers of not having enough information given to them by the pilots are threefold. Firstly, a poorly written logbook entry could lead to extended troubleshooting:

> Engineer: *"Last week a pilot wrote in a particular aircraft that one of the engines was slow to spool. Pretty much the write-up was 'engine slow to spool, especially in reverse' and that's the end of the log write-up. We had no indication of what sort of timeframe he was talking about or, you know, which regimes..."*
> Moderator: *"A lack of detail there?"*
> Engineer: *"Totally a lack of detail which meant, okay, we have no option then as engineering but to pull the airplane out of service, go and do engine runs, you know? We had to gas the airplane, take it down to the end, do engine runs.*

It seriously takes three to four hours to do that and that was the second to last flight of the day so it just threw the schedule into chaos...just the impact of that person, making an almost flippant logbook entry, on the Business was massive. They need to know the ramifications of what they're writing and, not discounting the fact that if they do feel something is wrong they should write about it..."
Moderator: *"But not to be vague?"*
Engineer: *"Not to be vague, you know, detail is important"*

Secondly, a poorly written logbook entry could require that the engineer locates the pilot to get additional information from them:

Engineer 1: *"we can go to Ops Control or to Crew Control and say we need to get hold of the pilot and they'll normally get hold of somebody and then transfer the call through, usually we manage to get hold of them, don't we?"*
Engineer 2: *"yeah, but then you can end up with issues, like I had an issue last week where I was trying to contact a pilot and I'm pretty sure he was screening his calls..."*
Engineer 3: *"I generally get Crew Control to call them because it will pop up with that and they probably think 'oh, allowances, I'll answer it'...and it's Engineering and we've got a problem!"*
(laughter)

Thirdly, a lack of information could result in the engineer not being able to resolve the defect and having to raise a follow-on log to seek further information from the next crew flying the aircraft:

> *"You go by what's written on the log in front of you or you have to ask for another log requesting more information from the next crew to give you the specific details to enable you to....but that's not ideal"* [Engineer]

In addition to expressing a desire for more information that was relevant, engineers also commented that they preferred it when pilots did not write too much in the logbook that was not relevant to the problem being discussed:

> *"You can get some captains who'll write up an EGT shift and they'll give you the altitude they were at, the engine parameters...how many people, what he had for breakfast – everything will be in the log!"* [Engineer].

> *"They'll write how high they were flying when the engine problem happened and I mean, who cares? The engine is the engine, you know what I mean, and sometimes they get mixed up in pilot mumbo-jumbo like 'we were on our way from [location] to [location] at seventeen thousand feet, well who cares? Let's concentrate on the actual issue and sometimes I don't think they do, do they?"* [Engineer]

> *"...the information that they do fill the log page with when they do, a lot of it is they're just putting down the factors they know in there which is what they're doing to help but a lot of them are not related to what you're doing....if there is a fault with our crews it's often that they'll start their log write-ups with you know, 'what I did in the holidays'..."* [Engineer]

The following exchange illustrates the difficulties pilots face with regard to providing the level of detail that engineers require and the potential implications for the engineering group when pilots write more than perhaps they should:

Engineer 1: *"A lot of the times they don't put enough information. Not only is it hard to decipher but say if an occurrence has happened, then they just put down one line and say, I don't know 'vibration felt' or...and that's it"*

Engineer 2: *"Not specific enough"*

Engineer 1: *"They're not specific enough, yeah. Because obviously we get to the aircraft, we may not even get to see the crew and all you've got is one sentence to work out what's going on with the whole airplane"*

Engineer 3: *"It's a fine line though isn't it..."*

Engineer 1: *"Yeah"*

Engineer 3: *"Between writing too much and not enough because sometimes they write too much and back you into a corner with what you have to do…like for example, a pilot report on the walk around check 'corrosion seen bulging from under a panel on the wing'. Well for a start, on a walk around check, how can you tell it's corrosion? And as soon as you mention the word corrosion we've got to go through a whole procedure to get it back serviceable so..."*

Engineer 1: *"And if it's under a panel you've got to take the panel off"*

Engineer 3: *"Yeah, you've got to take the panel off and on closer inspection it wasn't corrosion at all, just a bit of flaky paint"*

Moderator: *"Right"*

Engineer 3: *"But we're backed into a corner because he's mentioned corrosion"*

4.5.2.2 Intergroup Relationship between Engineers and Pilots

When considering the intergroup relationship between pilots and engineers, eight themes were identified as being significant in terms of influencing the way in which the two professions regard each other. The themes are distinct yet very much interrelated, a concept which will be developed in the analytical summary to follow. They are:

- ‘Appreciation of Self,
- ‘Perception of Other’,
- ‘Perceived Goals and Objectives’,
- Physical Separation’,
- ‘Trust’,
- ‘Aircraft Handover’,
- ‘On-Time Performance’, and
- ‘The Minimum Equipment List’.

‘Appreciation of Self’

“They never see us at work”

Across all focus groups, participants spoke frequently about a lack of appreciation from the out-group in relation to the demands of their job. The engineering groups raised a broad range of issues highlighting the implications of pilots not understanding their role. As noted under some of the other themes, engineers expressed frustration about the way in which pilots wrote logbook entries: *“They need to understand the ramifications of what they’re writing”* [Engineer] and communication over the MEL: *“we’re not always privy to everything in their world”* [Engineer]. Further examples provided by engineers conveyed a degree of irritation in the way in which pilots seemingly did not consider the repercussions of their actions:

> Engineer 1: *If the aircraft was departing at, say, 8am, you’d be at the aircraft at ten to eight, just enough time to put the tug on, do a little walk around and then be ready to go because you’re working for an 8 o’clock departure. And at five to eight the aerobridge has come off and they flick the beacon on and, you know, they’ve got the beacon on so traffic can’t pass behind. By rule we can’t walk behind the aircraft with it on and it just delays our process more. Then they get frustrated because you’re not ready to go, well I’m not ready because I’m working for 8am not 7:55 and then they get a bit tetchy at that*
> Engineer 2: *But you don’t get the ass with them when they’re ten minutes late and you’re waiting!*
> Engineer 1: *Exactly, ten, fifteen minutes and you’re just sitting there waiting. In situations like that I don’t think they really appreciate what we have to do. They’ve got their little screen and they see the door closed symbol and then they put their light on and it’s like, well I’ve got to go down there, check it’s closed, check for FOD, check there’s no damage and then come back up to the aircraft, up to the nose. I think times like that, that’s when you can hear the most resistance in their voice because you’re holding them up*

Engineers spoke of the implications for their group when pilots did not provide enough information regarding defects that required rectification. As noted in the two excerpts below, consequences might include an inability to adequately prepare for the task at hand or being left with a degree of uncertainty as to the exact nature of the defect:

> *"[if] you get a heads-up you can put the headset seal in your pocket when you go down there to save you driving back and forth, you can be prepared when you get to the aircraft can't you...it almost seems like saving face for them by not reporting some of it doesn't it? Like 'we've got an issue, we'll talk to you on the ground' – well what's your issue! That's quite a common radio call so you're left wondering but as an engineer you've got to prepare don't you. You like to know what some of the eventualities could be"* [Engineer]

> Engineer 1: *Typically we get 'it's the airplanes' fault' and that's almost across the board that one*
> Engineer 2: *Yeah, there's always something wrong with the airplane, even though when you start probing a bit...well, case-in-point this morning – a pilot rang up and claimed he had a weather radar fault and he told me what message he had and I thought about it for a moment and I said 'oh, do you have your inertials aligned?', 'yes, yes, yes, they're aligned', okay so I think a bit harder about this thing and where we're going to go from here and just while I was talking it through while I was looking up something 'oh, it's all come right now'. Just magically! And so I suspect the inertials weren't aligned*
> Moderator*: But he wouldn't have told you that?*
> Engineer 2: *No, but you never get that….*
> *(laughter)*
> Engineer 2: *….but once again, we're doing it remote, over the phone. I wasn't able to visually see what he is seeing. There was never the admittance 'oh, I got*

> *it wrong' from their end which makes our life hard because once again we're chasing a problem that is actually a ghost*
> Engineer 3: *We're not after a right and a wrong. We just need clarity of the information, of what happened*

With regard to job perceptions, a commonly held view of engineers was that pilots believed they were only looking after one particular aircraft at a time: *"[They think] all of us are there watching their flight, just their flight!"* [Engineer], and did not appreciate the realities of an engineer's workload:

> *"They've got no idea of the stress or the other issues you've had to deal with during the day and it sort of builds a picture as to why you are what you are I guess and the level of friendliness they get, but I don't think they'd understand that. I don't think they'd have a clear idea of what we do"* [Engineer]

> *"They just need to understand that we might not get back to them straight away because we might be up to here in something else. I've had that before, an ACARs will come in, I know it's there, I've read it and I'll get back to you in a moment, I've got some other stuff happening. And then five minutes later the phone rings and it's a Satphone call from them and you've got to answer it and I'm busy. I know some people will say 'oh, it only takes a minute to send back an ACARs but sometimes you haven't got that minute. I might look quickly and realise 'hey, they're a long-haul flight they've got seven more hours to run but right now I've got something AOG and I'm about to lose my crew in twenty minutes"* [Engineer]

Several engineers expressed a desire for pilots to take part in some maintenance work in order to gain an appreciation for what engineers do for a living: *"I think they should put overalls on once a week and go down to the hangar"* [Engineer].

> *"To improve communication, what I would like to see is maybe pilots come and sit with us for a time and do pushbacks and some routine maintenance and work nightshifts and just see what challenges we've got on the ground here and the weather we put up with and what we have to look at"* [Engineer]

The primary concern for the pilot groups was the fact that while they saw engineers busy working on the apron, engineers never saw pilots 'at work' as such. Pilots expressed frustration that as well as engineers not appreciating the full extent of their job, there is also a misperception amongst the engineering group about what a pilot's job actually entails:

> Pilot 1: *One of the major differences I think is that they never really see us at work. They see us on the flight deck before we depart...*
> Pilot 2: *That's true*
> Pilot 1: *...we see them at work. We see them under pressure, doing their job, working flat out trying to get airplanes turned around, trying to do all sorts of stuff, we see that all the time. They never see us at work. They see us on the ground, having just walked on...*
> Moderator: *Having a coffee*
> Pilot 1: *...hanging our hat up, you know, whatever, with a tray of sandwiches or something sometimes...*
> Pilot 3: *With a sandwich*
> Pilot 1: *...and they look at us and think...'poncers'! What a bunch of prima donnas! They never see us with crappy weather, minimum fuel, no alternate and the place has closed and all that"*

> *"It's like MOC, you know. They're sitting in a nice warm office with a cup of coffee, Sky sports on the TV and we're dodging cbs in the middle of the Pacific with some problems with the radar or some sort of thing like that, you know? So we're actively out there. They need to be sitting in the middle of some bad*

weather and all that sort of stuff to actually see what's going on sometimes" [Pilot]

One pilot had previously trained and worked as an engineer before becoming a pilot and shared the following thoughts on the lack of appreciation engineers have of what pilots actually do at work:

> *"I actually think the relationship between engineers and pilots is...they completely misunderstand each other! Watching all these prat-pilots wandering around, you know, bringing airplanes back and complaining about workload, complaining about 'where's my lunch' and I thought 'what a bunch of prats'. Having gone through pilot training and now on the other side of the fence, those engineers – generally speaking – their relationship is completely tarnished by a total lack of understanding of what it is to fly an airplane. And that's the nub of the issue – they have this picture in their mind and it's partly what the system does to them...they do not understand what the pilot is doing. I had it explained to me once when I was young, you won't learn the piano by sitting and watching the piano player; you've got to play it yourself. That's what these engineers are. They watch the pilots, they watch the piano player but they aren't actually doing it themselves, they've got no idea. They only see us delaying flights and arriving and complaining about broken airplanes….they've got no idea of what the pilot's done for the last ten, fifteen hours, whatever it's been. They just see the bit at the end"* [Pilot]

With regard to increasing the appreciation and understanding of each group's job, there was recognition that this needed to occur in order to improve relations and task efficiency:

> *"One of the barriers is a lack of knowledge of people's roles. We've got these two different worlds and…..we get that operational and engineering world*

> *crossing over and that's sometimes where things go astray. I think the lack of looking at it from someone else's perspective is certainly a barrier because if you understand that someone else has a role to play and they are as time pressed as you, you work with them to get the job done"* [Pilot]

Several pilots brought up the idea of engineers either taking part in simulator sessions or doing more flying in the jump seat in order to gain an appreciation of the workload for flight crew. One pilot had previously participated in such an initiative:

> "*...we put them in the sim, and we pretty much had non-normals the whole time we were in there and their appreciation of what we did changed remarkably - they'd never been put in a simulator and dealt with non-normals before and it works.*" [Pilot]

However, one pilot had a cautionary tale about how simulator sessions can actually increase misperceptions:

> *"The sim is all pre-loaded and they actually take it for a flight. They get airborne, they go out of [base location] to [base location] and land it and they do it all on the automatics and they come out of it going 'well is that all there is to it? We pay these guys x-amount of money and that's all there is to it? Confirms my thoughts that they're all a bunch of prats!"* [Pilot]

‘Perception of Other’

“I get the impression it’s a whole new world for engineers out there”

Participants spent a good deal, if not the majority of their time, expressing their thoughts and opinions about the out-group. As a result, ‘Perception of Other’ emerged as a central theme, and was analysed according to the views each group held of the other’s profession as well as what each group believed the other thought of them. Overall the pilot groups displayed a largely sympathetic view toward the engineers’ job: *“I get the impression it’s a whole new world for engineers out there”* [Pilot]. Pilots spoke of having a realistic understanding about the conditions in which engineers worked: *“they’re out there in the wet weather”* [Pilot], *“I see some extremely hard working and dedicated engineers that spend many, many hours of toil in some pretty average conditions”* [Pilot], and much of their discussion related to the demands being placed on engineers by the organisation. They frequently made observations such as: *“they’re under pressure all the time”*, *“they look stressed”*, and *“they’re just not happy campers”* when they discussed engineering resource and manpower:

> *“We understand that they’ve got other impediments to perhaps achieving what we would think should have been achieved last week. We don’t know their other stresses that they’re working under”* [Pilot]
>
> *“I have the perception that engineers don’t just sit around having coffee with their feet up. They’ve got three other aircraft so ‘alright, now I’ve got you done, I’ll get you out’ and they’re off to something else....so I think, you know, people have got to realise...”* [Pilot]

Pilots were also discerning when they spoke of the perceived differences in the way in which pilots and engineers were treated within the organisation. This included specific issues such as training, *“they do have human factors training but it’s so far last century – they’re still on* *the Dirty Dozen!"* as well as wider cultural concerns: *"they certainly know that we're in a better position in the way that we're treated inside the company"* [Pilot].

> *"I feel that we work in a relatively related and just culture. The impression I get from them and the way they behave, they work in a much more punitive environment than we do and they are more likely to get blamed for something and taken to task about it than we are. I get that feeling, that's the feeling I get."* [Pilot]
>
> *"[They are] subject to - in a lot of cases - a lot more critical or a much more harsh discipline system. When they do something that's out of line...I mean, you look at what happens to engineers when they're disciplined! Boy! They're not backward in coming forward to suspend their licences for three months"* [Pilot]

For the most part, engineers did not express such sympathetic views towards pilots. While there was an acknowledgement that perhaps the reason pilots were not good at defect reporting was not their fault: *"it's almost like there's no emphasis put on it from their training"* [Engineer], and that pilots too are subject to organisational pressure: *"they're being dealt to like everyone else. It's a different job what they're doing now to what it was ten, twenty years ago, they're doing a lot more hours"* [Engineer], supportive comments were infrequent. Although many would stipulate that their comments were *"a bit of a generalization"* or that *"not all pilots are like that"*, on balance much more time was spent portraying negative perceptions than positive: *"some are definitely not [respectful] in that you're the local grease-monkey"* [Engineer].

> Engineer 1: *"I find some of the 'won't admit any wrong-doing' thing very frustrating"*
> Moderator: *"Do you strike that a wee bit?"*
> Engineer 1: *"Quite often. A typical example, coming onto the gate too fast and then you've got to hook up a tug to shift the airplane back three feet because they've overshot the marks and the first thing they'll do is yell at you 'you need to get the airport company here and get the NIGS adjusted because the guidance system is all wrong' and then you politely try to explain to them 'well if you didn't come onto the gate so fast you would have stopped on the line and you're most likely the first person of the week that's got this wrong, and no one else has got this wrong' but they won't just say 'yeah, right, I was coming in too fast, I goofed that'"*
> Engineer 2: *"They are never wrong"*
> Engineer 1: *"Doesn't seem to be in their…"*
> Engineer 2: *"They can't be seen to be wrong in what they are doing and they don't admit it that they are wrong. Ever."*

Engineers often used jokes or sarcasm when speaking about pilots. This was particularly prominent when discussing their perceived wealth, with the cynical view that: *"they're underpaid for what they do"* [Engineer], *"they're prone to leaving their wallets on the flight deck so we can see it"* [Engineer], and also when speaking about what a pilot's job entailed. The following statements were made by engineers when talking about opportunities to travel in the flight deck:

> *"...you jump in there, you watch them flip their three switches and the plane goes off and you watch them put the park brake on at the other end"* [Engineer]

> Engineer 1: *"I've done plenty of miles in the cockpit, I'm sick of looking at it but some crews are almost obsessive that they want you there for the takeoff and landing. I just think they like to chew the fat a little bit and..."*

> Engineer 2: *"Talk about his shares..."*
> *(laughter)*
> Engineer 2: *"...farm down the country...milking machine problems..."*

With regard to how each profession perceived the other viewed them, the results across both sets of focus groups were insightful. Pilot participants thought that engineers' opinions of pilots were, in all cases, highly negative. Words such as *'overpaid'*, *'underworked'*, and *'demanding'* were used on numerous occasions, and the term *'prima-donnas'* was mentioned eight times throughout the course of the pilot focus groups. Other perceptions of what engineers thought of them included: *'dumb pilots, what do they know about aircraft'*, *'pilots are just a waste of time'*, with the degree of negativity emphasized with explicit language on occasion: *'f---ing pilots'*, *'bunch of f---ing prima-donna wankers'*. One pilot suggested that there may be: *"an element of envy"* toward their group and another offered the following explanation as to why he thought engineers did not like pilots:

> *"I'm sure there's a jealousy there too. Not a mean jealousy; the 'it's pouring with rain outside, I've been working on the aeroplane and here's this smart-arse, bloody pimply-faced so-and-so sitting in the warmth drinking his orange juice and chatting up the girls and I'm working my arse off here', you know, that sort of attitude. It's not just a jealousy of just 'I'd rather be sitting in that seat'...probably not flying the aeroplane, just a perception of it – and the pay!"* [Pilot]

While some engineers held optimistic views of what pilots thought of them: *"they appreciate our work"*, *"they respect us for what we do"*, *"they have a good opinion of us"*, others were more pragmatic: *"I'd like to think that it would be positive...certainly not all of it would be"*. However, the vast majority of engineers perceived that the opinions of pilots toward them were exceedingly negative with words such as: *"rude", "dirty", "lazy", "scum"* and *"trash"* being volunteered along with the remark that: *"they're a lot ruder about us than we are of them"*. Engineers also commented that pilots: *"think we know nothing"* and *"think we don't understand how difficult their job is"*.

> Engineer 1: *"I would say they say that we don't listen, we don't read what they've said. I'd say they'd say we're fairly arrogant in our approach a lot of the time, you know, you're not technical, we're not listening to you, you know, this is how it is…I'd think that, um, all those sorts of things would be in their summation"*
> Engineer 2: "*We don't understand how difficult their job is…"*
> Engineer 1: *"Yeah, we don't understand their job"*
> Engineer 2: *"…that would come up a lot*"

‘Perceived Goals and Objectives’

“by the way, I need two more duvets”

Talk regarding each profession’s goals and objectives was evaluated to determine whether pilots and engineers perceived their goals as superordinate or interdependent. Pilots unanimously held the belief that their goal is: *“to operate the aircraft safely”* [Pilot].

> *“The pilot never loses sight of the fact that safety is his number one concern and he’s got all these passengers’ lives at stake down the back”* [Pilot]

However, when pilots were queried as to whether engineers shared this goal with them, responses ranged from outright disagreement: *“they are coming from an OTP, minimum work, aircraft out on-time focus whereas we’re going for maximum safety focus”* [Pilot], *“there’s a lot of similarities in [our traits], but with a different goal or focus or objective”* [pilot], to the concession that whilst engineers also aspire to having a safe aircraft, they are motivated primarily by the regulatory requirements they must adhere to:

> Pilot: *“Their goal is to fix an aeroplane, our goal is to is to operate the airplane safely”*
> Moderator: *“So you’d say you’ve got different objectives or goals?”*
> Pilot: *“Absolutely, I mean their role is to fix an airplane or to get an airplane dispatched...it might not be fixed, but to get it dispatched. But hey, I’m not arguing that because that is their role.”*
>
> *“They should be common objectives but they come from different areas. I mean, they have to deliver a product that’s safe for flight and it’s our responsibility to make sure we’re happy with whatever we’re taking - what we’re accepting effectively- into the air and operational safety from that point on. I think the goals are common, they come from slightly different backgrounds I guess, but the end goal is safe transport operations...or it should be”* [Pilot]

> *"I guess they're reticent to put out an aircraft they think is bad...we hope"* [Pilot]

However, it was apparent from the way engineers spoke, that they also identified safety as a goal: *"ours is passenger safety at the end of the day, isn't it, safety of the aircraft"* [Engineer], *"we just want to get that aircraft away safe"* [Engineer]. In addition to aircraft safety, engineers also spoke frequently about On-Time Performance and a common objective amongst the group was dispatching the aircraft on time. When considering this particular goal, engineers were of the belief that, for the most part, pilots either did not share their concern: *"crews don't seem to be focused like us on OTP"* [Engineer], or at the very least, did not afford it the same level of importance as engineers:

> *"...we've got to keep in mind that the aircraft goes out on time. The pilots, they prefer to put safety first and it doesn't matter how long it takes. They want to make sure that everything is done properly. We're going to see that it's safe enough but we want to get the aircraft out...they seem to be much more for safety's sake and not too worried about the time"* [Engineer]

There was a sense among engineers that their efforts to achieve On-Time Performance were important for the company: *"I think we're absolutely focused on getting the airplane out for the company's benefit"* [Engineer], and were critical of pilots for not supporting this: "*I don't feel we have the same commitment from the pilot group"* [Engineer], some going so far as to suggest that the pilot group actively undermined this goal: "*I think a lot of those guys, they're more worried about their own personal wellbeing than the airline's"*. This view is clear in the following extract:

> Engineer: *"The airplane will have been delayed and it will be getting real close to their duty time and they start negotiating for days off or extra pay or whatever. That seems to be their only concern rather than the 400 passengers they're carrying"*
> Engineer 1: *"Everyone else is trying to turn cartwheels to get them out of there on time and all they're interested in is 'oh, we're short a crew meal and can I have another day off when I get back'...*
> Engineer 2: *"Oh, and by the way I need two more duvets"*
> Engineer 1: *"Yeah...as the aerobridge is pulling off they decide they want two more blankets for crew rest"*

This position was extended in one of the engineering focus groups where comment was made that some pilots even use safety as an excuse when they have their own motivations for not taking an aircraft engineering have deemed fit for service:

> Engineer 1: *"I think generally the perception across engineers, and certainly most of the ones I've talked to, is that they don't see the pilots as being generally focused on the good will and progression of the company"*
> Moderator: *"Do you guys agree? Disagree...?*
> Engineer 2: *"Yeah, yeah, I tend to agree. I mean a lot of guys, a lot of the pilot group just do go quietly about their business, take the airplane and go flying, yet you'll get the ones who will be a real stick in the mud 'No, I want this fixed now' and its 'ok pal, you want it fixed now, we're going to take massive delays and we're going to get blown out of the water here in terms of the schedule and...no that's fine, we'll fix it for you'"*
> Moderator: *"But do you think he's coming at that from a safety point of view or just a convenience..."*
> Engineer 2: *"I think it's a misguided safety point of view some of the time"*
> Engineer 3: *"It's undercover"*
> Engineer 2: *"It's undercover – they will always use safety as the backstop"*

‘Physical Separation’

“He’s not at the door so we’ll just go to the hotel”

A common theme across all focus groups was the physical separation between pilots and engineers and the way in which this is affecting their relationship. As there is no requirement for engineers and pilots to see each other on domestic turnarounds, a recurring discussion point was the degree to which physical contact had reduced as a result of this organisational change: *“there’s no engineers that come to see the airplane anymore. If you need one, it’s a real difficulty finding one”* [Pilot]. Pilots spoke of *‘facelessness’* with regard to engineering since the removal of engineers from the domestic aircraft turnarounds: *“they’ve sort of disappeared from domestic altogether in a way, so on domestic you almost feel like you’re by yourself”* [Pilot], and: *“the engineer is a faceless beast now and all you’ve got to look at is the paperwork that you’re looking at in front of you”* [Pilot]. Engineers concurred with this view, pointing out: *“the only time we get to see them is when they’ve got a problem”* [Engineer]. When queried as to whether they ever had time to go to the flight deck to meet and talk with the pilots, responses were along the lines of: *“no, very little”*, *“only when it breaks”*, and *“no social visits”*. Engineers agreed that the reduction in face-to-face contact was altering their relationship with pilots:

> *“There has been a very definite shift after we stopped seeing them every turnaround...now they can go days – weeks – without seeing an engineer. I think that the longer that they don’t see us, the less communication they have, the more we start becoming the boogieman and they start becoming the boogieman.”* [Engineer]

"But now that's all gone, absolutely gone, all of that interaction with the crew. Rightly or wrongly, it's just a dynamic that's changed." [Engineer]

With the reduction in physical contact, both groups spoke of lost opportunities, whereby information exchanges which would have once taken place face-to-face, no longer occurred:

"We would do the fuel on each transit and we'd take the fuel paperwork in and you had to physically deliver it to the crew 'cause you needed one of the copies of the triplicate to come back with you and if they had an issue they'd say 'oh we had this light flicker' or whatever and 'what do you think of that' and quite often the conversation would start about one of their observations." [Engineer]

"It used to be a great operation in the old days, you could chat to them about any little, minor things, and often now it's the little minor things. You're tired when you finish your flight. You think something happened during the flight, you think 'oh, I'll mention it to the engineer'... he's not at the door so we'll just go to the hotel" [Pilot]

The importance of interpersonal contact was also discussed in relation to establishing rapport between the two groups:

"You certainly don't get to meet and greet the engineers themselves so it's not until years have gone by you slowly build up a rapport of mutual respect" [Pilot]

"When I first started here we were still doing the fuel documentation and at that stage you pretty much knew every pilot 'cause you were going up to every transit...and since that has shut down suddenly you see a fairly good rotation – we must have hundreds of pilots – and you go up there and you just sort of see

> *this blur of faces and they yell things at you...yeah, it's hard to get a rapport with them....just so many, so many, so fast."* [Engineer]

One engineer offered the following example of how increased interpersonal contact leads to improved relations on the flight deck:

> *"There's one or two pilots that will come into our office and just sit for a while when they've got a bit of downtime and just have a chat with us and that's really good because they can sort of either talk about something outside of work or often they talk about things, a problem they may have had, and they'll come in and ask us 'oh is there any chance of having a look at the system for that' and we'll print out the maintenance manual for them...they'll come down, eat their lunch down here and have a chat to whoever is here. I find that really, really good 'cause it makes you feel more relaxed with them when you're on the flight deck talking with them. I think that sort of thing should be encouraged."* [Engineer]

Both groups agreed that they preferred to deal with those pilots and engineers they knew personally: *"it helps if you know the crew and they have a bit of faith in you"* [Engineer], with pilots going so far as to state that they received better service from the engineers they knew: *"if you know them, it makes a big difference in how they treat you and to get things sorted"* [Pilot]. One pilot illustrated this with the following comment:

> *"I get on very well with him but I've observed him with the other guys – abrupt to the point of almost rude, pain in the arse. I'll see him and say 'oh gidday, how are you?' and it'll be 'oh gidday, yah, yah, yah...'and then nothing is a problem. So it's kind of interesting. If they know you there seems to be a definite change in attitude in the relationship"* [Pilot]

Both professions spoke extensively about *"detached workforces"* and *"organisational silos"* and how they would enjoy more face-to-face contact. Pilots in particular lamented that there was little opportunity for this to occur: *"You just never see them, there's no CRM issues or training or time together, no refresher course or something..."* [Pilot]. One pilot who had previously been in the Air Force, commented that having more contact with the engineers lead to improved relations:

> *"...you leave your squadron buildings, you'd walk through the maintenance flightline hut, discuss any problem with the aircraft with guys who you'd know on a daily basis. You'd have camaraderie and, if you were doing test flights, they would come flying with you. The trust was built-in"* [Pilot]

When queried as to what improvements they would like to see within the organisation to improve their relationship, increased interpersonal contact was suggested by both groups:

> *"It would be bloody good to have some time together on a course somewhere...with the guys who are actually on the coal face, so you can spend some time talking...understand each other's issues."* [Pilot]
>
> *"A great way to break down the barrier would be to do some human factors training together."* [Pilot]
>
> [speaking of previously having an opportunity to attend a pilot CRM course] *"...that was actually quite good because you did get some feedback and they could put a face to a name or whatever and you could promote the cause and you could share a few things back and forward... I always found that to be a good interface between the two groups."* [Engineer]

'Trust'

"You feel like the wool is being pulled over your eyes"

The concept of trust between the two groups was explored and identified as an issue for the pilot group. Only one pilot spoke entirely positively: *"generally the trust is pretty good"*. While there were no specific claims of an outright lack of faith in line maintenance engineers, the balance of opinion was that there was a degree of wariness by pilots when it came to interacting with engineers. The rationale behind this caution was twofold. Some pilots had experienced receiving incorrect information from an engineer, or hearing about it occurring to other pilots:

> *"…the wrong MEL being applied and I know a colleague of mine has had it a number of times where he's had to park the aircraft and say this is completely wrong"* [Pilot]
>
> *"You could talk to a lot of the crew out on the line and they've been caught out at some point that actually the system hasn't been fool-proof and there have been errors despite what has been written up in [the logbook] and so that does undermine a little bit of confidence and raises, I guess, suspicion when you're sitting there with a log and the crew will start questioning it because they've been caught out in the past"* [Pilot]

The second reason pilots appeared to harbour misgivings was that engineers are not, in most circumstances, going to be travelling on board the aircraft: *"I mean the engineer might sign it out but they don't necessarily jump on the airplane and go flying with us"* [Pilot], a state of affairs which produced a certain amount of scepticism from pilots: *"[They're] playing around with an airplane that we're about to go flying in, you know?"* [Pilot]. In the excerpts below, the first pilot speaks of what he deemed an inadequate repair on his aircraft while the second observes differences in behaviours when engineers are required to fly in the aircraft following maintenance checks:

> *"I can guarantee if he was the engineer who was going to come flying with us, we wouldn't have been going flying"* [Pilot]
>
> *"Here's an observation - with the flight checks [we] quite regularly take an engineer which has turned out to be quite an interesting dynamic. There's no way that engineer will get on that airplane without doing his own walk-around and yet they're quite happy to dispatch us without a walk around. When he knows he's coming flying, all of a sudden off he is, looking here, there and everywhere, thumbing through the paperwork, the whole she-bang before he comes flying with us."* [Pilot]

The concept of trust also arose when one pilot spoke of having to rely on engineering on those occasions when he did not fully understand a MEL item:

> *"…it's quite confusingly written so when something arises that you haven't come across before, there is a feeling sometimes because of the engineer's perspective of trying to get something away reasonably expeditiously, there are occasions where you feel like the wool's being pulled over your eyes…and either you shouldn't have been dispatched or there should have been more clarification provided prior to that happening. So you were talking about trust earlier and, um, obviously it's not the rule but there are exceptions where you do feel you've been manipulated out on line or fobbed off out on line"* [Pilot]

The notion of reliance on engineering emerged within the theme of trust, with pilots expressing a degree of resignation with regard to the times where they have to do so. The following group of pilots are discussing the aircraft logbook and the lack of time they have to fully appreciate all the technicalities of an aircraft defect:

> Pilot 1: "*You just haven't physically got the time to, to...*"
> Pilot 2: "*So you're putting a lot of faith into their system...*"
> Pilot 1: *"into the engineers really"*
> Pilot 2: *"...their system, and you, you have to"*
> Pilot 3: *"You have to"*
> Pilot 4: *"You do"*
> Pilot 2: *"We'd never get airborne if you didn't so...the faith is definitely – probably* - *there, underlying"*

An illustration of resistance at having to trust engineers was provided by the following example in which a pilot spoke of an incident on his fleet where, during the pre-flight procedures, an engineer had incorrectly aligned the aircraft's inertial reference system. This error, while having the potential to significantly affect the flight crew should they get airborne, would be expected to be found and corrected prior to take-off. However, here the pilot speaks of the subsequent change in procedures which was put in place by fleet management following the event whereby pilots now re-do the alignment themselves in case of an error by line maintenance:

> *"If you think about it, that was definitely the engineering world coming into the operational world so we actually drew a line and said 'ok, first flight of the day, it doesn't matter what the engineer is doing, you turn their stuff off and you start again. Even if you look at it and think this is a perfectly good alignment and everything is fine. We need to draw a line between the operational world and the engineering world. We're the operators of the aircraft, we'll set the aircraft up for the operation'...it was interesting to me and in reality the things they do affect us right? The things we do don't really affect them"* [Pilot]

Aircraft Handover

"they'll just bail"

Being one of the few points of contact between pilots and engineers, the subject of aircraft handover was discussed extensively, particularly by the engineering groups. Pilots spoke positively about the times when there was an engineer available to meet the crew prior to departure and upon arrival at a port:

> Pilot 1: *"He'll just come up and say 'g'day' and 'how's things going?' and chew the fat"*
> Pilot 2: *"Which is really good"*
> Pilot 1: *"Because a lot of information is actually getting exchanged during that process"*
> Pilot 3: *"I was going to say, nothing better than that really. Certainly it's not every time by any stretch of the imagination but if you get an engineer who comes up there – and they're busy and it's a long walk up to the flight deck on the 400 and down again – and you arrive and they say 'it's a good ship guys, there's this open, this open and this has been deferred and I've done the daily..."*
> Pilot 4: *"Yeah"*
> Pilot 3: *"...or the opposite to that 'there's a minor problem, we've done this, this and this' and you have a briefing. Brilliant."*

Pilots were cognisant that engineers were a scarce commodity in some ports and if an engineer was not present to meet the crew when they arrived at the aircraft, they viewed this as a resource issue and not the fault of the engineers themselves:

Moderator: *“You don’t always get a briefing?”*
Pilot 1: *“Oh nah*
Pilot 2: *“No”*
Pilot 1: *“It’s fairly rare and it’s not their fault. It’s not their fault; it’s not how the system is designed. They’re busy down overseeing refuelling or fixing something in the cabin or what have you, but it’s pretty good.”*
Pilot 2: *“It’s interesting around the world, you know, where you go to other outfits and look at engineering where they’ve got more engineers, more time to spare, not under the same pressures.”*

Pilot: *It’s not a problem when you go to [name of overseas port] with [name of engineering contractor]. You get about four or five engineers crawling all over the place. So it’s a resource thing. I think it’s a resource thing to be honest and normally, if they’re there when I get off, I’ll have a quick chat to them and say ‘ok’ and if there was a problem just tell them what it was”*

Engineers too, appreciated the opportunity to meet with the flight crew but acknowledged that times had changed:

Engineer 1: *“When we joined the airline, a long time ago, the certifying engineer would wait for the crew to disembark and the crew would hand the engineer the logbook and they would have a little talk then”*
Moderator: *“Oh okay, and that doesn’t happen these days?”*
Engineer 1: *“No, but that’s not the nature of the commercialisation of aviation”*
Engineer 2: *“Less people. There were more people back then. The certifying engineer was up there all the time.*

Engineer 1: *“There is no formal handover of the aeroplane”*
Engineer 2: *“There is no handing over the keys”*

> Engineer 1: *"I could arrive at the aircraft and chock it and then go away somewhere else. I'll be busy on something else and both pilots are gone. So there's no actual, formal 'here's your aeroplane and you're responsible for it' and more than often they're gone by the time we get there.*

While there was acknowledgement that when a defect was of a more serious nature the majority of pilots would stay to speak with the arrival engineer face-to-face: *"the significant ones they tend to hang around"* [Engineer], *"if it's a big type defect, something genuinely serious, they will hang around"* [Engineer], engineers were, overall, critical that pilots left the aircraft too quickly upon arrival into port: *"they'll be gone. They'll come in and they'll just say 'oh, I've written up this' and then they'll just bail."*

> Engineer 1: *"They land and they often..."*
> Engineer 2: *"Just piss off"*
> Engineer 1: *"The rule is they can't get off this airplane and get home quick enough"*
> Engineer 2: *"Correct"*
> Engineer 3: *"Exactly, and we'll get a call a few hours later 'oh, oh, can you check the airplane because I think I left my backpack on board', or 'my laptop', or 'my cellphone'"*

The main concern for engineers when they did not get to speak to the flight crew following flight was the implications of having to decipher any logbook entries that the pilots had made:

> Engineer 1: *"They might be keen to get out of the cockpit and go and then you go and read the logbook and you find there are things there that you want...*
> Engineer 2: *"Clarification"*

Engineer 1: *"....clarification on and then it's difficult to get. So you either have to go and do a whole bunch of testing over again or, for the sake of a bit of communication...you could make your job a lot easier"*

"I think a couple of months ago, the captain came in with a reasonably significant defect and I think his entire write up was about four words in the logbook and that was it. He wrote it – he didn't enter any details across the header board – it was just 'da', closed, grab the bags 'cause he had the next plane waiting so he was straight across the terminal, into the next plane and he was gone by the time we got to the aircraft. So yeah, he was obviously dead keen to get back on schedule...probably the last flight of the day, it's about the only time they hurry." [Engineer]

Engineer 1: *"The crew would write up something but they'd be the first off the aircraft. If it was that important you'd think they might hang about a bit and say 'hey listen guys, we've had this, it did this, we saw this' but they're the first out that door.*

Engineer 2: *"Sometimes you get that"*

Engineer 3: *"Yeah"*

Engineer 1: *"Yeah...and I don't know what they're heading for, the Duty Free shop or whatever, but they're in a rush to get out"*

Engineer 3: *"Yeah there is that"*

Engineer 2: *"The real fun one is the internationals when they come in because we greet them on the headset and say, 'chocks-in, you alright?' and normally they'll come back and say 'the aircraft's good' or 'there's one in the tech log, one in the cabin log' or 'I had this and this is what we were doing' and you have an opportunity to have a little conversation. Sometimes you'll get 'aircraft's good, that's fine', whoosh, aerobridge is on and by the time you get up the stairs they're already off, leading the charge to immigration! You get in there and there's these screeds of stuff that they've written up and you think*

‘well if you’d told me this, whatever defect is there I would have asked questions two and three, you know...”
Engineer 1: “*yeah, quizzed them about it”*

Some engineers expressed an understanding from the pilots’ point of view as to why they might choose not to conduct a handover face-to-face, *“...it’s the end of a long journey and I understand that they want to go because they’ve had a long day and they shoot off”* [Engineer].

Engineer 1: *“They’re coming in with a different mentality then we’re going out with though, eh? Like you say, they’re finishing their journey and they’re focusing on shutting the aircraft down”*
Engineer 2: *“Mission completed!”*
Engineer 1: *“Yeah, they’re just ‘sweet, let’s go, let’s bail’ whereas we’re like...we’ve just begun so we go out there and then it’s like...you’ve got two different ways, two different roles in thinking there and that’s when you encounter problems”*
Engineer 3: *“Sometimes they write stuff that, you know, had they just hung around for a few minutes and spoken to the certifying engineer...the problem is so...not nearly as drastic as they’ve written it up to be and it would have been nice if they’d hung back a few minutes and said ‘hey, I’ve just written a log here, it’s about blah, blah, blah’ and then you can at least hear it and decide whether you want to talk to them further. I mean the certifying engineer has got work to do downstairs, but if they’ve got something that sounds worthwhile, it’s not a problem just to pop up and talk to them before they go. Because, yeah, we know they’re at the end of a long flight and that they want to go.*
Engineer 4: *“You wish they would do sometimes, just to clarify what their issue was”*

On-Time Performance

"There's a lot of finger-pointing"

The subject of On-Time Performance (OTP) was raised across all focus groups and in a number of contexts. The notion of OTP as a goal for each group has been noted (see the theme 'Perceived Goals and Objectives') and the following extracts expand this concept as well as illustrate additional ways in which OTP influences the relationship between pilots and engineers. Pilots expressed concern with respect to the blame which is systematically implied by the use of a delay code whenever the aircraft is late for departure, *"the trouble is, then the blame game starts and everyone is trying to avoid getting blamed for the delay and that's the problem"* [Pilot].

> Pilot 1: *"...the problem seems to be amplified by this On-Time Performance and the witch hunts that go on with who's responsible for the delay. For example, you might call up an engineer to fix something and he'll say 'are you going to wear the delay?'"*
> Pilot 2: *"Yeah"*
> Pilot 1: *"You know? Which is becoming OTP focused and not let's sort this out..."*
> Pilot 2: *"Yeah"*
> Pilot 1: *"...and because of that it starts friction and they'll reluctantly go away and do it and say 'well it's on your head' sort of thing whereas it shouldn't be that way. It should be if it needs fixing, fix it and let's go and if it's delayed, it's delayed. But there's now this 'I've got to justify to my boss why I was delayed' and we've got to justify to ours and it's definitely amplified the issues I think."*
> Pilot 2: *"You can understand the driver with OTP and I think the ability to allocate the delay codes makes sense from a systematic view point of seeing where the faults lie but the driver is more the wearing of blame as opposed to*

looking at systematic errors and therefore, because of the allocation of blame, it becomes the conflict or friction between the two bodies"

Engineers too spoke of blame:

> Engineer 1: *"It's engineering who gets it"*
> Engineer 2: *"Always I'd say"*
> Engineer 1: *"It always gets dropped on engineering"*
> Engineer 2: *"Yup, it always does"*
> Engineer 3: *"There's a lot of finger-pointing"*
> Engineer 1: *"Absolutely"*

> *"The crew had a problem with the avionics door and they knew about this 25 minutes before departure, but they weren't concerned. I said 'why didn't you call me?' and they were like 'oh, we called MOC' and then he said 'but we weren't bothered because we've got a fast flight time so we're not bothered if we go a bit late'. I said, 'well that's alright for you isn't it but I'm the one who gets the delay, I'm the one who has to fill in the report, not you!'"* [Engineer]

However, while pilots acknowledged that OTP is a pressure they experience *"the pressure, it's enormous as one knows"* [Pilot], they unanimously agreed that it is a far larger stress for line maintenance engineers:

> Pilot 1: *"OTP is important but I'll tell you what, we'll go when we can go and that's it. Engineering, if you talk to them, they are just so concerned about a delay going down to engineering it's unreal and I don't think they've moved through that yet, they're getting a lot of pressure"*
> Pilot 2: *"Well they're answering to it every morning at the briefing they have down there at the hangar. I mean every delay down to engineering, someone's explaining why and the pressure is really on them"*

Pilot 1: *"Yeah, so those line engineers they're really conscious of engineering delays"*
Pilot 2: *"And if they can push it on to someone else then that's going to happen"*

"The engineers, the line guys, don't like collecting the blame for a late departure due to technical reasons...they don't like getting clobbered for a delay and you notice that if they think the aircraft needs to be held back for a bit, quite a lot of pressure comes on. There's a sudden increase in management engineers that start arriving at the aircraft, quite a lot of interrogation goes on with the engineer, sometimes quite confrontational" [Pilot]

Pilot 1: *"The delay codes don't worry me"*
Pilot 2: *"I think the delay codes mean a lot more to other people than they do to us...if someone wants to put a delay code on me, I say 'fine, I'll take it"*
Pilot 3: *"occasionally engineers get a bit uptight about delays, you know, if they think it's their fault. Someone asked us the other day if we'd take the brakes off early to get it on time and we said 'no, we can't go, we're not going' but that was their view and it wasn't even the engineers problem – we were all ready to go but there were airplanes taxiing behind, that was the delay but he still wanted it to appear as though it went on time"*
Pilot 1: *"And where the logic in that?"*
Pilot 3: *"To get [name of an engineering manager]'s On-Time Performance looking good!"*

"I think they seem to be quite susceptible to the pressure they're obviously under for all the on-time stuff, they're quite concerned about all that. It really does – not cloud their thinking – but they're definitely under pressure from that all the time" [Pilot]

As well as acknowledging that OTP was an important focus for engineers, pilots commented on the effect this was having from their perspective. They agreed that by already being under significant time pressure, engineers might not want to hear pilots bringing up aircraft-related issues, nor did they have time to exchange pleasantries on the occasions when engineers were in the flight deck:

> *"...the last minute refuelling policy they've got...they're under pressure all the time which then impacts on the rest of their workload. If you then tell them 'well we've got some problems' you know, in the back of their heads they've got this on-time performance fuel requirement that's got to be done then 'oh Jesus! You've just given me something else to do. I don't need this!'* [Pilot]

> *"When the engineer does come on board you're normally pretty busy and if he wants to….some of them are quite chatty, you know, nice guys obviously, but man it's irritating cause you're really focused on trying to get stuff done"* [Pilot]

Pilots also expressed concern regarding the effect OTP pressures might be having on engineers with regard to the quality of their work: *"if they're stressed out there, how quickly are they trying to fix something down below?"* [Pilot]:

> *"The MEL reference numbers, often they're close together but the wrong one was written in and that's generally time pressure. The engineer's been on board, he's looked at it, he's quickly glanced through and thought 'oh, that's the problem' write it up, dah-de-dah and in one case it resulted in the wrong performance figures. Because they'd applied the wrong MEL, the wrong performance figures had been put in and it's just an on-going effect. One day, because of those pressures, ultimately the performance won't be done for something like that..."* [Pilot]

Engineers themselves, however, spoke very little about OTP pressure. There was acknowledgement that it was experienced: *"if we're one minute late the phone rings, honestly, that's what happens, one minute..."* [Engineer], assurance that it would not affect the quality of their work, *"if we're defecting then OTP is a long way down the list of priorities"* [Engineer] and recognition that they were not afforded the luxuries that pilots were:

> Engineer: *"You can push them off the gate here and sometimes it will be five minutes before they taxi as they're running through their checklists. A briefing's a briefing and there's no set time for how long that takes but we don't have that leeway, we don't have any of that cause the pushback's got to happen now and if it doesn't happen now you've got to fill out a delay report. Whereas you can push it back on time and it sits off the gate for five minutes while they run through the checklist again"*

The Minimum Equipment List

"It's the biggest point of contention, generally speaking…"

Participants shared their thoughts on the interpretation and application of the Minimum Equipment List (MEL) as well as their views regarding how each group interfaced with the other on those occasions when the MEL was required to be used. Pilots expressed that interpretation of the MEL could be considerably challenging for them: *"…in places it's gobbledygook"* [Pilot]. A prevalence of words such as '*confusing*' and '*difficult*' described the language used in the MEL and there was suggestion that pilots felt they lacked the technical knowledge to understand it:

> *"I have no engineering background so I hate it. I pick up a MEL and think 'bugger me'…you know? This is* <u>*very*</u> *confusing"* [Pilot]
>
> *"Sometimes it's easy, sometimes it needs a bit of thinking, and other times it's darn near impossible. You don't even know what they're talking about and you can't find any reference in our books to it."* [Pilot]

In contrast, engineers appeared a lot less concerned about interpretation difficulties. Pilots were of the view this was because the MEL was in fact designed by engineers to be used by engineers: *"Well it's an engineering document isn't it, it's written for them rather than us"* [Pilot]. Whilst there was acknowledgement that some MELs were *"a bit curly to read"* [Engineer], engineers seemed relaxed about the fact that the MEL can be open to interpretation, *"It's written that way on purpose…it's not black and white, it's grey"* [Engineer].

The application of the MEL also appeared to be a source of frustration for pilots and one which provided insight into their perceptions of the engineering group's goals and objectives. The discussions exposed a marked distinction in the way pilots viewed the application of the MEL: *"We look at it from a pilot's perspective as how it affects us operationally in flight and we view it as such…"* [Pilot], and how they perceived it was used by the engineering group. There was agreement amongst all the pilot participants that whenever the MEL is applied, they will consider the implications from an operational perspective: *"Our role is probably to look at it and say 'what are the implications of an aircraft that's not a hundred percent', or 'it's dispatchable but do I want to take it'…"* [Pilot]. However, the overwhelming feedback from pilots was that engineers did not consider the operational effects of applying a MEL: *"…so you look at it and think well this is a big deal, and they may look at it and think well what's the big deal, we'll just defer it and away you go"* [Pilot]. Pilots instead were of the opinion that the MEL was being used by engineering for the purposes of achieving On-Time Performance:

> *"…for an expeditious turnaround and to stay within the On-Time Performance requirements, they may just do either a quick fix or just, ah, defer the item without perhaps fully appreciating the downstream effect it would have from an operational perspective."* [Pilot]
>
> *"…they're so driven by on time departures that everything is done at an expeditious rate to get you out on time and that's why they flick it on MEL and all that…they don't have, or don't want to make the time to fix it because it will cost them a delay."* [Pilot]
>
> *"…I think they're drawn into politics a little bit from their upper management that say this has all got to go out on time…the easiest thing to do with this airplane is to MEL it."* [Pilot]

For their part, engineers did not mention using the MEL to conform to on-time performance requirements. Indeed, they seemed to hold a more simplistic view on applying the MEL: *"…the MEL, for us, is there to dispatch an aircraft with an issue"* [Engineer]. However, as far as the so-called lack of concern for the operational implications when applying the MEL, engineers pointed out that that they are not always aware of the operational ramifications for the pilots: *"you don't have a crystal ball do you!"* [Engineer]. For example, one engineer talked about having to apply a navigational-related MEL without knowing whether the pilot would require the equipment to fly the approach:

> Engineer: *"…some of the navigation-type MELs have 'as long as the approach procedure does not require its use' – how the hell do I know? I've got, um, no concept of whether it will be required to fly a certain approach so, once again, we're reliant on Flight Planning [Department] to come back to us and tell us if he's flying an approach that requires this equipment, you know? So quite often you'll get a captain ringing you up and having a go at you over the phone, you know, 'I can't take this airplane, what are you thinking giving me this?'…and it's like, well we've got no complete concept of whether you require it or not…so, yeah, he doesn't understand that we're not always privy to everything in their world, you know?"*

In an attempt to avoid the above difficulties, engineers spoke of talking directly with the pilots at the time of application: *"I think if you've just written a fresh one on it, I like to hang around and read it together so we're all in agreement"* [Engineer]. There was, however, only one example of positive communication which involved a level of cooperation and understanding between both parties:

> Engineer: *"I think in regards to discussion between engineers and pilot, I think it's like a community decision – not community – a committee decision on it isn't it? You'll try and apply a MEL or you will apply a MEL, and they'll look at it and they'll give you their view and if they don't like it, they'll tell you, and of course they'll be looking at the MEL from the operational side of it…where we're purely – well not purely – but mostly looking at it from the engineering side of it and what our implications are in regard to procedures. We might have to do certain procedures with that MEL but they have to look at the operational side of it and that where we have to…certainly have a bit of dialogue on what their requirements are to apply that MEL. Sometimes we might not know, ah, it could be dependent on fine weather or something like that. We don't necessarily know what the weather is like up the country so this is where we have to bring them into the conversation and you come to an agreement with them…so that's where that communication is really important, you know, with the MEL."*

Both groups provided evidence of conflict when interacting over the MEL. When asked by the moderator to describe what happened when one pilot sought clarification on a MEL which had been applied incorrectly by engineering, the pilot responded: *"Oh, they'll argue. They argued initially, you know, 'dumb pilot – what do you know about this', basically that sort of attitude…you've got to stand your ground"* [Pilot]. One engineer spoke of having to 'sell' the MEL to the flight crew, the success of which depended upon the particular engineer's communication ability:

> *"That's a big part of the line job, there's a certain amount of salesmanship in there when we start getting curly defects or something like that, you've got to – not sell the aircraft to the crew – but you've got to help talk the crew through the defect and you certainly have to appear that you know a hundred and ten percent what you're talking about. You might not necessarily know that but you sure as*

> *shit better say it to them 'cause they can smell blood – as soon as they smell blood, they're off like sharks."* [Engineer].

4.6 Discussion

The data from the focus group sessions reveal a complex relationship between pilots and line maintenance engineers, a relationship which is challenged by significant external influences present in the operational environment in which the two groups work. Thematic analysis of the focus group sessions facilitated the identification of distinct themes which signified the foremost issues for both pilots and engineers. During the mapping and interpretation phase of the thematic analysis, the themes which had been identified were examined in two ways. Firstly, themes which were considered to directly discourage communication between the two groups were categorised as *Communication Impediments.* Secondly, consideration was given to whether each theme negatively influenced the way in which the two groups related to each other and, if so, these themes were classified as *Intergroup Relationship Impediments*.

4.6.1 Issues affecting Communication

Problems with specialised terminology appear to lead to two distinct outcomes. Firstly, difficulties may ensue for maintenance personnel when the terminology used by pilots does not accurately match that which would be used by a line maintenance engineer. This is exemplified by the discussion of the engine problem in one of the focus group sessions where it was revealed that pilots were typically writing that the engines was *'slow to spool'* but, according to engineers, a more accurate description would be *'differential acceleration'*. Differences in terminology has been highlighted as causing difficulties in communicating between groups (Eunson, 2008; Nelson & Quick, 2013) and the outcome in this particular context may lead an engineer to pursue a rectification process not appropriate for the actual defect. Engineers confirmed that poor descriptions caused practical difficulties for them either by impeding their ability to troubleshoot or having to gather more information either from the pilots involved or the next flight crew to operate the aircraft. In addition to hindering defect rectification, the use of jargon and abbreviations is serving as a differentiating factor between the two groups as described by Huseman et al. (1976) and Growler & Legg, (1981). Evidence was found that some individuals perceive the differences in terminology as a *'language'* unto itself as was described by the term *'pilot-speak'*. This builds a barrier between the two groups by heightening the salience of their distinct social identities (Postmes, 2003), distancing the professions and reinforcing the notion that one group is 'closed' to members of the other. This concept is evident by use of descriptive attributes such as '*closed-shop'*, *'us and them'* by both pilots and engineers.

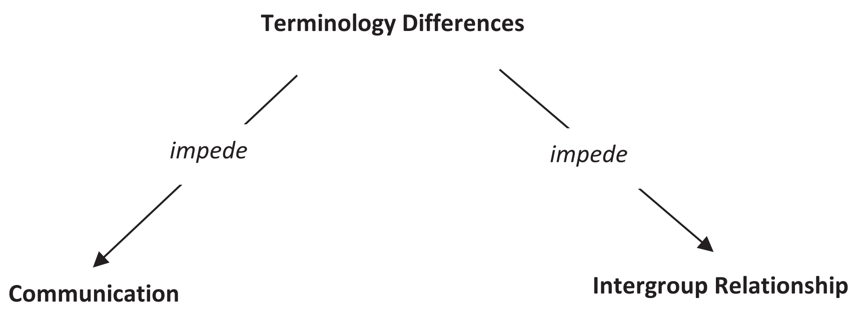


Figure 4.4 Terminology differences can impede both communication function and a healthy intergroup relationship between pilots and line maintenance engineers.

The ease with which intergroup communication takes place is influenced by an individual's skill and ability to interact with another and it is clear from the discourse that the two professions seem to struggle (or *'flounder')* on occasion. Pilots tended to distance themselves from the idea that they were poor communicators: *'we're encouraged to communicate effectively'*, however, a recurrent feature of the discourse was that poor communication practices are inherent between the two groups. Engineers stated that successful operations were reliant on the ability to communicate effectively but also recognised that they were not particularly good communicators. Regardless of which profession might be deemed as being most proficient, the impression remains that the groups at times lack an ability to engage satisfactorily with each other. Consistent with this explanation is the notable pattern of accounts whereby participants claimed to be made to feel uncomfortable during communication interactions, for example: *'they pick and pick and pick until they destroy you'* or *'the engineer will deal to me as though I asked a stupid question'*. It is reasonable to expect that recipients of such behaviours might well be discouraged to actively seek an interaction with a member of the out-group beyond what is required by operational necessity.

The two means by which the groups frequently communicate present difficulties as both the logbook and the radio have significant drawbacks. The first problem is that the absence of body language can impede the ability to communicate effectively (Dwyer, 2012; Andrews & Baird, 2005; Becker & Wortmann, 2009), a situation which was described as already being challenging for the two groups. What would ideally be a mutual exchange of information supported by tone, inflection, facial expressions, hand gestures and the like becomes: *"just one way"*. Further, while communication via the radio at least allows an exchange of information to take place in 'real time' (albeit in the absence of body language) the logbook could be deemed a considerably inferior medium as it provides the added complexity of temporal differences. The focus group participants readily acknowledged that the logbook contributes to issues with terminology for both engineers: *"the interpretation of one English word can throw you off track completely"*, and for pilots: *"they write in tech speak"*, leading to possible aircraft rectification difficulties for engineers and potential aircraft delays while pilots seek clarification of what has been written. These findings align with the Media Richness Theory (Mohan et al., 1997; McShane & Glinow, 2009) discussed in Section II of the Literature Review in that lean media with low data-carrying capability are suitable only when, both sender and receiver have common expectations and shared mental models. The themes which were revealed in the focus group discourse indicate clearly that this is not the case for pilots and engineers.

The discussion surrounding the logbook also provided an insight in to what appears to be a lack of knowledge by the flight crew regarding what information engineers require about aircraft defects. Pilots acknowledged that they struggle with the content of their entries: *'we don't give them enough information'*. This issue resonated with the engineering group and further reinforced their position that pilots do not appreciate the complexities of an engineer's job: *'they assume that we know all the contributing factors'*. Noteworthy from the engineering discourse was the problem that poor logbook entries from pilots can lead to, specifically with regard to the group's ability to rectify aircraft defects in a timely fashion. In summary, it might be said that the medium by which these two groups communicate increases the potential for problems due to differences in terminology and further magnifies a lack of skill and ability by pilots to convey pertinent information to the engineering group.

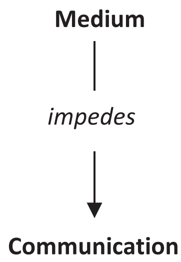


Figure 4.5 The types of media used to communicate can impede effective communication between pilots and line maintenance engineers.

4.6.2 Factors affecting the Intergroup Relationship

Reviewing the attributes which were used to describe in-group and out-group characteristics, it is plausible that both pilots and engineers are engaging in social categorisation. Each group described themselves in a more positive light than they did the other group; pilots described themselves positively 88.9% of the time versus 62.7% of the time when describing engineers and engineers described themselves positively 78.9% of the time versus 41.1% of the time when describing pilots. This aligns with the findings associated with SIT in that categorisation occurs as means of identifying and distancing the in-group from the out-group (Anastasio, et al., 1997; Haslam et al., 2003). This is further supported by the fact that each group believed the other thought more negatively about them than was actually the case as noted from the discourse in the analytical theme *'Perception of Other'*. This reflects one of the major by-products of Social Identity Theory whereby more intergroup disagreement is perceived by group members than what actually exists (Chambers & Melnyk, 2006; Hogg & Abrams, 1998). Indeed, examination of the words which the two groups used to describe themselves actually reveals many shared qualities; 42% of attributes used to describe the 'in-group' are common to both pilots and engineers.

Another signature which marks the presence of psychosocial barriers is the identification of out-group homogeneity bias (Forsyth, 2006; Hogg, 2004). An example of this can be seen when examining the assigned attributes of each group whereby the ingroup was described as being made up of: *'many types of thinkers and personalities'* in comparison to the outgroup which was described as having a: '*narrow range of personalities'*. The uncertainty and lack of trust on the part of the pilot group is also characteristic of ingroup-outgroup bias. The fact that the pilot group did not specifically claim to distrust engineers, aligns with Brewer's (2009) explanation based on empirical research.

With regard to the intergroup relationship, the frustrations expressed by each group when proclaiming that the other profession has a lack of understanding of what their occupation entails has repercussions which extend beyond mere egocentric indulgences. The intergroup relationship is being aggravated by a sense of irritation that the out-group does not appreciate the job demands of the in-group, a notion supported by the literature with regard to conflict between highly specialised groups. With each group positioning themselves as the one who has the most difficult job, undesirable competitive tendencies develop (e.g. us pilots are *'dodging cbs in the middle of the Pacific'* as opposed to engineers who are *'sitting in a nice warm office with a cup of coffee')*. Interestingly, it would seem that there is some understanding of the occupational challenges faced by the out-group, however, each profession appears more focused on the <u>perception</u> that the other does not appreciate their job requirements. It is not surprising therefore that both pilot and engineers conveyed their desire for the other group to spend some time experiencing the occupational challenges they face.

Other themes which appeared to contribute to negative perceptions of the out-group were ‘perceived goals and objectives’ and ‘trust’. Despite the fact that engineers viewed the safety of the aircraft as a goal for their group, pilots perceived that engineering personnel were often more interested in OTP requirements. While OTP clearly is an important objective to engineers, it would appear less so for the pilot group possibly due to what seems to be a lesser amount of organisational pressure placed on them. In any case, engineers perceive pilots as being dismissive toward their efforts to despatch the aircraft on time, commenting that: *“everyone else is trying to turn cartwheels to get them out on time”*. This contributes to the perception from engineers that pilots are more egotistically motivated: *“all they’re interested in is ‘oh, we’re short a crew meal”*. The end result appears to be that both groups perceive themselves as having interdependent as opposed to superordinate goals, a significant contributor to intergroup conflict (Sherif et al., 1961; Schneider, 2004; Vaughan & Hogg, 2005; Buchanan & Huczynski, 2010).

The discourse relating to the MEL was particularly insightful with regard to the role it plays in the flight crew-maintenance interface. On face value, the MEL might be considered to be the source of task-related conflict as purported by Suzuki et al. (2008), however, the manner in which pilots spoke about the MEL suggests that the difficulties it creates may have a more complex influence on the intergroup relationship itself. As opposed to merely presenting an operational challenge when it is required to be applied, the MEL appears to be contributing to a negative perception amongst pilots of the out-group as it was connected to numerous themes, specifically ‘perceived goals and objectives’: *“they’re so driven by on-time departures…that’s why they flick it on the MEL…they don’t want to make the time to fix it”*, ‘trust’: *“you feel like the wool’s being pulled over your eyes”* and a ‘lack of appreciation of self': "*[they] just defer the item without perhaps fully appreciating the downstream effect it would have from an operational perspective*". The MEL was also associated with the engineer's negative perception of the outgroup: *"you'll get a captain ringing you up and having a go at you over the phone…he doesn't understand that we're not always privy to everything in their world"*. The fact that the MEL is implicated in these themes strongly suggests that, in addition to simply being the source of task-related conflict, it is also acting to exacerbate difficulties within the intergroup relationship. This supports the notion that task-related conflict is inextricably linked to personal conflict (Pelled et al., 1999; De Dreu & Weingart, 2003).

The perception on the part of pilots and engineers that their goals are separate as opposed to interdependent could be seen to contribute to each group's feelings of a lack of appreciation. Using the example voiced by an engineer that: *"everyone else is trying to turn cartwheels to get them out of there on time and all they're interested in is 'oh, we're short a crew meal…'*, a pilot may well claim that his or her crew meal is an essential requirement to be able to operate in a safe physiological state and engineers simply don't appreciate this due to their lack of understanding of the pilot's occupation. Similarly, perceived interdependent goals also appear to influence the degree to which each profession trusts the other. While pilots argue that safety is their '*number one concern'*, this is viewed with an element of circumspection by at least one engineer: *'it's an undercover – they will always use safety as a backstop'*. By the same token, what pilots perceive as being the most important goal for engineers (*"trying to get something away reasonably expeditiously")*, also appears to influence the faith they have in the group: *"you feel you've been manipulated out on line"*.

Appraising the way in which these themes are related, it appears that perceiving their goals as interdependent promotes feelings of mistrust a lack of appreciation. These issues all appear to be exacerbated by the difficulties associated with the MEL, the result of which increases a negative perception of the outgroup.

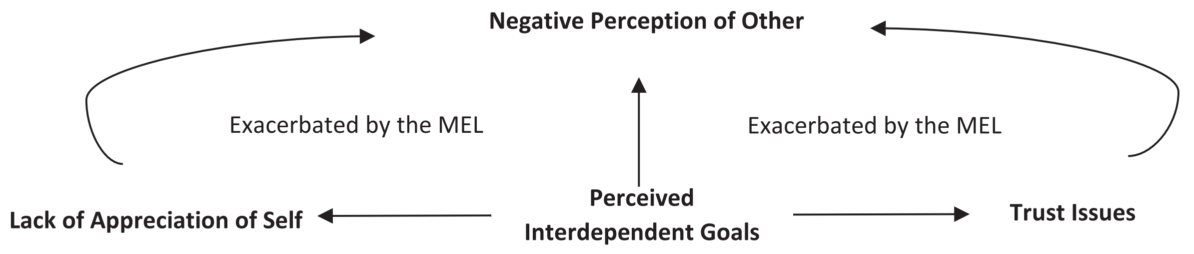


Figure 4.6 Problems with operational documentation such as the MEL can exacerbate traditional intergroup relationship issues

With pilots and engineers harbouring negative perceptions of each other, the outcome is the establishment of an impediment to a healthy intergroup relationship.

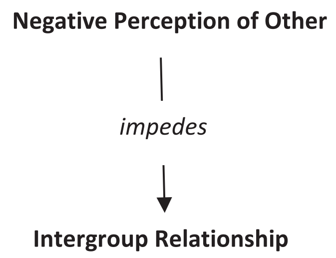


Figure 4.7 A negative perception of the out-group impedes a healthy intergroup relationship between pilots and line maintenance engineers

The issues which are proposed as either contributing to, or exacerbating the negative perception of the out-group, are all influenced by a marked lack of physical contact between the two groups. This absence of contact appears to act in three ways. Firstly, participants claimed that by removing the procedure whereby the engineer would visit the flight deck on (domestic) aircraft turnarounds, an opportunity for information to be exchanged had been taken away: *"a lot of information is actually getting exchanged during the process"*. Additionally, the ability to be able to speak to the crew in order to query a logbook entry is also lost and, as acknowledged by the engineering discourse, this can directly affect their ability to rectify an aircraft defect. The second effect of reduced physical contact is the loss of an opportunity for a pilot and engineer to establish rapport, a factor both professions deemed as important in relation to their ability to communicate in an effective manner *"it makes you feel more relaxed with them when you're on the flight deck"*. A lack of rapport can be considered a barrier to effective communication and interaction (Krivonos, 2005; 2007; Ford, 2011). Thirdly, a lack of physical contact is deemed to be contributing to the issues which are driving negative intergroup perceptions. As discussed in Part IV of the Literature Review, decreased contact between groups is a recognised barrier to effective communication within organisations (Papa et al., 2008) and can lead to hostility and perceptual distortions (Allport, 1954; Brewer & Gaertner, 2004) as well as increasing the likelihood of mistrust between groups (R. Fisher, 1993).

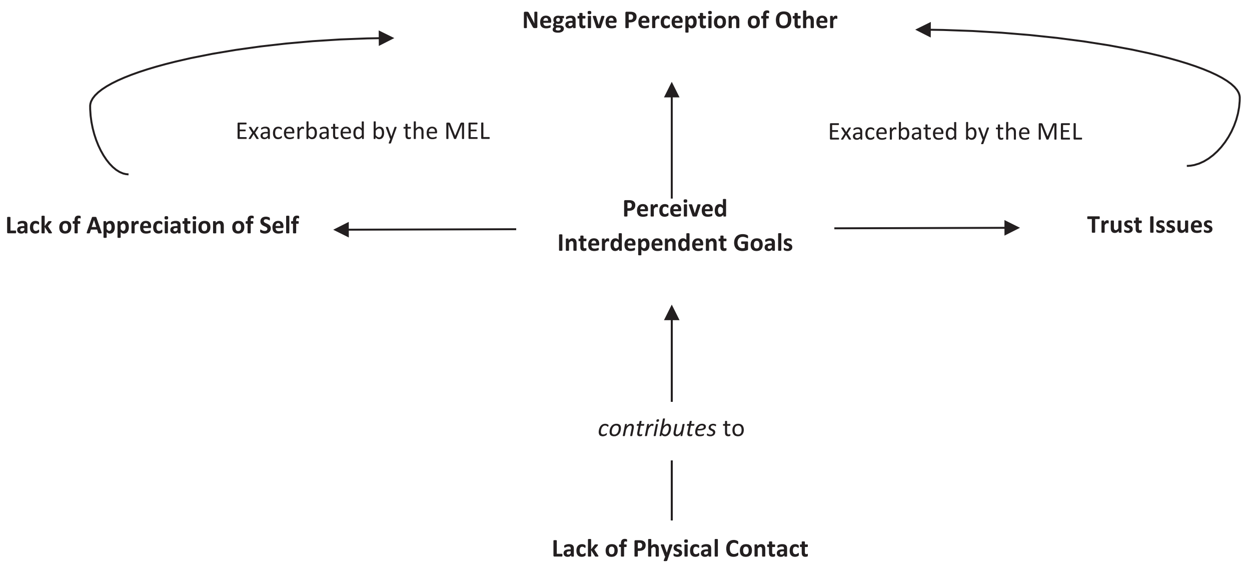


Figure 4.8 Lack of contact between pilots and line maintenance engineers contributes to negative perceptions of the out-group

Contributing to the physical separation between the two groups are On-Time Performance pressures: *"everyone's backs are against the wall for the on-time pressure"*, lack of a formal handover: *"I'll be busy on something else and both pilots are gone"*, and no opportunity to see each other any other time: *"you just never see them, there's no CRM or training times together"*.

As exemplified in the pilot discourse, flight crew are cognisant of the pressure line engineers experience and are perceptive to the reception which may occur when interruptions are necessary: *"if you then tell them 'well we've got some problems'...then 'oh Jesus! You've just given me something else to do! I don't need this!"* While there is no evidence that this would actually dissuade a pilot from communicating with an engineer when operationally necessary, it certainly supports the claim that there is little time for pleasantries: *"man it's irritating, cause you're really focused on trying to get stuff done"*, despite the contention that it is these very types of interaction that both build rapport and lead to pertinent operational information exchange. Furthermore, and in support of the research surrounding the attribution of blame when superordinate goals are not met (Carr, 2003; Vaughan & Hogg, 2005) it would appear that the On-Time Performance system contributes directly to a degeneration of the intergroup relationship by the introduction of negative competition (*'blame-game')* leading to *"finger-pointing"*, *"friction"* and *"conflict"*.

The absence of any joint-training for the two groups appears to have a twofold outcome. As illustrated by the engineering accounts of job hindrances: *"they flick the [aircraft] beacon on...and it just delays our processes more"*, an inability to adequately prepare for an aircraft's arrival: *"you'd like to know what some of the eventualities could be"*, and difficulties with regard to rectifying defects: *"we're chasing a problem that is actually a ghost"*, it would seem that there is a significant lack of understanding by pilots of engineering requirements. The latter issue is particularly prominent with logbook entries made by pilots who are not aware of the information that engineers require: *"you don't get the full story"*. In addition to this tangible outcome, it is also worth noting that by not having an opportunity to be taught and practise techniques that facilitate communication across different professions, the likelihood remains that pilots and engineers will not possess the skills required to do so, further contributing to what has already been identified as a poor ability to communicate effectively.

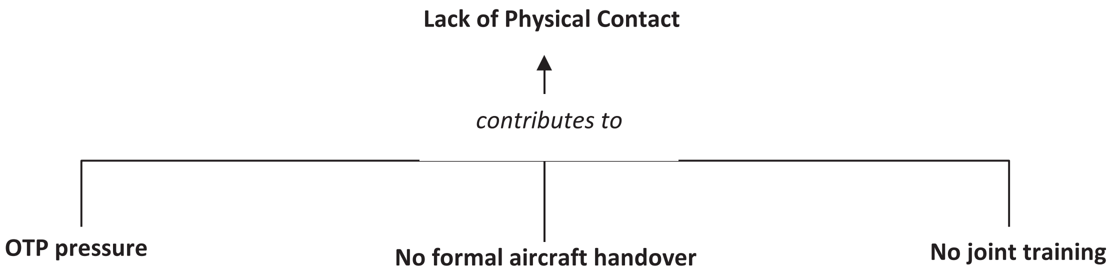


Figure 4.9 OTP pressures, lack of a formal aircraft handover and no opportunity for classroom time together mean pilots and line maintenance engineers have very little contact with each other

With consideration to all the themes discussed above, the resultant conceptualisation of the impediments to effective communication between pilots and line maintenance engineers is presented in Figure 4.10.

4.7 Summary

This study aimed to explore the issues that pilots and engineers identified as being impediments to effective communication between their two groups. Thematic analysis of the focus group discourse has identified that the majority of the communication barriers discussed by the participants were reflective of a problematic intergroup relationship. The source of the relationship difficulties is reflective of typical psychosocial influences which can affect groups within organisations, especially those professional groups whose identity is particularly salient. The presence of behaviours associated with this phenomenon are exacerbated by a lack of physical contact between the two groups which is driven primarily by organisational factors that are beyond the control of either group. In addition to having to engage effectively despite an over-arching relationship which is problematic, flight crew and line maintenance engineers face other difficulties. There are challenges imposed when attempting to communicate across professional boundaries where the language used by each group creates the potential for misunderstandings. Moreover, these difficulties are compounded by the fact that the medium in which they primarily communicate appears inadequate for this purpose.

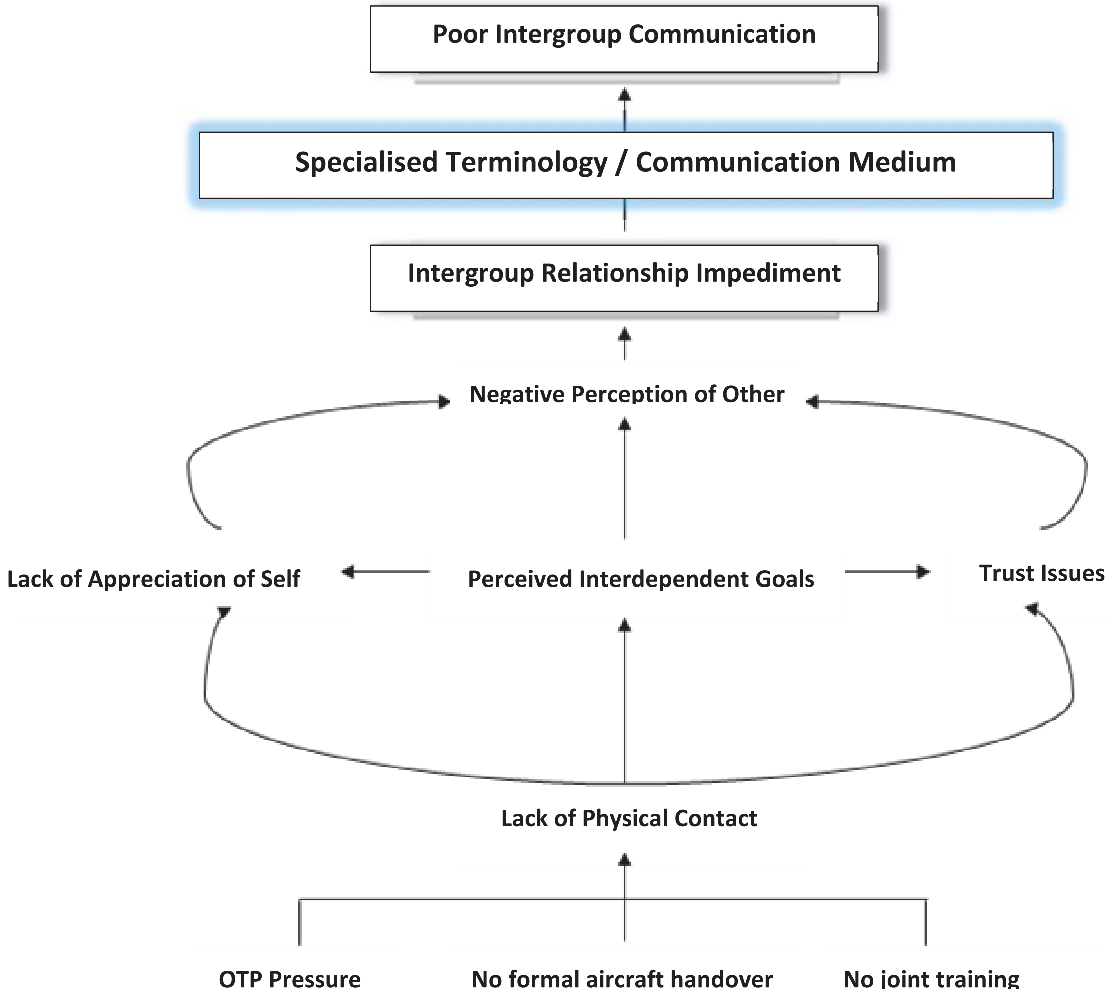


Figure 4.10 Conceptual framework of impediments to effective communication between flight crew and line maintenance engineers.

CHAPTER FIVE

Interaction Analysis of Communication between Airline Pilots and Line Maintenance Engineers

The second study explored communication between airline pilots and line maintenance personnel within an operational environment. As previous studies have focused almost exclusively on written communication (i.e. the logbook), this research was designed to investigate another medium, specifically radio/telephone communication. Results from Study One suggest interactions between flight crew and engineers were problematic due to a poor intergroup relationship coupled with reliance on less-than-adequate media such as the logbook and radio when attempting to communicate. It was anticipated that these difficulties would be evident during their interactions with each other during day-to-day activities, hence the desire to explore actual operational communications between the two groups.

The interactions chosen for this study were pilot-initiated radio and telephone communication exchanges regarding routine aircraft operational issues. Guided by the outcomes from Study One, the research was designed to collect various communication markers so that an assessment could be made as to the manner in which the two groups interfaced during their professional interactions.

The guiding research question for Study Two was:

How do the impediments identified in Study One influence the way in which pilots and engineers communicate in an operational environment?

The focus group sessions suggested that both airline pilots and aircraft engineers considered the out-group did not communicate well and this was exacerbated by the use of specialised terminology and poor communication media. Findings also suggested that task-related difficulties such as MEL interpretations and OTP pressures were influencing the development of a negative perception of the out-group, resulting in interpersonal conflict which in turn was hindering the ability to communicate effectively. The second study was therefore designed to seek evidence regarding the various aggravations that the groups were supposedly dealing with. This chapter details the research methodology, results of the second study and concludes with a discussion in which the findings are considered in relation to the research question.

5.1 Method

In order to capture the various dimensions and functions of the communication process, Interaction Analysis was selected. Hirokawa (1988) describes Interaction Analysis as being designed to "to obtain quantitative, descriptive information regarding the nature of the interaction process." (p. 231), thereby producing results which are informative on numerous levels. Jordan and Henderson (1995) advocate Interaction Analysis as:

> an interdisciplinary method for the empirical investigation of the interaction of human beings with each other and with objects within their environment. It investigates human activities, such as talk, non-verbal interaction, and the use of artefacts and technologies, identifying routine practices and problems and the resources for their solutions (p.39)

Interaction Analysis is well-placed not only to assess any difficulties with verbal communication between pilots and line maintenance engineers, but also with any of the accompanying documentation and processes. Interaction Analysis is frequently used as a tool to study communication exchanges within the medical arena (see Boon & Stewart, 1998, for a review), and while patient-physician discourse might initially seem somewhat removed from pilot-engineering discourse, the two scenarios are, in fact, not dissimilar. Charon, Greene and Adelman (1994) state that “to practice effective medicine, the doctor not only must deliver technically competent care but also must recognise the narratives that the patient brings to the encounter” (p. 955). This can be likened to the aviation environment whereby an engineer must attempt to recognise the descriptions a pilot gives about a particular defect in order to identify the most likely cause of the problem.

The roots of analytical interaction research lie in ethnography, particularly participant observation (Jordan & Henderson, 1995) and the field is dominated by what Peräkylä (2004) describes as two powerful traditions; the works of Harvey Sacks[40] and Robert Bales. Whilst the Sacksian tradition utilises conversation analysis as a technique for studying interaction, the work of Bales (1950a; 1950b; 1954; 1970; 1999) focused on quantitative analysis to examine human interaction. The influence of his original method of coding communication exchanges, Interaction Process Analysis (IPA), is still, according to Perakyla (2004), “felt in most social psychological interaction research which categorizes behaviour and counts it” (p.2). Indeed, Keyton (2003) describes Bales’ work as seminal, and the IPA categorisation system as “well accepted and a sound method for identifying the communicative functions of group problem solving and decision making” (p. 260).

[40] For more on the Sacksian tradition of Interaction Analysis, see Peräkylä’s 2004 paper ‘Two traditions of interaction research’.

IPA is designed with a distinct focus on socio-emotional and task-based components (Gorse & Emmitt, 2007) and categorises communication in accordance with interpersonal goals such as expressing emotion, or task-related goals such as information concerning the particular job at hand. Whilst designed for research in a laboratory setting, IPA has since been used in naturalistic settings (Bales, 1953; Eskola, 1961; Pena, 2004) in such fields as construction (e.g. Gameson, 1992; Gorse, 2002; Gorse & Emmitt, 2003), medicine (e.g. Fremon, Negrete, Davis & Korsch; 1971), multi-disciplinary professional teams (e.g. Bell, 2001; Atwal and Caldwell, 2005), labour mediation (e.g. Landsberger, 1955), online discussion groups (e.g. Fahy, 2005; Finegold & Cooke, 2006) multi-cultural communication research (e.g. Nam, Lyons, Hwang & Kim, 2009) and video gaming (e.g. Pena, 2004). Indeed, in the medical arena for example, the Rotor Interaction Analysis System or RAIS (Rotor & Larson, 2002) was developed directly from IPA specifically for use in the medical domain. In terms of methodological strengths, IPA has been proven to have a good degree of representational validity[41] (Poole & Folger, 1981), face validity (Philp & Dunphy, 1959), construct validity (Allen, Comerford & Ruhe, 1989) and demonstrated acceptable inter-rater reliability (Borgatta & Bales, 1953).

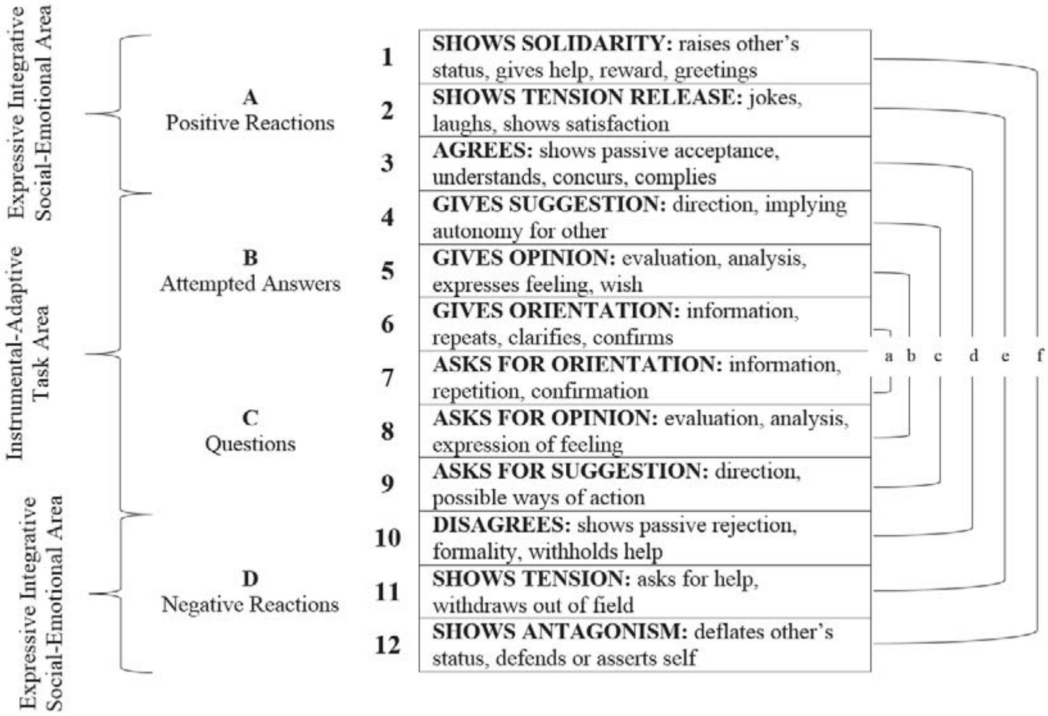
Prior to finalising the decision to use IPA for this study, it was deemed prudent to review the tools used when studying interaction within the medical field as patient-physician interaction has been extensively researched over the years. Interaction Analysis has not been undertaken within the aviation domain and so it was determined that a measure of confidence could be

[41] Representational validity is a concept specific to communication coding schemes whereby the categories used should reflect the meanings of utterances with a view to duplicate the outcomes of interpretative processes (see Poole & Folger, 1978; Folger & Poole, 1980).

gained by ascertaining which instruments are considered most suitable by practitioners within a more established field of research. Boon and Stewart (1998) conducted a review of the various classification systems used to measure patient-physician interaction over a ten year period from 1986 to 1996. Of the 44 coding schemes reviewed, 21 had only been used in a single (published) study and 15 had never been validated. The two most frequently used instruments were IPA and Rotor Interaction Analysis System (RIAS), both of which were deemed to have acceptable degrees of reliability and validity. As RIAS is a specifically tailored medical version of IPA, it was concluded that IPA would indeed be the most suitable coding scheme to use and additional categories would be incorporated where necessary to capture the specific elements which were of interest in the pilot-engineer discourse.

5.2 Research Design

The IPA categorisation scheme (Bales, 1950a; 1950b; 1999) contains 12 content-specific categories (Figure 5.1) which are inherently related to the ability to communicate effectively in order to achieve the desired group goal. The interaction is separated into two dimensions: social and task-based communication. Task-based communication contains the interactions needed to complete the task at hand (the exchange of ideas, information and opinions) while relationships are established and maintained through interactions which contain social and emotional content. Depending on a particular group’s function, composition, and goals, differences will be found in the level of task-based and socioemotional interactions. Six categories (1-3 and 10-12) describe socioemotional communication and six categories (4-6 and 7-9) describe task-related communication. These categories will each be described in turn.



KEY: **a = problems of orientation**
b = problems of evaluation
c = problems of control
d = problems of decision
e = problems of tension reduction
f = problems of reintegration

Figure 5.1 Bales' IPA Categories (1950)

A. Categories 1-3: Positive socioemotional communication.

The first category is for communication which shows solidarity or friendliness. Any act which is considered to demonstrate friendliness such as showing hospitality, affection, approval, appreciation, encouragement, or complementing and expressing gratitude would fall into this category. In addition, greetings and farewells are included in category one.

The second category is for communication which demonstrates tension release or 'dramatizes'. Any act which emphasizes a hidden meaning or emotional implications such as joking, laughter, or the manifestation of a release of tension in a good-natured manner.

The third category is that of agreement. Any act that demonstrates accordance with facts, inferences, hypotheses either by way of encouragement to the speaker or by means of substantiation of content.

B. Categories 4-6: Task-related attempted answers

The fourth category is for communication which gives suggestion and leads the direction of a task. Any act which guides, counsels, persuades in a neutral manner are examples of this category.

The fifth category is for information which gives opinion. Any act which attempts to problem solve, decision-make, offers beliefs, values or references to future time perspectives are scored in this category.

The sixth category is for communication which gives orientation. Any acts which report factual information, verifiable observations and experiences in an objective, non-inferential neutral tone are scored in this category.

C. Categories 7-9: Task-related questions

The seventh category is for communication which asks for orientation. Any acts which involve requesting a factual, descriptive, objective type of answer based on experience, observation or empirical research falls into this category.

The eighth category is for communication which asks for opinion. Any act which seeks interpretation, beliefs, judgements, diagnosis, and level of understanding or insight is coded in this category.

The ninth category is for communication which asks for suggestion. Any act which requests guidance for problem solving and attempts to pass the initiative to the other respondent can be categorized in this way.

D. Categories 10-12: Negative socioemotional communication

The tenth category is that of disagreement. Any act which disagrees with a statement of information, opinion or suggestion falls into this category as does withholding help.

The eleventh category is for communication which shows tension. Any act which demonstrates internal conflict between expected conformity and opposition desires such as nervous laughter, disconcertion or 'holding back'. Reactions to disapproval where the respondent appears embarrassed or chastised are also scored in this category as are expressions of frustration.

The twelfth category is for communication which shows antagonism and appears unfriendly. If a respondent shows antagonism by being disparaging, sarcastic, critical, or being passively aggressive, it is coded in this category.

Figure 5.1 shows the 12 IPA categories arranged by Bales in such a way as to differentiate between the four different communication functions (A-D). The 12 categories illustrate the process of how the particular communication function is achieved. Additionally, Bales references communication pairs (a-f), the purpose of which is to signify *problems of communication* (a), *problems of evaluation* (b), *problems of control* (c), *problems of decision* (d), *problems of tension management* (e), *problems of integration* (f).

In order to capture the specific nature of pilot-engineering communication some additional information was sought based on results from the first study. Whilst the practice of incorporating additional categories as a means of tailoring IPA for a specific study has been undertaken for specific research purposes (e.g. Pena, 2004; Finegold & Cooke, 2006), it was decided that the following supplemental information could be gathered separately without requiring incorporation of additional categories :

1. Time: *Overall length of communication, length of time each speaker communicates*
2. Medium: *Quality of communication medium*
3. Subject: *Topic of communication*
4. Terminology: *Clarifications of understanding*
5. Tone: *Manner between speakers*
6. Information gathering technique: *Open versus closed-ended questions*
7. Listening technique: *Back channel responses (verbalisations of attention to and/or acknowledgement to the speaker e.g. 'hmmmm', 'uh-huh'), interruptions/talk-overs/cut-offs*

Of the above seven categories, both 'Tone' and 'Medium' are subjective measurements and therefore two rating scales were used to facilitate the scoring process. To measure of the quality of the medium, the standard aeronautical 1-5 readability scale was used and a 5-point semantic differential scale was used to measure the tone of each speaker. It was acknowledged that rating a speaker's tone was particularly subjective so an interrater reliability check was conducted on a sample of the data[42] resulting in an interrater reliability agreement value of $\kappa = 0.61$. This scale can be found in Appendix G

5.3 Research Procedure

5.3.1 Data Collection

The second study utilised data in the form of audio-taped discourse between flight crew and engineering personnel at Airline ABC. As detailed in Chapter 2, prior to dispatch flight crew are able to speak to line maintenance personnel either face-to-face or via VHF radio. In addition, at Airline ABC's home base, the Maintenance Operations Centre (MOC) is contactable by VHF radio for aircraft on the ground or airborne (provided the aircraft is within line-of-sight range with the MOC station). For those aircraft which are airborne and beyond line of sight range of MOC, flight crew are able to use the aircraft SATPHONE to contact MOC. Discounting any technical problems, the SATPHONE can be used anywhere on Airline ABC's route structure.

In total, three sources of engineering support are available to flight crew:

1. Line Maintenance. This VHF frequency (131.9MHz) is available for aircraft on the International and Domestic Ramps at Airport A. The frequency is common and shared by various other Airline functionalities such as the Operations Centre,

[42] The data was the sample used for the interrater reliability check of the IPA coding categories. See Section 5.3.3 *Data Coding* below for details.

Load Control, Crew Control and Flight Planning. Pilots requesting to speak with an engineer will pre-fix their message accordingly. In addition, this frequency is also monitored by MOC personnel and flight crew may use this frequency to contact them also.

2. MOC narrow-body desk. This is a phone line (channel 32) to the MOC duty engineer responsible for narrow-body[43] operations (B737, A320). Flight crew can call the phone line directly from either a land-line or cell phone, or if airborne via the aircraft SATPHONE.
3. MOC wide-body desk. This is a phone line (channel 33) to the MOC duty engineer responsible for wide-body[44] operations (B767, B777, and B747). Flight crew can call the phone line directly from either a land-line or cell phone, or if airborne via the aircraft SATPHONE.

The three voice channels listed above are recorded by the airline. The recordings are in a digital format and accessible for a period of three months before being destroyed. Access is provided via an online website which requires a secure log-on and password supplied by the airline to those personnel requiring access. Notification regarding the proposal to access the audio recordings was sought by the researcher in accordance with the Massey University Low Risk Notification Guidelines. Subsequent to the Notification being logged in the Low Risk Database, written approval to access the audio recordings was sought and granted by

[43] Term for aircraft with a single aisle seating configuration.
[44] Term for aircraft with a dual aisle seating configuration.

the Airline in October 2013. Upon receipt of the approval, the process of data extraction began.

The first sample of data which was gathered from the site was for the period 1 December 2013 to 31 December 2013. All VHF calls to Line Maintenance on the 131.9MHz frequency are recorded on a discrete channel within the online website. Whilst accessing the channel and listening to the audio sound files is a straightforward process, the process of extracting the data was reasonably time-consuming because the VHF frequency is used by several different groups for their own requirements. Hence, every audio file recording was required to be opened and reviewed in order to filter those files which met the research criteria. Files which were saved for use in the study were:

1. All calls on the VHF frequency from Airline ABC aircraft to Line Maintenance
2. All calls on the VHF frequency from Airline ABC aircraft to the Maintenance Operations Centre

Files which were rejected for use in the study were:

1. Any calls on the VHF frequency from Airline ABC aircraft to stations other than Line Maintenance or MOC
2. Any calls on the VHF frequency made from flight crew of other airlines

The process was subsequently repeated for the two MOC phone channel lines 32 and 33 which correspond to the wide-body desk and narrow-body desk. Again, as there was no means of determining in advance which audio files were of interest for the study, all in-bound phone call files were required to be reviewed. Files which were saved for use in the study were:

1. Any calls of an operational nature from Airline ABC pilots received on the MOC wide-body desk
2. Any calls of an operational nature from Airline ABC pilots received on the MOC narrow-body desk

All other files containing calls to either the wide- or narrow-body desks at MOC were rejected.

A second sample of data from the MOC phone channels 32 and 33 was extracted in the manner described above for the period 1 January 2014 to 31 January 2014. All audio was saved as digital media (.wav ‘Wave Sound’ files) according to date and the channel of origin. Files were also backed up on secure USB flash drives.

5.3.2 Data Preparation

Excel spreadsheets were utilised for organisation of the data. Each audio file was tagged according to date and channel extraction. The file would then be played and the following information was gathered and attached to the file number within the spreadsheet:

i. Aircraft type
ii. Length of call
iii. Readability of call
iv. Tone of pilot’s voice
v. Tone of engineer’s voice

vi. Purpose of call
vii. Researcher's comments on anything appearing noteworthy

All files were also categorised as to whether they would be suitable for IPA analysis. Suitability was assessed in relation to the amount of interaction which took place between the pilot and engineer who were speaking. During the initial preparation of the data, described above, it became apparent that the majority of calls made on the VHF station would not be suitable as there was insufficient interaction between the two parties. This was due to the fact that the majority of calls from pilots to Line Maintenance were merely simple requests (e.g. from a pilot for an engineer to bring something out to the aircraft) or to pass on information (e.g. flight crew informing Line Maintenance that their inbound aircraft was carrying a defect). In these cases, the calls simply consisted of the pilot talking and the engineer making a brief acknowledgement. However, occasionally more in-depth exchanges took place and where these were deemed suitable for subsequent IPA analysis, a note was made on the file for this to be undertaken. Conversely, all calls from flight crew to either the narrow- or wide-body desks at MOC were substantial and contained multiple communication exchanges and therefore all of those calls were suitable for IPA analysis.

5.3.3 Data Coding

Following the initial data preparation described above, those audio files which were deemed suitable for IPA coding were subject to the following additional analysis:

i. Speaking length – Engineer
ii. Speaking length – Pilot
iii. Number of open-ended questions asked – Engineer

iv. Number of open-ended questions asked – Pilot
v. Number of close-ended questions asked – Engineer
vi. Number of closed-ended questions asked – Pilot
vii. Number of interruptions and/or instances of cut-offs and/or talk-overs – Engineer
viii. Number of interruptions and/or instances of cut-offs and/or talk-overs – Pilot
ix. Requests for repetition (did not hear speaker) – Engineer
x. Requests for repetition (did not hear speaker) – Pilot
xi. Requests for clarification of information provided by the speaker – Engineer
xii. Requests for clarification of information provided by the speaker – Pilot
xiii. Number of back-channel responses made when listening – Engineer
xiv. Number of back-channel responses made when listening – Pilot

For the purposes of data coding, transcription of the audio files was not undertaken. The digital files allowed for unlimited play-backs and were able to be paused and re-wound with ease meaning that the researcher could listen to the communication as many times as necessary during the coding process. The two exceptions to this were as follows:

a) one file was randomly selected and transcribed by way of example to illustrate the coding process; this transcript along with its associated IPA coding can be found in Appendix H.
b) files subject to the interrater reliability check (see below) were transcribed.

The unit for analysis for coding was a single, simple clause i.e. complex and compound sentences were broken down so each clause was allocated a separate code. Fragmented and incomplete speech was allocated a code provided the speech unit itself was able to be interpreted as a meaningful communication act. The codes used in IPA are mutually exclusive content categories and therefore each unit of analysis was allocated only one category from 1-12 (see figure 5.1). Bales himself acknowledged the difficulty that mutually exclusive categories pose given the multi-functional nature of communication (Bales, 1950) and therefore established the following two priority rules to be used during the classification process:

1. View each act as a response to the last act of the other, or as an anticipation of the next act of the other
2. Favour the category more distant from the middle. Classify the act in the category nearer the top or the bottom of the list[45]

The audio file transcripts selected for analysis were coded in chronological order from 1 December 2013 through to 7 January 2014. As the coding process took place over several months, it was decided to undertake an internal reliability test for consistency of coding over time. In order to do so, the first week of transcripts that were coded (December 1 to December 7, n = 19) were re-coded by the researcher in order to determine concordance of codes as well as any variability in the units of analysis. A total of 30 extra speech acts were coded the second time representing an increase of 4% (682 speech acts in the first round of coding, 710 speech acts in the second round of coding). The nineteen transcripts which were recoded provided an exact concordance opportunity of 456 (19 transcripts x 12 categories x 2 groups). Following the recoding, an agreement of 349 was achieved (76.5%). Given that the difference accounted not only for a change in category during the second coding session, but also the

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[45] In reference to the list of categories 1 through 12, the middle, therefore, being categories 6 and 7. The argument put forth is that technically every speech act could be classified as giving and/or receiving information which represent categories 6 and 7 (Bales, 1950).

incorporation of the additional 30 speech units (which automatically precluded concordance to whichever transcript they were assigned to), this was deemed satisfactory. The final six transcripts which were recoded (December 6 and 7) provided exact concordance which indicates the point whereby a stability of coding had obviously been reached as well as consistency with the unit of analysis. With regard to the acts which were reassigned into a different category, it is worthy to note the pattern of change. The task-based interaction areas (categories 4-9) decreased from 77% of the total interactions to 73% of the total interactions, whilst the socio-emotional categories (categories 1-3 and 10-12) increased from 23% of total interactions to 27% of the total interactions. This change is most probably due to the researcher becoming more practiced at following Bales' second priority rule which states that coding should favour the category more distant from the middle by classifying the act in the category nearer the top or the bottom of the list. The researcher acknowledges the criticality in doing so; as was discovered during the coding process, any speech act can technically fall into the middle categories but the resultant interaction profile would not be sensitive to the more subtle, yet just as significant, socioemotional speech.

In addition to the internal scoring consistency check, an interrater reliability check of the researcher's coding was also undertaken. The process of training a second coder was conducted using specifically selected audio files in order to provide examples of all the possible categories. For the subsequent interrater reliability check, ten audio files were randomly selected and these files were transcribed by the researcher[46] prior to being coded

[46] The reason for providing a transcript was twofold. In order to eliminate bias, it was desirable that the coder was not associated in any way with the aviation industry. Given the technical nature of the communication and the difficulties presented by the audio medium, it was decided that having a transcript to refer to whilst listening to the tapes would facilitate better orientation and comprehension of the (cont. on next page)

by the second coder. While Bales himself advocated the use of the chi-square test as a measure of inter-coder reliability for IPA, any non-significant return indicates only that the observed differences between the coders are not more than what would be expected by chance i.e. no inferences can be made about any levels of agreement. Therefore, in order to check reliability, a decision was made to use a standard interrater reliability matrix in order to test the kappa value. Of the 390 speech acts that were coded, perfect agreement was found for 307 giving an interrater reliability coefficient of 0.787 and a Cohen's Kappa value of $\kappa = 0.747$.

5.4 Data Analysis

The data preparation process indicated that a staged analysis would be appropriate as, while not all the audio files were suitable for IPA, all the files did contain information of value with regard to basic interactions between the two groups. For this reason the dataset as a whole (all audio files, $N = 459$) was firstly treated to a basic level of descriptive statistical analysis. These results are reported in Section 5.5.1 and relate to the general communication characteristics of the data such as the nature of the call, length of dialogue, quality of the medium and manner between speakers.

The subset of data which was deemed suitable for IPA ($n = 107$), was then analysed separately. The results from IPA are conventionally reported in tabular form with raw scores from each interaction category converted to percentage scores from which the portions of time spent interacting in each category are charted in order to produce a 'profile'. This profile

conversation. For practicality purposes, having a transcript also eased the process of coding itself as the coder was able to mark the transcript with the codes.

can then be used for comparison against other group interaction profiles and also against a set of scores proposed by Bales as a frame of reference (see Bales & Hare, 1965). Traditionally, consideration is also given to the patterns reflected by the pairwise categorisation of communication functions (a-f, see Figure 5.1) as well as task vs socioemotional patterns (A-D, see Figure 5.1) and both these relationships were analysed for the pilot and engineering groups.

In addition to the interaction profiles and communication patterns, differences between group IPA category scores were tested for significance. Initial review of the raw score distribution skewness and kurtosis suggested that the data might violate the assumptions required for parametric testing. A Shapiro-Wilk test confirmed that the data did indeed violate the assumption of normality and was therefore more suited for non-parametric testing. Consequently, the Mann-Whitney U test was initially selected to examine between-group differences within each of the IPA categories. Prior to performing the tests, however, homogeneity of variance was checked using the Levene test. Data in Categories 1 through to 7 was found to have equality of variance but data in categories 8 through to 12 did not. With regard to heteroscedasticity, the Mann-Whitney U test assumes equality of variance is not violated; variances (and moderate differences in skewness) can adversely affect the Type I error rate (Kasuya, 2001; Fagerland & Sandvik, 2009). In order to compensate, results from statistical data modelling (Zimmerman & Zumbo, 1993; Zimmerman, 1998; Ruxton, 2006) demonstrate that a sound alternative in this situation is to transform raw data which fails a normality test (i.e. non-parametric data) to ranks before performing a t-test for inequality of variance (Welch's t-test). With this in mind both the Mann-Whitney U test and Welch's t-test were conducted, the results of which were comparable (+/- .5) across all categories. The results reported are those of the Welch's t-test. The results from the Mann-Whitney U test can be found in Appendix I.

For the additional communication data that were gathered during the IPA phase (questioning technique, speaker interruptions, clarification requests, repetition requests and back channel responses), differences of significance were tested using either chi-squared goodness of fit or Fisher's exact test. Correlation measures were performed using Spearman's Rank Order correlation. Given the data was treated as non-parametric, boxplots were used for descriptive displays, however, means and standard variations are also reported for supplementary purposes.

An alpha level of .05 was used for all statistical tests.

5.5 Results

The results are reported according to the two stages of coding and analysis which were undertaken. The first section of results focuses on the full dataset of combined audio files which were sourced from the Line Maintenance radio frequency 131.9MHz and MOC phone channels 32 and 33. The second section presents results from the subset of data which was further analysed using the Interaction Process Analysis technique.

5.5.1 Characteristics of the Audio Files

A total of 459 audio file recordings were analysed. Table 5.1 shows the source of the recordings:

Table 5.1 *Source of audio files*

	Date Ranges		*TOTAL*
	1/12/13 – 31/12/13	*1/1/14 – 7/1/14*	
VHF 131.9	362	-	362
MOC channels 32/33	79	18	97
TOTAL	441	18	459

The number of calls made from pilots to engineers on the Line Maintenance frequency 131.9MHz between 1 December 2013 and 31 December 2013 totalled 362. In contrast, there were significantly fewer calls made to the MOC channels; a total of 79 calls were made in the month of December and a further 18 calls were made in the first week of January. The two sources combined provided a dataset of 459 calls.

5.5.1.1 Aircraft Type

All aircraft types flown by Airline ABC were represented in the dataset. Representation is reflective of both the individual fleet sizes as well as the nature of operations; short-haul aircraft fly more sectors thus the majority of the calls (76.3%) were made by narrow-body types. Table 5.2 shows aircraft representation with fleet sizes at the time of data collection indicated in brackets.

Table 5.2 *Number of calls by aircraft type*

Fleet	VHF 131.9	MOC channels 32/33	TOTAL
A320 *(20)*	152	43	195
B737 *(8)*	146	9	155
B767 *(5)*	19	25	44
B747 *(2)*	10	8	18
B777 *(13)*	33	12	45
Unknown	2	-	2
TOTAL	362	97	459

5.5.1.2 Length of Call

The 362 calls recorded on VHF 131.9 from 1/12/13 to 31/12/13 totalled five hours, two minutes and three seconds. The 97 calls recorded on MOC channels 32 and 33 from 1/12/13 to 7/1/14 totalled five hours, forty-two minutes and twenty-three seconds. This provided a combined total of ten hours, forty-four minutes and twenty-six seconds worth of audio on the 459 files. Table 5.3 depicts the length of calls by audio file source.

Table 5.3 *Total length of calls from each audio source*

	Number of audio files	*Total length of all calls*
VHF 131.9	362	05:02:03
MOC channels 32/33	97	05:42:23
TOTAL	459	10:44:26

Average call lengths varied between the two sets of data (see Figure 5.2). As noted in the methodology section above, calls made to Line Maintenance on VHF 131.9MHz were considerably shorter (*M* = 00:00:50, *SD* = 00:00:43) than calls made to the Maintenance Operations Centre (*M* = 00:03:32, *SD* = 00:02:42).

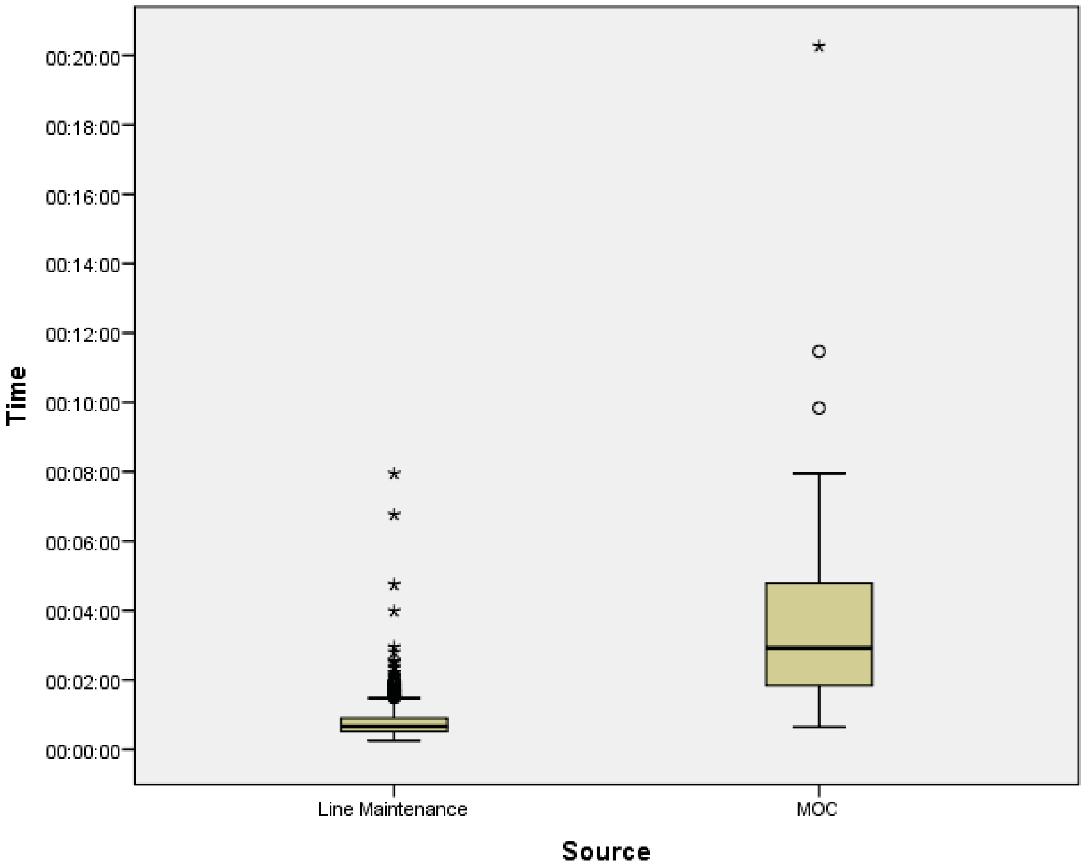


Figure 5.2 Length of calls by source

As the two boxplots illustrate, the distribution characteristics of call length are notably different between the two sources. The vast majority of calls from pilots to Line Maintenance were both shorter and less variable in length (Interquartile Range = 23 seconds) than those put to MOC which is reflective of the different nature of calls as discovered in the data preparation stage. Both sets of data contained outliers[47] all of which were lengthier calls representing occasions where more in-depth discussion took place.

5.5.1.3. Readability of Call

The readability of each call was rated using the standard aviation radiotelephony (RTF) readability scale. The RTF scale measures readability on a scale from 1 (unreadable) to 5 (perfectly readable). The results are shown below in Table 5.4 and Figure 5.3:

Table 5.4 *Readability of audio files by source*

Readability	VHF 131.9	MOC channels 32/33	TOTAL
1 = unreadable[48]	-	-	-
2 = readable now and then	2	12	14
3 = readable but with difficulty	8	10	18
4 = readable	69	37	106
5 = perfectly readable	283	38	321
TOTAL	362	97	459

[47] Standard outliers (greater than 1.5 x Interquartile Range) are represented by circles and stars denote extreme outliers (greater than 3 x Interquartile Range).

[48] Note there were no 'unreadable' calls as any files which were unable to be read were discarded in the initial data gathering stage. While it is acknowledged that this missing data skews the results, this was unavoidable given that for VHF 131.9MHz the common frequency meant that unreadable calls could not be positively identified as pertaining to the data set itself. Similarly, for the MOC channel 32 and 33 calls, it was unable to be determined whether the unreadable calls were those of interest to the study or other non-related calls.

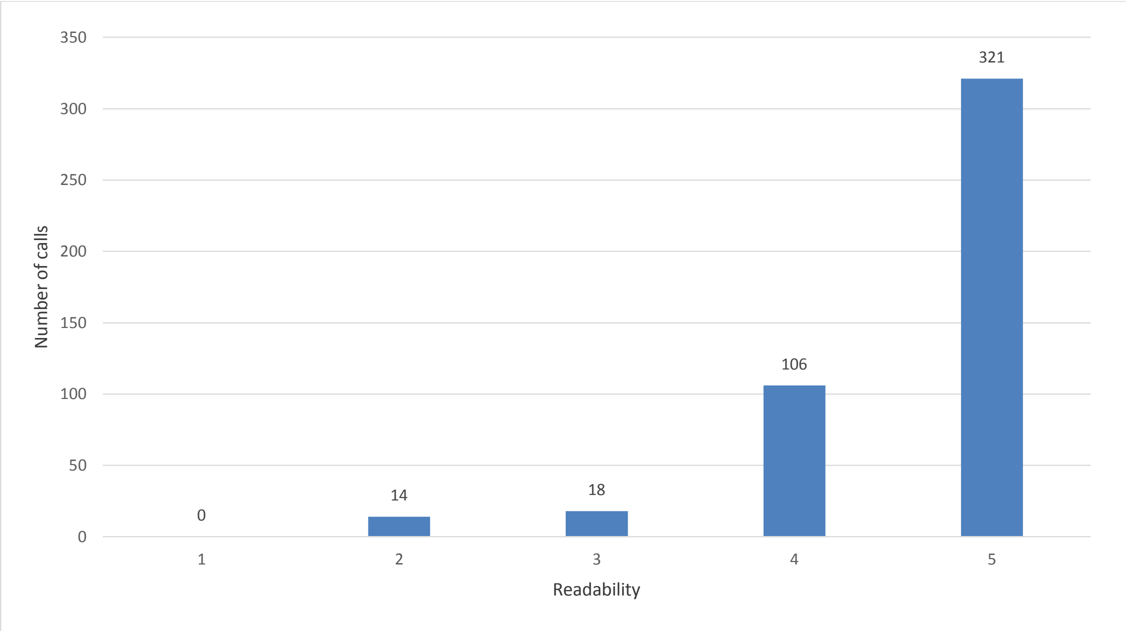


Figure 5.3 Readability of all calls rated on FRTO scale 1-5, *N*= 459

While not necessarily an issue of call quality, a total of 36 calls from pilots on the 131.9MHZ frequency either went unanswered or were answered by another party (e.g. Ramp staff or MOC personnel) in an attempt to help given that Line Maintenance appeared uncontactable. Similarly, there were eight instances where pilots had either called prior to landing on the frequency, or spoken to MOC during flight about a defect but upon arrival of the aircraft Line Maintenance personnel indicated that no message had been passed on to them.

5.5.1.4 Tone of Speakers

All audio file conversations were assessed in terms of each speaker's manner. Tone was measured subjectively on the friendliness scale shown in Appendix G. Scores for pilots are shown in Table 5.5 and scores for engineers are shown in Table 5.6.

Table 5.5 *Friendliness of pilots for all calls*

Tone	VHF 131.9	MOC channels 32/33	TOTAL	%
1 = unfriendly	1	1	2	0.4
2 = somewhat unfriendly	7	16	23	5.0
3 = neutral	254	53	307	66.9
4 = somewhat friendly	89	22	111	24.2
5 = friendly	11	5	16	3.5
TOTAL	362	97	459	100

Table 5.6 *Friendliness of line maintenance engineers for all calls*

Tone	VHF 131.9	MOC channels 32/33	TOTAL	%
1 = unfriendly	2	0	2	0.4
2 = somewhat unfriendly	35	8	43	9.6
3 = neutral	225	61	286	63.7
4 = somewhat friendly	75	25	100	22.3
5 = friendly	15	3	18	4.0
TOTAL	352[49]	97	449	100

Data were subsequently collapsed into three categories (‘Unfriendly’ = Tone 1-2, ‘Neutral’ = Tone 3, ‘Friendly’ = Tone 4-5) for a chi-square test of independence with the resulting $\chi^2(2) = 6.679$, $p = .035$ indicating significance. Pairwise comparison using a Bonferroni-

[49] Note the VHF 131.9 calls do not total 362. Ten files did not contain audio from engineers i.e. a pilot’s call went unanswered, or another party answered on behalf of maintenance.

adjusted p value of .017 showed engineers used unfriendly tones more frequently than pilots $\chi^2(1) = 5.723$, $p = .017$ (Figure 5.4).

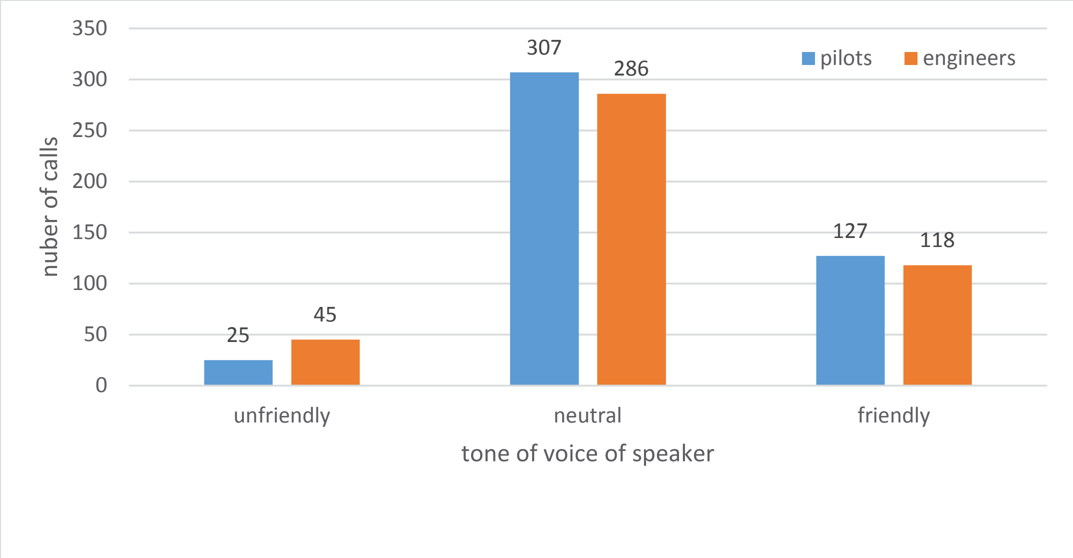


Figure 5.4 Voice tone during 362 operational calls between pilots and line engineers

5.5.1.5 Purpose of Call

All calls (N = 459) were classified as to their purpose. Table 5.7 depicts the purpose of each call which was made on VHF 131.9MH. All calls made to MOC Channels 32 and 33 (n = 97) were classified as 'discussion required' and the subject of those calls is reported in Section 5.5.2.7, below.

A number of the calls made by pilots (n = 32) required maintenance personnel to request further information from the flight crew prior to being able to render assistance. This information was generally of an identifying nature e.g. "*We need your aircraft registration*" or "*which gate are you on?*" There were also six instances whereby pilots directed their issue to the incorrect party, that is, MOC instead of Line Maintenance or Line Maintenance instead of MOC.

Table 5.7 *Purpose of calls to Line Maintenance on VHF 131.9MHz*

Nature of Call	***Explanation***	***Examples***	***Number***
Simple Service Request or Question	Pilot requests an item be brought to the aircraft Pilot asks straight-forward question	'Can we have some Sanicom wipes' 'The ACARS printer needs a new roll' 'We need two extension seat belts' 'Could we have a new headset to the aircraft' 'Do we have brake cooling fans available?' 'Does the aircraft need to be shut down?' 'How far away is the refuelling truck?'	61*
Outbound aircraft at the gate with a problem	Request by crew for an engineer to fix a component/system before aircraft can depart	'The IFE isn't working can someone come out?' 'The flight deck door won't latch, we need an engineer' 'We've noticed a screw missing during the walk-around' 'Can someone come and reset our ACARS, it's locked up' 'A wingtip light has broken, we need it replaced'	64
Inbound aircraft with problem	Pilot gives maintenance a 'heads-up' they are inbound carrying a defect and will be writing it up in the log (needs rectification before next sector)	'We just had a bird strike on final approach' 'We've had a fluid spill in the flight deck' 'Cabin seat has broken, FA has written it up' 'We've had a bleed air issue in flight' 'We're writing a log for a fuel discrepancy on the last sector'	132**+
Discussion required	A more in-depth discussion required before issue can be rectified e.g. paperwork discrepancies, MEL questions, complex defect	'The logbook says the 48hr check is due but we can't find evidence that this has been done' 'The logbook has been signed off but we don't think the problem is fixed' 'This aircraft had an engine run ex-hangar check but there's no evidence in the fuel log' 'We think the aircraft is on the incorrect MEL number' 'We've just had a hung start – is there history on this aircraft?' 'ATSU screen is blank can you talk us through a re-set?	98
Other	Call does not fit any of above categories	Follow-up call e.g. 'did you receive our previous call?' Request to disregard previous transmission Issue has been rectified	7

*On nine occasions pilots requested a service/item that was not part of the line maintenance job functionality.
**Flight crew specifically requested that they wanted an engineer to meet them upon arrival on seven of these occasions.
+ On nine occasions pilots queried whether they needed to write a logbook entry or an engineer reminded them to write a logbook entry.

5.5.2 Interaction Process Analysis

The dataset used for IPA was made up of all data files sourced from MOC channels 32 and 33 (n = 97). Additionally, a total of 10 calls on VHF 131.9MHz were deemed to have enough interaction[50] between the two parties to warrant further analysis using IPA. These calls were added to the MOC-sourced audio files for IPA coding giving a dataset of N = 107. The total length of audio file used for analysis was almost six hours (05:59:15).

5.5.2.1 Speaking Lengths

The length of time pilots and engineers spent talking during their interactions was recorded for comparison. Figure 5.5 depicts the comparative lengths of speaking time per interaction for both groups. The average time spent talking during a call was slightly higher for pilots (M = 00:01:15, SD = 00:00:52) than engineers (M = 00:01:07, SD = 00:01:07). However, as can be seen from the boxplot illustrations, the characteristics of the distribution lengths are very similar in terms of Interquartile Range (pilots = 00:01:04, engineers = 00:01:01) and Median (pilots = 00:00:46, engineers = 00:00:59). Both groups also contained outliers which relate to the particular calls which were longer in duration. Figure 5.6 shows that the distribution of speech during the 107 interactions was approximately one third of the total time each for pilots and engineers, with pauses and silence making up the other third of interaction. In total, pilots spoke for 02:13:04 and engineers spoke for 01:58:47.

[50] Only calls which were over one minute in length and contained at least ten speech acts by one of the parties were considered.

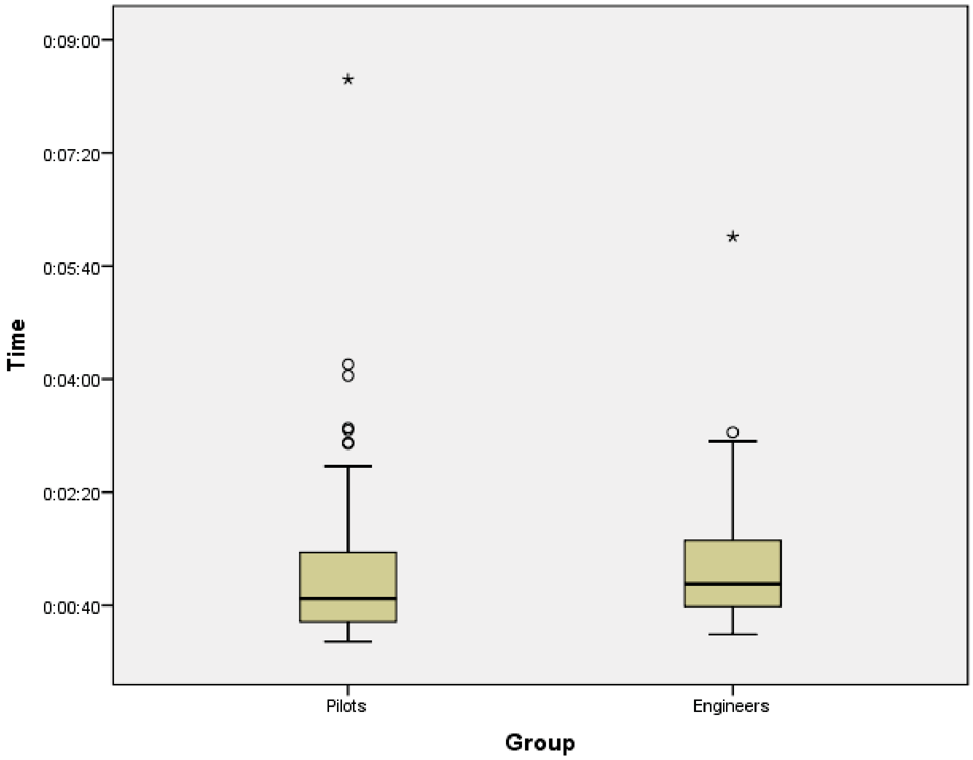


Figure 5.5 Length of speaking time during interactions

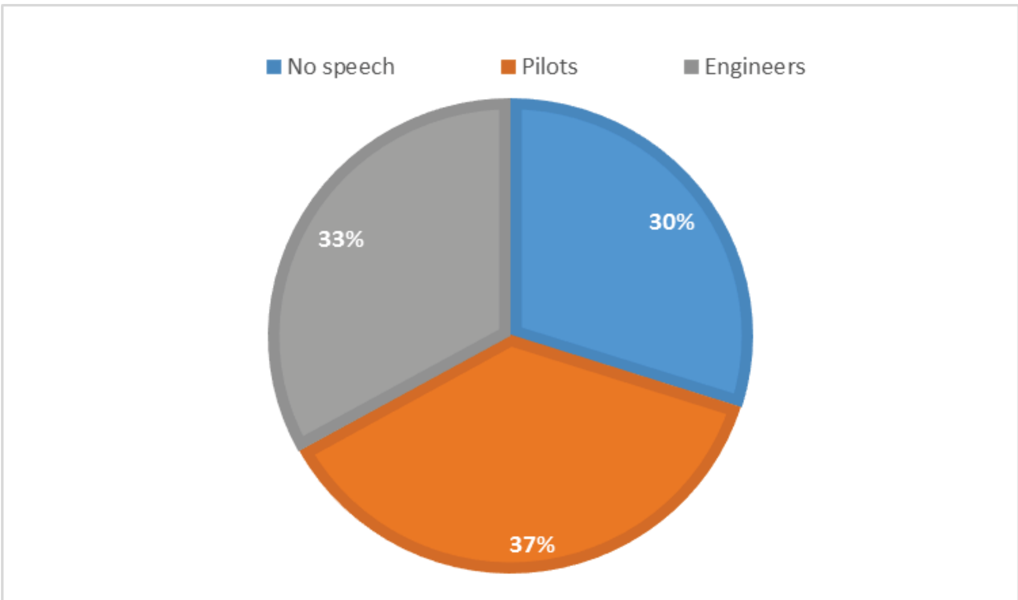


Figure 5.6 Distribution of speech during interactions

5.5.2.2 Distribution of Question Types

Questioning techniques between the two parties were analysed. Table 5.8 depicts questioning preferences for pilots and engineers.

Table 5.8 *Distribution of question types between pilots and line maintenance engineers*

Question Type	Pilots	Engineers	TOTAL
Open	78	50	128
Closed	185	149	334
TOTAL	263	199	462

A total of 462 questions were asked, giving an average number of questions per call of 4.3. Pilots asked 32.2% more questions than engineers with an aggregate rate of one question approximately every 30 seconds of speaking time compared to one question every 36 seconds for maintenance personnel. Both groups used closed questioning to a greater extent than open questioning (Figure 5.7), with engineers asking three times more close-ended questions than open-ended questions. Pilots also used a closed questioning technique over twice as frequently as they used open-ended questions. Results from Fisher's exact test showed that the difference between the distribution of question types between pilots and engineers was not significant (p = .295).

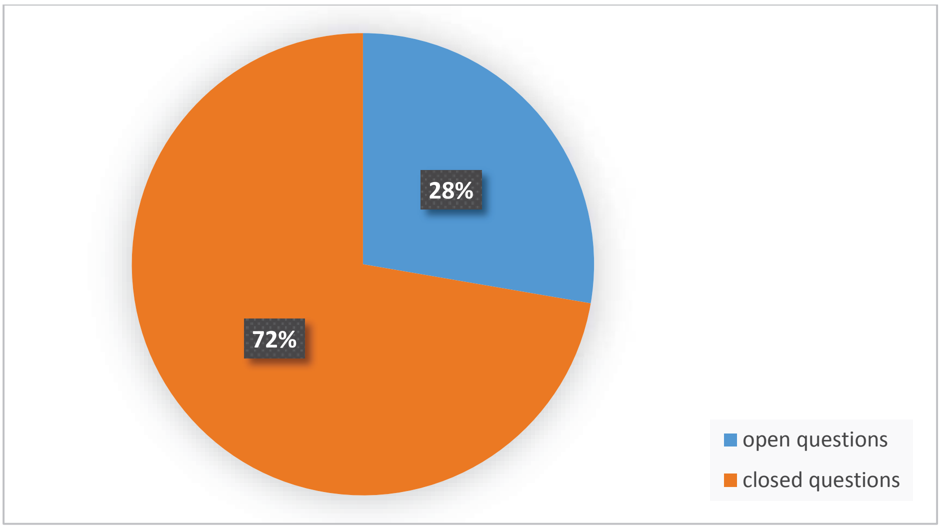


Figure 5.7 Questioning technique used by pilots and engineers during 107 operational calls

5.5.2.3 Interruptions, Cut-offs, Talk-Overs

The frequency of interruptions by the listener during conversation between the two parties was recorded. Table 5.9 depicts the number of interruptions made by pilots and engineers during the other party's speech turn.

Table 5.9 *Total number of interruptions by pilots and line maintenance engineers*

	Pilots	Engineers	TOTAL
Interruptions, cut-offs, talk-overs	167	125	292

A total of 292 interruptions were made, giving an average number of interruptions per conversation of 2.7. Against the total length of all calls (including silence), this accounts for one interruption every 74 seconds. In comparison to each party's speaking length, pilots interrupted engineers once every 43 seconds of speech, while engineers interrupted pilots once every 64 seconds of speech. Using frequency counts of interruptions, a chi-square test for goodness-of-fit showed that the number of interruptions by pilots as compared to engineers was significant $\chi^2(1) = 6.041$, $p = .014$. Figure 5.8 shows frequencies of interruptions per conversation.

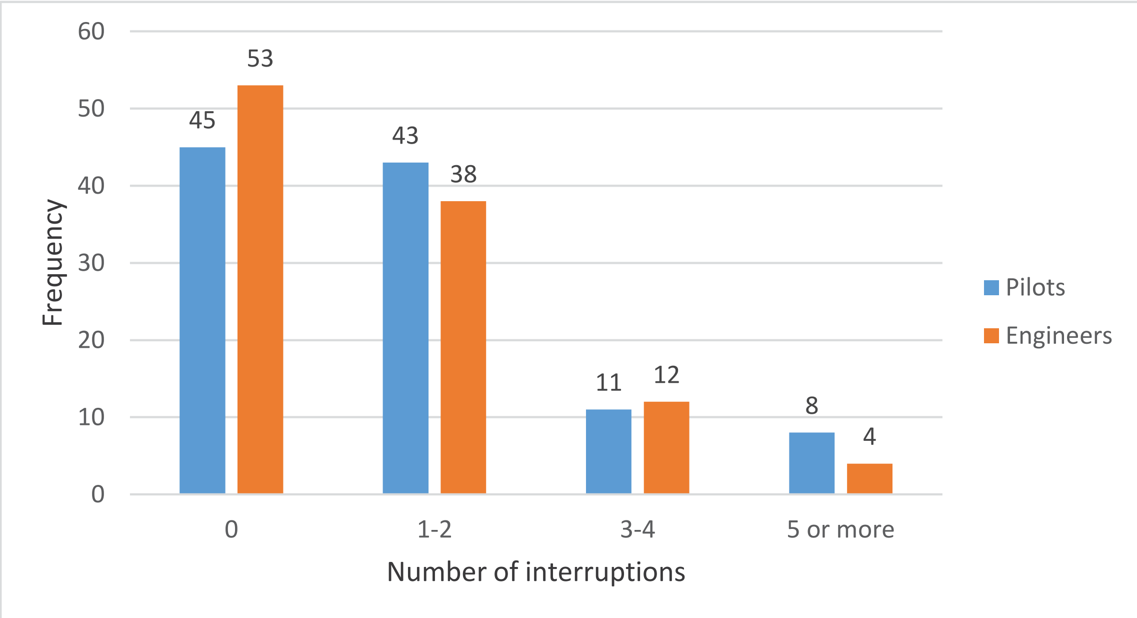


Figure 5.8 Frequency distribution of interruptions per conversation, N = 107

5.5.2.4 Requests for Repetitions

In addition to the readability rating, call quality was also analysed using the number of times a speaker was requested to repeat themselves. Table 5.10 shows the number of times the phrase ‘say again’ or similar was used.

Table 5.10 *Total number of repetition requests made by pilots and line maintenance engineers*

	Pilots	Engineers	TOTAL
Repetition requests	28	16	44

Repetition requests between the two groups was not significant according to a chi-square goodness-of-fit test, ($\chi^2(1) = 3.273$, $p = .070$). Figure 5.9 shows the frequency of requests by either for the speaker to repeat themselves.

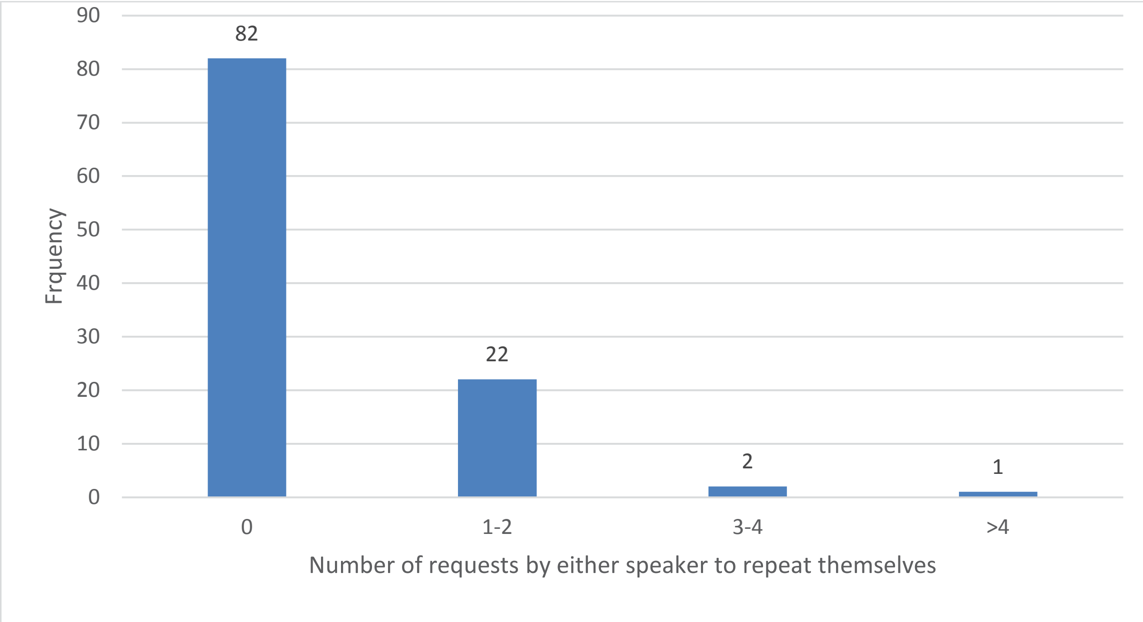


Figure 5.9 Frequency distribution of requests for speaker to repeat themselves per conversation, $N = 107$

5.5.2.5 Clarification Requests

The number of times a request for the speaker to clarify themselves (in order for the listener to understand what was meant) was noted and results are shown in Table 5.11

Table 5.11 *Total number of clarification requests made by pilots and line maintenance engineers*

	Pilots	Engineers	TOTAL
Clarifications	56	64	120

A chi-square test of goodness-of-fit showed that requests for clarification between groups was not significant ($\chi^2(1) = 0.533$, $p = .465$). Figure 5.10 shows the frequency of clarification requests by both parties per conversation. Fifty-one conversations did not require either speaker to clarify themselves, whereas 56 conversations required either one or both parties to clarify themselves at least once or more.

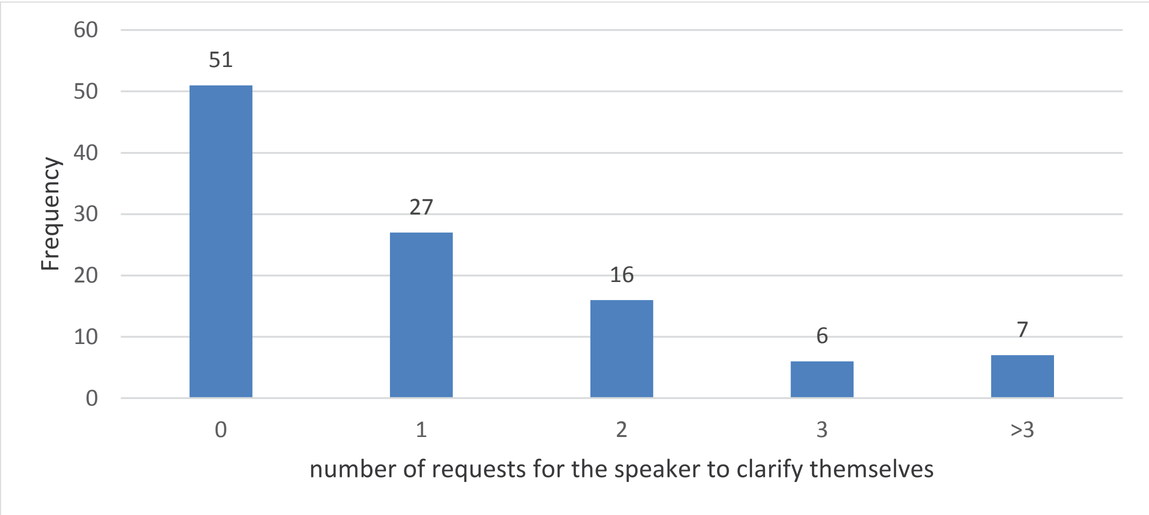


Figure 5.10 Frequency of clarification requests by either speaker per conversation, $N = 107$

5.5.2.6 Use of Back-Channel Responses

Frequency of back-channel responses (verbalisations of attention to and/or acknowledgement to the speaker e.g. 'hmmmm', 'uh-huh'), by the listening party was noted. Table 5.12 shows the number of back-channel responses made by pilots whilst listening to engineers speak and by engineers whilst listening to pilots speak.

Table 5.12 *Total number of back-channel responses made by listening party*

	Pilots	Engineers	TOTAL
Back channel responses	128	213	341

Engineers provided 62.4% of the back-channel responses whilst pilots provided 37.5% of the back-channel responses. Engineers provided more back-channel responses to pilots at a rate of 1.66:1. Figure 5.11 shows the number of back-channel responses by each party per conversation. With regard to the engineering group, there were more conversations which had one or more back channel responses (n = 56) than there were conversations with no back-channel responses (n = 51). Pilots, however, had over twice as many conversations (n = 78) where they provided no back-channel responses, than conversations where they did provide back-channel responses (n = 29). Using frequency counts of back-channel responses, a chi-square goodness-of-fit test showed that the number of these responses by engineers compared to pilots was significant, ($\chi^2(1) = 21.188$, $p < .001$).

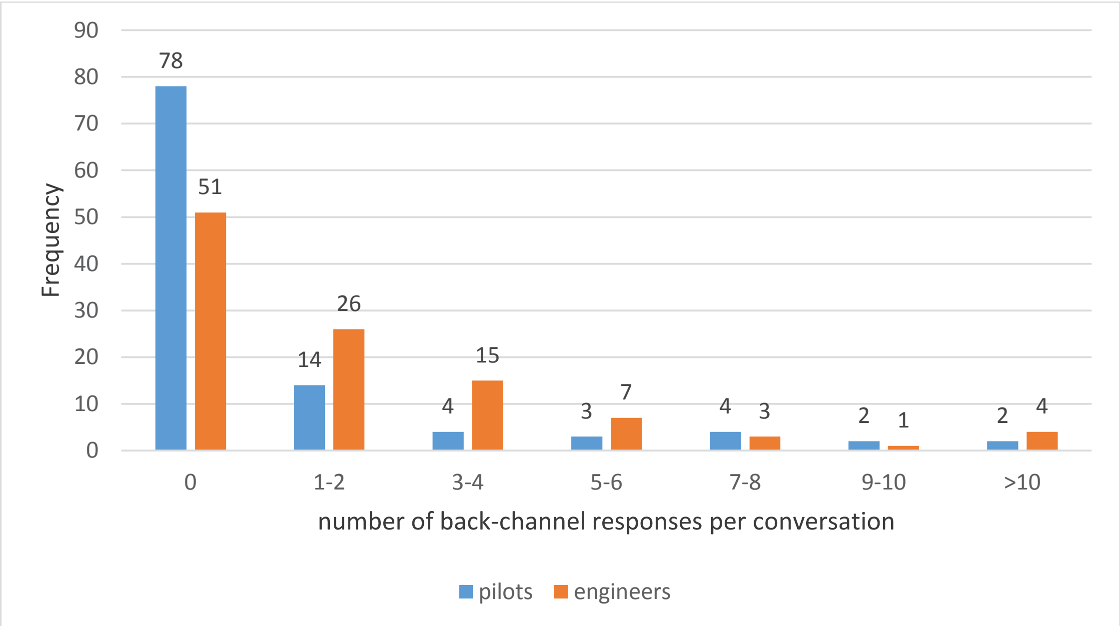


Figure 5.11 Frequency of back-channel responses per conversation, N = 107

5.5.2.7 Subject of Call

Calls were classified depending on the main subject of discussion between the two parties. Table 5.13 shows the nature of conversations for the calls as well as the number of each type of conversation which was analysed using IPA. Note the frequency count is higher than 107 as the subject categories were not mutually exclusive.

5.5.2.8 Interaction Process Analysis Outcomes

A total of 4793 speech acts were coded across the 107 audio files. Table 5.14 shows the raw scores for pilots and engineers according to the 12 categories proposed by Bales (1950a; 1950b) as well as the percentage score which represents the interaction profile for each group. The aggregate score is also calculated in order to produce the combined interaction profile for the two groups. The column on the far right displays what is proposed by Bales as a 'normal' range of percentage scores (Bales, 1970), thus providing a frame of reference by which to compare particular interaction profiles[51].

Figure 5.12 displays the interaction profiles of pilots versus engineers whilst Figure 5.13 and depicts the combined group scores against Bales' suggested upper and lower medium range.

[51] Researchers using IPA typically benchmark against one of the two sets of data published by Bales in order to assess what kinds of situations have similar or different profiles. In 1950, a set of suggested upper and lower limits for each of the 12 categories was provided as a means of assessing the frequency of each type of interaction (Bales, 1950b). The suggested limits were based on 23,000 raw observational scores from all IPA studies which had been conducted by Bales' and his colleagues at that point in time. The fact that these observations had been taken from groups of varying sizes and compositions (i.e. pre-schoolers to adults), led to Bales cautioning "We do not know how badly biased this collection of scores may be as a sample of something larger. They are simply all of the raw scores we have to date on all the groups and tasks we happen to have observed for a variety of reasons" (Bales, 1950b, p. 262). Refined suggested score norms were subsequently published (Bales, 1970) following a meta-analysis of 21 studies using IPA (see Bales and Hare, 1965). All raw scores in each of the given studies were added together to form one percentage profile. For each of the 12 categories, the 21 profiles were divided into thirds to represent the seven highest cases in each category, the seven cases in the middle range and the seven lowest cases in each category. The proposed norms which were subsequently made available (and used in this research) are the medium ranges from the middle seven cases.

Table 5.13 *Subject of call*

Subject of Call	Explanation	Examples	No
Inflight system discussion	Calls from aircraft inflight informing MOC of a system fault/malfunction	We've had an EGT shift do you want the figures for record?' 'The cabin lights are malfunctioning, can you talk us through the troubleshooting process?' 'There's a fuel discrepancy on this aircraft, can you check the paperwork for the previous engine run?	46
Legality to depart	Pilot query regarding aircraft status Pilot concern that aircraft is not fit for flight	'Can we go without a full oxygen complement with X number of passengers on board? 'The exit sign above door 2R is missing, does it need to be there?' 'We're not happy with the fuel leak drip rate being measured by the engineers'	13
MEL discussion	Discussion specifically regarding an MEL e.g. applicability, interpretation	'We think the engineers have written up the wrong MEL in the logbook' 'There are two MELs on this aircraft but the CDL figures for one don't seem right'	10
Paperwork	Discussion involving status of aircraft documentation	'There's a trip number discrepancy in the logbook can you clarify it for us?' 'Is the Notice to Crew regarding the TCAS system applicable to this tail number?' 'Is this Service Bulletin still relevant?'	10
Outstation Guidance	Pilot seeking guidance from MOC as to how to proceed at a station without line maintenance	'How do we write-up the bird strike we had?' 'Can you talk me through the alternate transit certificate paperwork?' 'We've just pushed back and we're getting XXXX ECAM message, can we depart?	17
Other	All other calls not fitting above categories	'Can you tell us how long the damage inspection is going to take? 'We can't get hold of Line Maintenance and there's a placard in the flight deck that needs removing' 'Can you give us any more information on the performance limitations with the reverser locked out?'	13

Table 5.14 *IPA scores for 107 pilot/line maintenance engineer interactions*

	Category	***Engineer Raw Score***	***Engineer %***	***Pilot Raw Score***	***Pilot %***	***Combined Raw Scores***	***Combined %***	***Bales' Estimated Norms %***
Shows Solidarity	1	232	10.1	261	10.5	493	10.3	*2.8 – 4.8*
Tension Release	2	49	2.1	39	1.6	88	1.8	*7.5 – 12.2*
Agrees	3	264	11.5	151	6.1	415	8.7	*12.7 – 19.4*
Gives Suggestion	4	372	16.2	189	7.6	561	11.7	*2.9 – 5.2*
Gives Opinion	5	509	22.1	541	21.7	1050	21.9	*15 – 22.7*
Gives Orientation	6	472	20.5	683	27.4	1155	24.1	*15 – 22.8*
Asks for Orientation	7	169	7.3	147	5.9	316	6.6	*4.0 – 7.2*
Asks for Opinion	8	35	1.5	101	4.1	136	2.8	*1.4 – 2.8*
Asks for Suggestion	9	3	0.1	50	2.0	53	1.1	*0.5 – 1.2*
Disagrees	10	35	1.5	61	2.4	96	2.0	*3.6 – 6.3*
Shows Tension	11	81	3.5	132	5.4	215	4.5	*4.4 – 7.5*
Shows Antagonism	12	82	3.6	133	5.3	215	4.5	*2.4 – 4.4*
		2303	100		100	4793	100	

Figure 5.12 Interaction Profiles of Pilots and Line Maintenance Engineers for 107 interactions

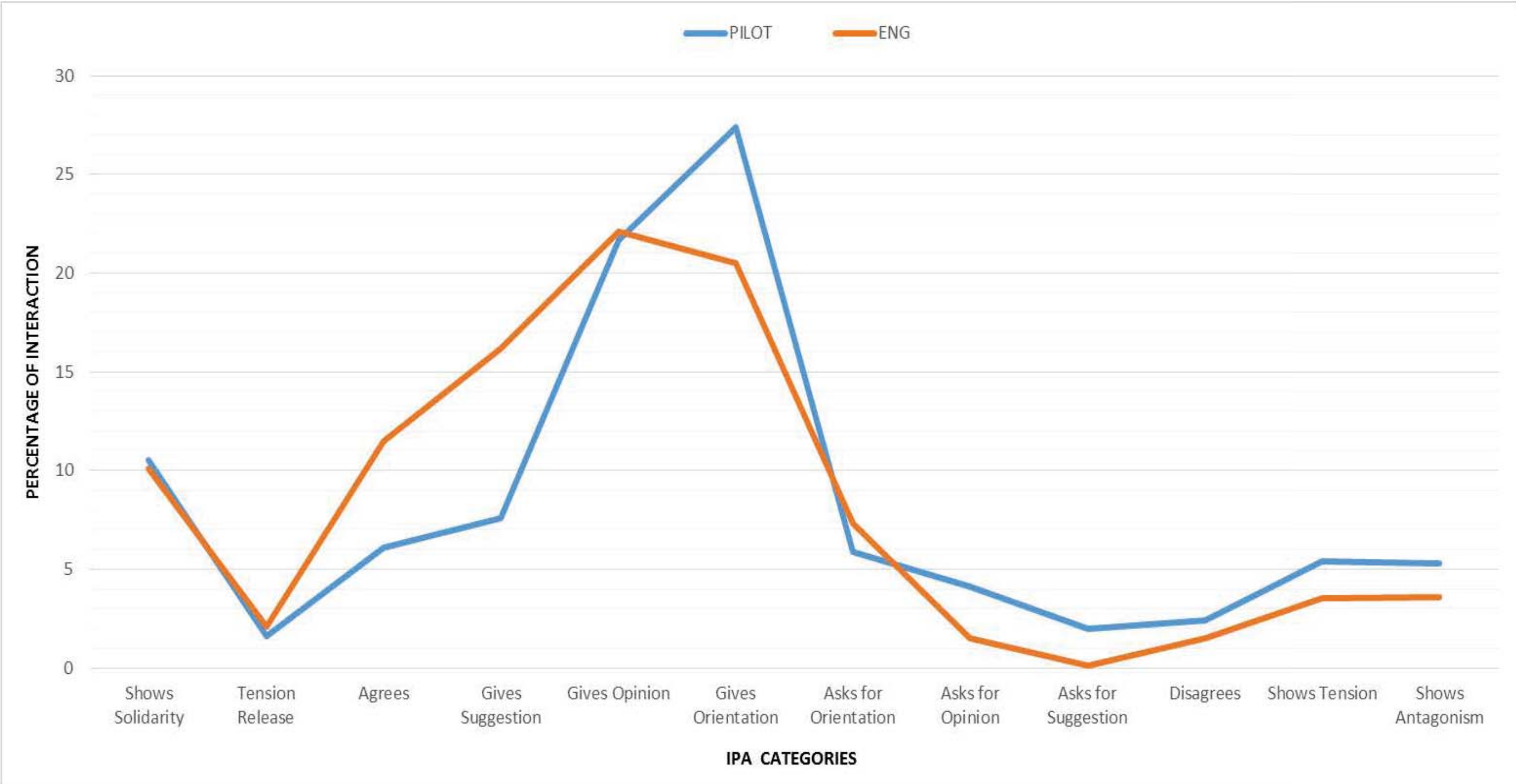
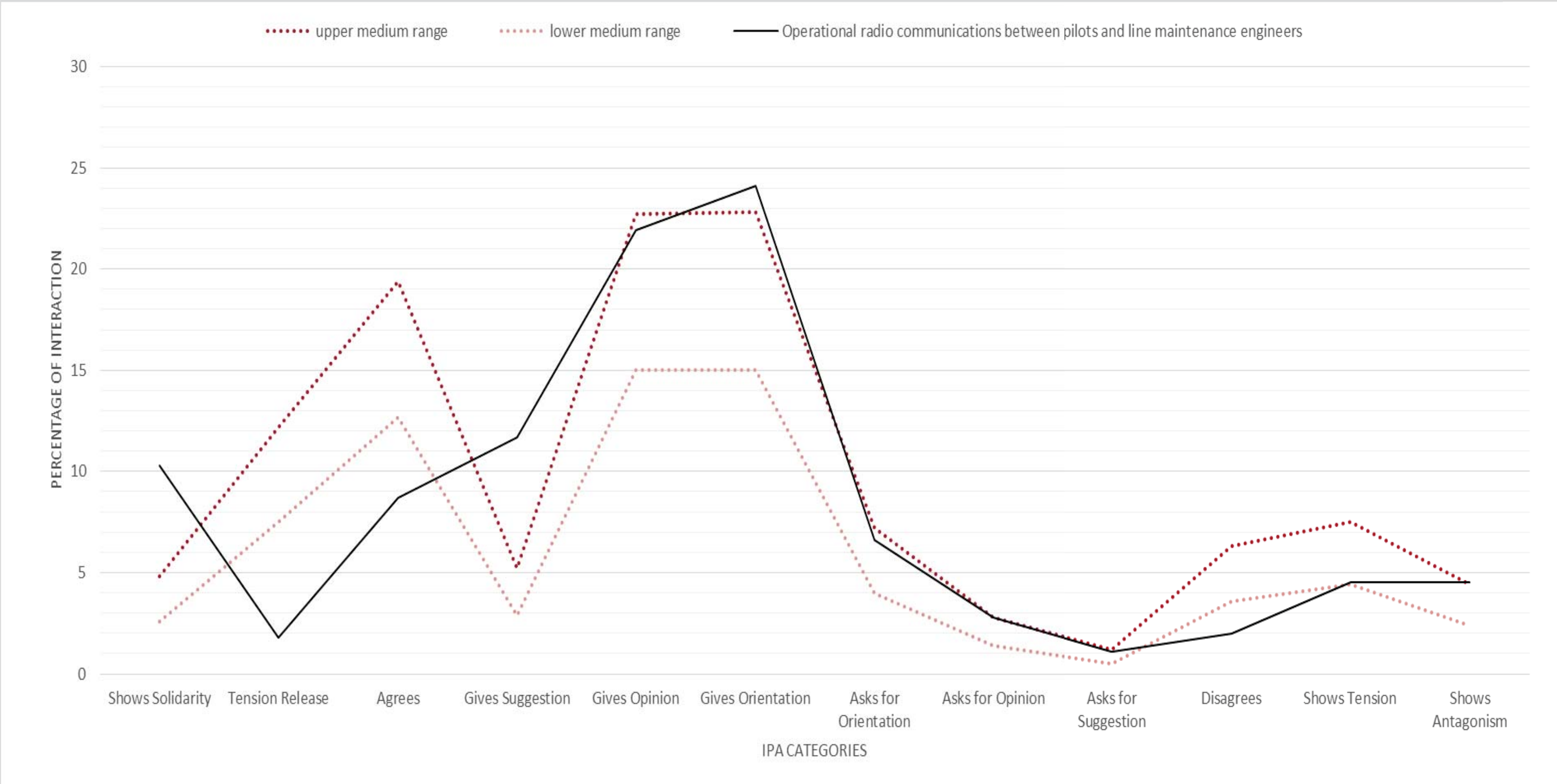


Figure 5.13 Interaction Profile of operational radio communication compared with Bales' suggested medium range



Differences between groups

Raw scores in each category were utilised in order to explore similarities and differences between the two groups. Table 5.15 shows the summary of the raw score data for pilots and engineers across the 12 IPA categories.

Table 5.15 *IPA results for pilots and line maintenance engineers*

	Pilots						Engineers							
					95% confidence						95% confidence			
Category	*Mdn*	*M*	*SD*	*SE*	lower	upper	*Med*	*M*	*SD*	*SE*	lower	upper	*t*	*sig*
Shows Solidarity	2	2.44	1.51	0.15	2.15	2.73	2	2.17	1.50	0.14	1.88	2.46	1.321	.188
Tension Release	0	0.36	0.74	0.07	0.22	0.5	0	0.46	0.92	0.09	0.28	0.64	0.815	.416
Agrees	1	1.41	1.72	0.17	1.08	1.74	2	2.47	2.34	0.23	2.02	2.92	3.760	< .001
Gives Suggestion	1	1.77	1.89	0.18	1.41	2.13	2	3.48	3.89	0.38	2.73	4.23	4.089	<.001
Gives Opinion	6	5.06	4.36	0.42	4.23	5.89	4	4.76	4.84	0.47	3.83	5.69	0.476	.635
Gives Orientation	4	6.38	4.23	0.41	5.57	7.19	3	4.41	3.54	0.34	3.73	5.09	3.699	<.001
Asks for Orientation	1	1.37	2.02	0.19	0.98	1.76	1	1.58	2.44	0.24	1.11	2.05	0.672	.503
Asks for Opinion	0	0.94	1.34	0.13	0.68	1.20	0	0.33	0.84	0.08	0.17	0.49	4.034	<.001
Asks for Suggestion	0	0.47	0.70	0.07	0.33	0.61	0	0.03	0.17	0.02	0.00	0.06	6.276	<.001
Disagrees	0	0.57	1.52	0.15	0.28	0.86	0	0.33	1.05	0.10	0.13	0.53	1.361	.175
Shows Tension	0	1.25	1.98	0.19	0.87	1.63	0	0.76	2.02	0.20	0.37	1.15	1.812	.072
Shows Antagonism	0	1.24	2.38	0.23	0.78	1.7	0	0.77	2.14	0.21	0.36	1.18	1.540	.125

Differences of significance between pilots and engineers were observed in five of the twelve IPA categories. Within the positive socio-emotional categories (1-3), engineers *agreed* (Category 3) with pilots (M = 2.47, SD = 2.34) significantly more frequently than pilots agreed with engineers (M = 1.41, SD = 1.72), $t(194) = 3.760$, p < .001. However, the degree of *friendliness* (Category 1) shown by pilots was not significantly different (p = .173) to that shown by engineers and similarly, the number of acts of *tension release* (Category 2) such as laughter and joking displayed by engineers was not significantly different (p = .809) to pilots.

For the task-based interaction categories (4-9), significant differences were noted between pilots and engineers within four of the categories. In terms of giving direction, engineers *gave suggestion* (Category 4) to pilots (M = 3.48, SD = 3.89) significantly more frequently than pilots gave suggestion to engineers (M = 1.77, SD = 1.89), $t(154) = 4.089$, $p < .001$, while pilots *gave orientation* (Category 6) to engineers (M = 6.38, SD = 4.23) significantly more frequently than engineers gave orientation to pilots (M = 4.41, SD = 3.54), $t(205) = 3.699$, $p < .001$. With regard to requests, pilots asked engineers for their *opinion* (Category 8) significantly more (M = 0.94, SD = 1.34) than engineers asked pilots for their opinion (M = 0.33, SD = 0.84), $t(178) = 4.034$, $p < .001$. Pilots also asked engineers for *suggestions* (Category 9) significantly more frequently (M = 0.47, SD = 0.70) than engineers asked pilots for suggestion (M = 0.03, SD = 0.17), $t(117) = 6.276$, $p < .001$. Differences between the groups within the categories *gives opinion* (Category 5) and *asks for orientation* (Category 7) were not significant.

With regard to the negative socio-emotional categories, although pilots displayed higher frequency of *disagreement* (Category 10) than engineers and also showed more *tension*

(Category 11) and *antagonism* (Category 12) than engineers, there was no significant difference between the groups in either of these three categories, $p > 0.05$.

Table 5.16 depicts the interaction categories grouped into task-based communication and socioemotional communication (categories A-D) with the percentage of time each group spent interacting in them.

Table 5.16 *Distribution between task-based and socioemotional interaction categories*

% of time spent in:	**A (Socioemotional) Positive Reactions Categories 1-3**	**B (Neutral Task-based) Attempted Answers Categories 4-6**	**C (Neutral Task-based) Questions Categories 7-9**	**D (Socioemotional) Negative Reactions Categories 10-12**
Pilots	18.1	56.7	12.0	13.2
Engineers	23.7	58.7	9.0	8.6

Within the communication which served a neutral functionality (i.e. task-based), a comparison of the raw scores which combined to make up Category C revealed that pilots spent a greater proportion of their time with questioning interactions (M = 0.93, SD = 1.5) than engineers, (M = 0.64, SD = 1.64), $t(635) = 2.291$, $p = .022$. There were, however, no significant differences between pilots and engineers with respect to communication which attempted to provide answers (Category B). In relation to the socio-emotional categories, a comparison of the raw scores which make up category D showed that pilots engaged in significantly more negative socio-emotional communication (M = 1.02, SD = 2.01) than engineers (M = 0.62, SD = 1.81) $t(633) = 2.682$, $p = .008$, while engineers engaged in significantly more positive socioemotional talk (Category A) (M = 1.70, SD = 1.90) than pilots (M = 1.4, SD = 1.62), $t(624) = 2.097$, $p = .036$.

IPA research has traditionally considered the amount of time spent on particular problem-solving functionalities. When pilots and engineers are considered together as a dyad (i.e. a pair of entities treated as one), Table 5.17 shows the percentage of time the pair spend engaged in the various problem-solving processes. As can be seen in Figure 5.1, the pairings are made up as follows: (a) gives orientation, asks for orientation, (b) gives opinion, asks for opinion, (c) gives suggestion, asks for suggestion, (d) agrees, disagrees, (e) tension release, shows tension, (f) shows solidarity, shows antagonism.

Table 5.17 *Distribution of interaction across problem-solving functionalities*

Time spent on:	*Raw count*	*% of total speech acts*
(a) Problems of Communication	1471	30.7
(b) Problems of Evaluation	1186	24.7
(c) Problems of Control	614	12.8
(d) Problems of Decision	511	10.7
(e) Problems of Tension Reduction	303	6.3
(f) Problems of Reintegration	708	14.8
TOTAL	4793	100

Finally, the IPA categories for each group were ranked according to the frequency of use (see Table 5.18). The top three categories used by the pilot group were *Gives Orientation* (n = 683), *Gives Opinion* (n = 541) and *Shows Solidarity* (n = 261). The top three categories used by the engineering group were *Gives Opinion* (n =509), *Gives Orientation* (n = 472) and *Gives Suggestion* (n = 372). Whilst the only commonly shared rank was *Asks for Orientation* (pilots n = 147, engineers n =169), there was a strong positive correlation between the rank order of each group $r_s(10) = 0.921$, $p < .001$.

Table 5.18 *IPA category speech acts by frequency of use*

Ranking	Pilot	Engineer
1	*Gives Orientation*	*Gives Opinion*
2	*Gives Opinion*	*Gives Orientation*
3	*Shows Solidarity*	*Gives Suggestion*
4	*Gives Suggestion*	*Agrees*
5	*Agrees*	*Shows Solidarity*
6	*Asks for Orientation*	*Asks for Orientation*
7	*Shows Tension*	*Shows Antagonism*
8	*Shows Antagonism*	*Shows Tension*
9	*Asks for Opinion*	*Tension Release*
10	*Disagrees*	*Asks for Opinion, Disagrees*
11	*Asks for Suggestion*	-
12	*Tension Release*	*Asks for Suggestion*

5.6 Discussion

Analysis of the results indicate evidence of the concerns identified by pilots and engineers in the focus group sessions. The results are now considered in relation to the findings from Study One.

5.6.1 Communication Ability

During the focus group sessions, there was acknowledgement from both groups that pilots struggled to communicate effectively using the logbook medium. However, both the pilot group and the engineering group indicated a perception that pilots were superior in terms of general communication ability, a belief attributed to the fact that pilots were afforded better communication training as part of their job. Yet in this study of the spoken medium, markers traditionally accepted as being indicative of good communication were displayed more frequently by engineers. When assuming the listening role during their interactions with pilots, engineers used back-channel responses significantly more frequently than pilots, a trait typically attributed to being an accomplished listener (Duncan, 1972; Berko et al., 1995; Ward & Tsukahara, 1999). Furthermore, when pilots assumed the listening role, they made significantly more interruptions than engineers did, displaying a trait which is generally not associated with good communication skills (Berko et al., 1995). While this is insufficient evidence to make a general statement that one group is superior in terms of communication ability, it does argue against the claim made in the focus groups that pilots are ‘better’ communicators than engineers.

Analysis of the results revealed both similarities and differences in the way in which pilots and engineers communicate. With regard to speaking length, neither group dominated the other when they interacted; speaking length was relatively balanced with each group’s speech making up roughly a third of the total interaction time. Similarities between the two groups were also evident with regard to the way in which they framed their questions with both groups preferring a closed questioning technique over open questioning. This result is insightful as had one group preferred a different method than the other, it may have been indicative of a naturally different communication style leading to potential frustrations when interacting. There were also similarities between the two groups in their patterns of communication with regard to the various IPA speech acts. The rank order of each of the 12 categories was very similar between the groups with a strong correlation between pilots’ and engineers’ preferred communication functions. These findings suggest that the two professions share comparable communicative styles with regard to the fundamental elements of speech. Had either group dominated the interaction or there was a marked contrast in the way pilots and engineers structured their transmissions, any move towards improving the communication between the two groups may have included additional challenges.

5.6.2 Communication Medium

One of the concerns which emerged from the focus groups was the fact that the media used for communicating were hindering effective communication between the two professions. The medium for interactions in this study was the radio and while the quality in terms of "readability" was generally good, there were several instances where conversations took place on a poor line and requests for repetition had to be made. Whenever this occurs, frustration can arise and the potential for a miscommunication increases. This was noted during the analysis; when listening to calls of poor quality there were occasions where one or both of the parties resorted to shouting in an attempt to be heard.

In terms of building rapport between the two speakers, the radio does not lend itself to lengthy conversations, particularly on the common frequencies where extraneous talk is generally discouraged so as not to 'tie up' the channel for other parties wishing to use it. This was evident by the fact that the average call time between pilots and engineers on 131.9MHz was only 50 seconds, well short of the four minutes that Zunin and Zunin (1974) argue are critical in establishing rapport. Additionally, operational pressures such as OTP are possibly influencing the brevity of communication exchanges with Line Maintenance. Given the evident difficulty pilots had contacting Line Maintenance on occasion, it is not particularly surprising that when an engineer was eventually found, even less time remained for pleasantries. Mutual and courteous introductions have been recommended as a means to establish a positive working environment between pilots and flight attendants (FAA, 1988; Kirvonos, 2005; 2007, Ford, 2011), however, this did not always happen in the communication exchanges between flight crew and engineers. The results from the calls which were analysed using IPA showed that approximately 12% of time was spent engaged in the friendly acts of *showing solidarity* and *tension release*, but it was noted that only some speakers took the time to establish a friendly connection with the other party. While some speakers asked how the listener was or used their name throughout the conversation, others did not bother to introduce themselves save for a job title, leaving the other party in the dark as to whom they were conversing with.

While the logbook as a medium was not the focus of this study, the frustrations the two groups shared during their focus group sessions were evident during the present study. Many of the calls pilots initiated to engineers concerned questions regarding the status of the logbook or interpretation of an entry. Indeed, issues with terminology, one of the impediments identified in Study One, became apparent when listening to the communication exchanges. Clarifications with regard to what the speaker meant when they were describing an issue were requested in over half (52%) the IPA audio files and, on more than one occasion, a pilot admitted to an engineer they probably were not describing a defect particularly well. Given the frequency that the two professions queried terminology during their radio conversations, it is understandable that when the logbook is the sole communication medium there are opportunities for misunderstandings.

5.6.3 Sources of Conflict

Based on the findings from Study One, it was expected that a certain amount of conflict would be evident in the communication exchanges. Using the IPA categorisation system, a quantitative measure of conflict could be made as socioemotional communication is used both to engage in, and manage conflict. Discussion without conflict fell into the

‘Task-Neutral’ categories (4-9). These speech acts involved non-emotive exchanges between the two parties and took the form of giving and receiving *orientation*, *opinions* and *suggestions*. Discussion which did involve conflict was measured in categories 10 – 12. Task-related conflict was classified by category 10 (*disagrees*), which was a measure of a negative reaction but only in relation to the subject at hand i.e. non-emotive. Interactions which fell into categories 11 (*shows tension*) and 12 (*shows antagonism*) were used as the measure of interpersonal conflict in line with the definitions provided by Jehn (1995).

There were several findings of interest with consideration to sources of conflict between the two groups. Firstly, however, it should be noted that the majority of interaction between pilots and engineers (68%) was spent in the task-neutral categories implying that the bulk of communication between the two groups took place free of any discord; a positive finding in terms of professional interaction. An inability to balance socioemotional interactions with task-based exchanges may have been indicative that conflict was not being adequately managed and threating the ability to communicate effectively. Notwithstanding, when determining what would be an appropriate level of socioemotional communication for pilots and engineers, consideration should be given to what might be expected of this group in terms of previous IPA research. Bales’ ‘norms’ are based on results from experimental groups within controlled settings and subsequent studies have shown that work groups (as opposed to social groups) tend to have considerably lower levels of socioemotional interaction, including conflict (Landsberger, 1955; Gameson, 1992; Bell, 2001; Atwal & Caldwell; 2005; Gorse & Emmitt, 2007). Moreover, socioemotional interaction tends to occur in the later stages of a group’s development once members have had exposure to the prevailing attitudes and opinions of the group (Bales, 1950a; 1970). IPA research indicates that typical levels of socioemotional interaction are not achieved in temporary groups (Gameson, 1992). All other things being equal, it would therefore be expected that pilots and engineers would have less socioemotional communication than the norms proposed by Bales as they are interacting for only brief amounts of time about work-related matters.

With regard to task-related conflict, both groups scored below the lower limit provided by Bales as an indication of a 'normal' range (3.6% – 6.3%) in category 10. However, while this could be suggestive of a low level of task-related conflict, the fact that interpersonal conflict with regard to the combined score in category 12 was 4.5% (at the higher end of the 'normal' range of 2.4% - 4.4%) may be indicative of the blurred relationship between the two types of conflict as suggested in section 3.11 of the literature review. The fact that the IPA categories are mutually exclusive added to this complexity. For example, the subject matter of a particular communication exchange may have been task-related (e.g. the MEL, an aircraft system or the logbook) but the moment any tension or unfriendliness was expressed, the speech act was assigned to categories 11 or 12, supporting the claim (Pelled et al., 1999; De Dreu & Weingart, 2003) that the presence of one type of conflict is often accompanied by the presence of the other.

Whilst the two types of conflict cannot be entirely differentiated, what is of interest is that both groups showed *tension* and *antagonism* more frequently than the less-emotive category of *disagreement* indicating that once any difference of opinion does arise, it is more likely to be handled in a negative and unconstructive manner. This is especially true of the pilot group who used significantly more negative speech acts than engineers and also registered a higher score than Bales suggested norm for acts of *antagonism*. This is particularly unusual for dyadic interactions whereby scores in category 12 are typically significantly lower than the norms provided by Bales (O'Dell, 1968; Bales, 1999). Thus the engineer group score of 3.6%, despite being within the normal range for *antagonism* might also be considered as high for a two-person interaction. This is possibly reflective of the operational pressures facing pilots and line maintenance engineers and certainly lends evidence to an outward display of the frustrations which were raised during the focus group sessions.

Given the outcomes from the focus group, it was somewhat unexpected to see that both pilots and engineers scored well above the normal range in category 1, *shows solidarity*. One explanation for this is that the data Bales used is drawn from longer interactions such as meetings and discussion groups (Bales, 1970). Greetings and farewells are marked in Category 1, both of which take up a certain amount of time and therefore attribute a higher percentage of interaction if the conversation is brief as in the case of the phone conversations. Tension release by both pilots and engineers is also markedly lower than the norms proposed, however, this is supported by the research on dyads using the IPA system (O'Dell, 1968; Bales, 1999) which shows that tension release is significantly lower in groups of two.

5.6.4 Themes affecting the Intergroup Relationship

Examination of the communication exchanges provided evidence of issues which had been identified as contributing to a problematic intergroup relationship. The lack of physical contact between the two groups was notable by the number of times pilots either requested an engineer to come to the aircraft or engaged in in-depth system discussions which would perhaps have been more easily conducted in person. Also observable was the lack of understanding regarding the engineer's job role as evidenced on the occasions where flight crew requested services which were not part of the line maintenance function or queried as to whether they should be writing up technical logs for maintenance discrepancies. A lack of information such as gate numbers or aircraft registration appeared to cause frustration for engineers, and the reminders which were given to flight crew that they must write up a technical log insinuated that engineers were not altogether confident that this would occur. Concerns which had been raised by pilots in the focus group sessions were also present in the communication exchanges. Reservations about the aircraft's legality to despatch and doubts surrounding the application of the MEL were both subjects of discussion between flight crew and MOC engineers.

The frustrations which are contributing to discord between the two groups appear to be reflected in the use of negative socioemotional speech and negative voice tones during some communication exchanges. When the speaking party engages in such behaviour, it may create a negative impression with the listener which further fuels an unhealthy perception of the out-group, as identified in Study One. With the communication medium and specialised terminology already exacerbating the attempts to communicate across the professional boundary, a vicious circle of poor intergroup communication forms, similar to that described by Eiff and Suckrow (2008). With reference to the conceptual model developed in the previous chapter, findings from the second study can now be incorporated as shown in Figure 5.14

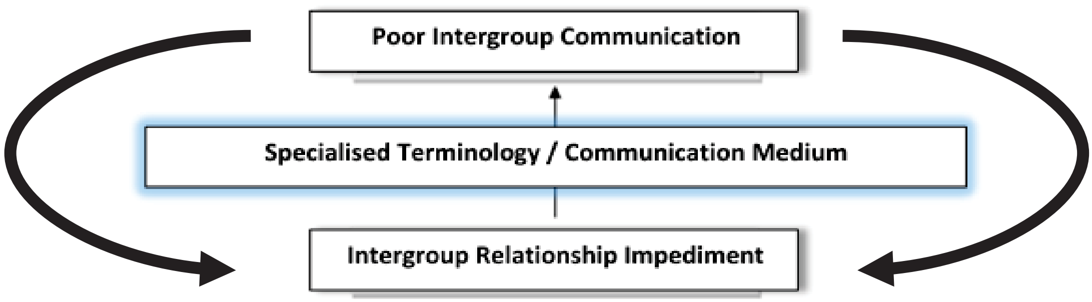


Figure 5.14 Evidence of poor intergroup communication supports the concept of a vicious cycle

5.7 Summary

This study aimed to explore communication between airline pilots and maintenance personnel within an operational environment. Analysis of audio recordings facilitated the investigation of numerous interactions between flight crew and maintenance engineers and provided insight to communication exchanges utilising a medium which has previously not been examined in this context. The use of Interaction Process Analysis allowed the communicative functions of the operational interactions to be discovered thereby revealing the balance of socioemotional and task-related discourse between the two groups as well as the type of conflict which presented.

Overall, both pilots and engineers have similar communication structure and style when interacting in an operational environment. This includes the tendency to use speech acts which are deemed to reflect interpersonal conflict more frequently than task-related conflict, despite the source of the conflict events being operationally (task) related, which is possibly indicative of the problematic intergroup relationship. While the majority of time communicating was spent engaged in the non-emotive task-related functions of sharing information and opinions, the level of socioemotional interaction is considered relatively high given the group composition (dyadic), function (temporary), and goals (work-related). Poor communication indicators such as negative tone of voice and speech acts categorised as antagonistic only serve to impede a healthy intergroup relationship. Findings from this study also supported a number of the concerns which were raised by pilots and engineers in the focus group discussions. Difficulties with both the radio and logbook as communication mediums were evident as were differences of opinion over the MEL and a lack of understanding of the engineering job function.

With an understanding of the impediments which are affecting communication between pilots and engineers, the third stage of the research now moves to explore the consequences of problematic interactions in relation to airline operations and flight safety.

CHAPTER SIX

Operational and Safety-Related Implications Associated with Pilot-Maintenance Interface Issues

The identification of the impediments to effective communication between pilots and line maintenance engineers along with the investigation of their operational interactions, set the stage for Study Three. This explores more directly the effects of communication difficulties between pilots and maintenance personnel with regard airline operations and flight safety. It might logically be assumed that poor communication between the two groups will manifest itself in some undesirable ways, yet, to date, this has not been studied. With this in mind, the following research questions were developed:

How do the impediments which were identified by pilots and line maintenance engineers affect airline operations and flight safety?

i) *Can problematic interfaces between flight crew and maintenance personnel be associated with events which negatively impact on airline operations?*

ii) *Can problematic interfaces between flight crew and maintenance personnel be associated with events which negatively impact on aircraft safety?*

This study seeks to explore the associations between pilot and engineer discord and any negative ramifications this has on airline operations within a global context. In line with the previous chapters, this chapter details the research methodology and results of the third study and concludes with a summary discussion in which the findings are considered in relation to the research questions.

6.1 Method

6.1.1 Research Design

The first two studies took place at Airline ABC, however, using the organisation as a setting for the current study presented difficulties in terms of the research design. Specifically, in order to map associative relationships, a large data sample was required if the results were to be presented with confidence. The data was therefore sourced from the United States Aviation Safety Reporting System (ASRS) programme in the form of confidential safety reports submitted by flight crew and engineers to the ASRS database which is administered by the National Aeronautics and Space Administration (NASA). By utilising a large database of reports, those occurrences applicable to the study could readily be acquired in sufficient numbers to add confidence to the findings.

For this study, reports of interest were deemed to be those specifically concerning deficiencies in the interface between flight crew and maintenance personnel. It was anticipated that these problematic interface events would take the form of those impediments to effective interactions identified in the previous two studies. Reports would therefore be coded, firstly according to the nature of the issue at hand, and secondly by the outcome in terms of effects on flight safety and/or the airline operation. As the database only contains reports relating to adverse events such as incidents and accidents, the design of the study was such that it would not be possible for the results to be representative of all maintenance-flight crew interactions. While the study design precluded the ability to present data associated with positive outcomes for flight safety and airline operations, the ASRS database has proven to be well-suited to in-depth examination of associations between contributing factors and adverse outcomes (Hobbs & Kanki, 2008b; Bao & Ding, 2014) thus making it a good source of data for this particular study. Since the information available to the researcher was limited to those details submitted by the reporter, it could not necessarily be assumed that there were direct causal relationships between particular impediments and consequences.

To explore patterns of association, Correspondence Analysis (Benzécri, 1969) was selected as a suitable analytical technique. Similar to Principle Component Analysis, but using categorical variables as opposed to continuous data, Correspondence Analysis (CA) portrays multivariate relationships within and between row and column points of a data matrix by their physical closeness on a perceptual map (Malhotra, Charles & Uslay, 2005). The technique utilises chi-square equations to determine similarities between the frequencies of each cell in a contingency table and the categories are then represented on the map by points based on the chi-square (Euclidean) distances between the categories; points having a stronger association are proximal and those with a weaker association are further apart (Doey & Kurta, 2007). The data within a contingency table are multidimensional, however, CA reduces the number of dimensions of the perceptual map so that it can be easily visualised (i.e. a bi-plot). According to Greenacre (1984; 2007) the gains in interpretability far exceed the small loss in accuracy that occurs from reducing the dimensions of the map. While the axes of the map are simply mathematical constructs and therefore not required to interpret the display (Gittins, 1990), the significance of association of the contingency table is measured by 'inertia' which is the spread of points around the axes origin using Pearson's mean-square contingency co-efficient (Malhotra et al., 1990). Inertia is calculated as the weighted average of squared chi-square distances between row and column profiles and their average profiles (Benedixen, 1996). With the origin of the map being considered the centroid of expectations, if the points are significantly distant from the origin, the null hypothesis (that the array is no different than expectations) can be rejected (Malhotra et al., 2005).

CA is an exploratory data analysis technique where no assumptions about underlying data distribution are made, rendering it well-suited for use where no *a priori* hypothesis has been formed (Greenacre & Blasius, 1994). As described above, one of the main benefits of employing CA is that it can be particularly useful in transforming the complexity of large data tables in order to reveal the associative relationships between variables. Whilst the method itself is traditionally associated with the biological sciences and market research (Doey & Kurta, 2011), within the field of aviation CA has been employed to analyse global airline industry perceptions (Kaynak, Kucukemiroglu & Kara, 1994), adventure tourism safety (Bentley, Page, Meyer, Chalmers & Laird, 2001), patterns in maintenance error during aircraft servicing (Hobbs & Kanki, 2008b) and contributing factors to maintenance error (Bao & Ding, 2014). These latter two studies utilised reports from the ASRS database with Hobbs & Kanki (2008b) praising the use of CA, declaring that as a tool designed for exploratory analysis, the method showed promise for use in large-scale database analyses. As the ASRS database was known to contain reports relevant to this research (see Section 1.2), it was decided to utilise this resource for the current study.

6.1.2 Data Source

The ASRS program is recognised as being the world's largest source of information pertaining to aviation safety and human factors, having received over 1.1 million reports since its inception in 1976 (NASA, 2014). Reports are submitted by a range of aviation professionals including flight crew, cabin crew, air traffic controllers and, since 1996, maintenance personnel. The system is designed as a confidential, voluntary and non-punitive means of collecting information regarding unsafe aviation events for the purpose of identifying deficiencies in the United States aviation system. Report forms are designed in such a way as to collect both standard information surrounding an event (e.g.

time, date, location) as well as a detailed narrative from the reporter including human performance considerations such as the chain of events, decisions which were made, and perceived contributing factors. When reports are received they are reviewed and coded by aviation analysts who may contact the submitter for more information. The de-identified reports are subsequently made available to the public via the electronic database which is accessible on the ASRS website (www.asrs.arc.nasa.gov) and reports dating back to 1988 are obtainable in this manner. Searches of the database are conducted either by selecting particular fields of interest in line with the ASRS coding taxonomy (e.g. aircraft type, flight conditions, type of event) or word-specific searches captured within the submitter's narrative. Results which are returned can then be exported in various formats depending on the user's requirements and for the purposes of the current study, Excel spreadsheets were utilised.

6.1.3 Research Sample

The data of interest were broadly defined as being any reports concerning situations where the interface between flight crew and maintenance personnel was seen to be deficient due to difficulties communicating with each other. This covered instances where pilots and engineers interacted directly, as well as occasions of indirect contact, such as communicating via the logbook. Situations where flight crew sought maintenance-related information through a secondary source such as the MEL or other documentation was also included.

To obtain reports which would be relevant to this study, two data downloads covering a ten year period were made. The first retrieval was designed to capture pilot-engineer interactions taking place on the ground and used the following query:

Date of Incident: between January 2005 and January 2015

AND Federal Aviation Regulations: Part 121

AND Event Type: Aircraft Equipment Problem (Critical OR Less Severe)

AND Reporter Function: Captain OR Check Pilot OR First Officer OR Lead Technician OR Technician

AND Flight Phase: Parked

The second retrieval was designed to obtain pilot-engineer interactions which took place during flight. To reduce the potential return of non-relevant reports associated with airborne events, additional filters were used for this query:

Date of Incident: between January 2005 and January 2015

AND Federal Aviation Regulations: Part 121

AND Event Type: Aircraft Equipment Problem (Critical OR Less Severe)

AND Reporter Function: Captain OR Check Pilot OR First Officer OR Lead Technician OR Technician

AND Detector: Flight Crew OR Maintenance

AND Flight Phase: Taxi OR Takeoff OR Initial Climb OR Climb OR Cruise OR Descent OR Initial Approach OR Final Approach OR Landing

AND Contributing Factors: Aircraft OR Human Factors OR Logbook Entry OR MEL AND Human Factors: Communication Breakdown OR Time Pressure OR Confusion OR Troubleshooting

The two queries provided 1187 and 2995 reports respectively. Approximately three quarters of the reports were not applicable to the study[52], however, rather than refine the search criteria further and risk not capturing relevant events, the two sets of reports were

[52] These were the reports that were captured by the search criteria but did not concern the pilot-maintenance interface e.g. malfunctioning equipment during flight that the pilot attended to without input from maintenance, self-reported maintenance errors from aircraft engineers. Also excluded were reports which lacked sufficient detail for analysis.

instead screened by the researcher. Following screening of the reports, which also included removal of duplicates and reports which lacked sufficient detail, a resultant data set of 1100 reports remained for coding and analysis. Of the 1100 reports analysed, 1055 were submitted by flight crew (95.9%) and 45 (4.1%) were submitted by maintenance personnel. This was deemed to be representative of the demographic of aviation personnel who submit reports to the ASRS programme[53].

6.1.4 Data Coding

The reports were coded so as to create two variables for analysis. The first category of codes, (A), was labelled '*Reported Issue'* and were representative of the problematic interface between flight crew and maintenance personnel. These codes provided the descriptors to encapsulate the nature of the concern or problem which was described by the reporter within their report narrative. For the purposes of analysis, this category was deemed mutually exclusive. Therefore, if a report contained more than one issue it was 'split' accordingly and treated as multiple reports. The first category of coding was undertaken inductively with emergent codes being incorporated as the researcher became familiar with the various types of reports within the dataset. Similar to the process undertaken in Study One, codes split and merged until a final set of 11 codes remained. Table 6.1 lists the Category A codes, along with associated explanations and examples[54,55]. An example of a full report can be found in Appendix J.

[53] The total number of reports in the database for the period January 2005 to January 2015 was 52,680 of which flight crew reports made up 75.1% (39,548) and maintenance reports made up 7.0% (3666).

[54] The examples given are not ASRS reports in their entirety, rather abridged excerpts which were chosen in an attempt to succinctly illustrate the code.

[55] As the reports are sourced from the US, the terminology used to describe maintenance personnel is different to that used in New Zealand, with the term 'aircraft mechanic' or simply 'mechanic' being used rather than 'engineer'.

Table 6.1 *Category A codes: Reported Issue*

Name / Plot Code	***Description***	***Example***
Defect Rectification Disagreement **/** **DFCT RECTF DISG**	Disagreement between flight crew and maintenance personnel regarding the work undertaken in order to rectify an aircraft system. Includes disagreement about the status of an aircraft in terms of airworthiness and/or legality and/or acceptability to flight crew to operate	*"Number 1 engine leak found on walk around by [flight] crew….Maintenance Control wanted an engine run to check for leaks…Maintenance Control's instructions were: after engine was stable at idle, it was to be run for 3-5 minutes. Started engine and when idle was reached I started clock; at 0:40 seconds the mechanic said to shut down engine. I thought he had found the leak so I shut it down and stopped the clock at 0:57 seconds. He returned to the cockpit and said all was good, no leak. <u>I asked why he didn't let the engine run for the required amount of time. He replied that he did. I pointed to my clock and said he clearly did not</u>"* (ASRS report no. 1116102)
Logbook Procedures **/** **LOG PROC**	Complaints regarding perceived incorrect use of the logbook including engineers signing for work not yet done and attempts by maintenance personnel to influence a pilot's write-up	*"After opening the passenger/cargo door at gate, received an OVBD COOL caution and a DISPLAY COOL FAIL status message that would not clear. I went through the QRH checklist and even after selecting 2 other fans, messages would not clear. I wrote it up and called Maintenance Control. In the middle of the write up, he interrupted me and asked if I had cycled the passenger door….I was told to do that so they could save the money from calling out local maintenance. I cycled the doors and the message cleared. <u>I wanted to continue the write up but he had me mark 'Entered in Error' across my write up instead. I reminded him a couple of times that I believed the write up was required and I was disregarded</u>"* (ASRS report no. 1061610)
MEL Disagreements **/** **MEL DISG**	Disagreement between flight crew and maintenance personnel concerning the application of a particular MEL number or disagreement regarding the maintenance action procedures applicable to a particular MEL	*"I arrived at the aircraft and discovered the right center fuel boost pump inoperative and on MEL 28-02-02R. After reading the MEL it was my belief that the incorrect MEL was reflected for the right center fuel boost pump and that the correct MEL for the right center fuel boost pump was MEL 28-02-01R….<u>I advocated for MEL 28-02-01R and Maintenance held hard and fast to their issue MEL 28-02-02R</u>. I advocated that if the [other] pump failed and fuel was burned from the wing fuel tanks the Center of Gravity (CG) of the aircraft would be in question since the normal fuel burn sequence was being violated"* (ASRS report no. 1005611)
Deferral Disagreements **/** **DEF DISG**	Disagreement between flight crew and maintenance personnel regarding whether an aircraft is acceptable to operate with a system inoperative deferral in place	*"I found that the aircraft had a deferred item, EGPWS inoperative. The deferred item listed the reason for deferral was it needed software reload. <u>As we were to fly over mountainous terrain at night, I entered a refusal of the aircraft</u>…." (ASRS* report no. 795252)
MEL Confusion **/** **MEL CONF**	Events where confusion surrounds the operation of an aircraft system following application of a complex MEL or the interaction of multiple MELs on an aircraft system	*"Maintenance Control had applied MEL 27-93-01B ELAC #1 inoperative, [a] very complicated MEL with operational procedures.....<u>it is too hard to follow, and allows the opportunity for too many mistakes to be made - honest mistakes that may affect safety of flight.</u> The fact that this took over 1 hour reflects the complexity of this MEL and its application, in addition to the understanding of it by the flight crew and mechanic...It is difficult to use, hard to understand, and many times, requires several readings of the procedure for even a minimal understanding of what is required"* (ASRS report no. 925311)

Pilot Write-Up **/** **WRITEUP**	Issues regarding pilot descriptions of aircraft defects in the logbook such as a lack of detail or unclear wording. Includes write-ups which should have been made but were not and flight crew not informing maintenance of aircraft defects	*"Inbound flight attendants reported a seat back was broken and failed to stay upright. Due to the fact that the seat back was secured in the upright position and the seat not used, we assumed that the matter could be dealt with at the next station (the captain's write-up was info to maintenance). We discovered on the flight to our destination that the write-up should have been cleared by Maintenance back at the previous station. In the future any logbook write up should be discussed with Maintenance and the MEL procedures checked before making the decision to proceed with the flight*" (ASRS report no. 1033077)
Engineer Sign-Off **/** **SIGNOFF**	Issues regarding maintenance sign-offs in the logbook being unclear as to the rectification of the defect. Includes instances where pilots express a desire for more information or history regarding a system defect	*"There were four [logbook] write-ups the previous week about the right engine having hung start at 50% on the first start, with the second start as being slow to accelerate. In addition, there was also one write-up stating the engine didn't start on two attempts on one of those days. This log entry was the only entry that had maintenance actions... all of the other log entries merely stated 'No further action needed per Line Maintenance Operations'. A call to Maintenance Control revealed that they actually had replaced both igniters, fuel nozzles and done some rigging... I am asking why this maintenance work is not entered on the log history. Without these entries, it appears that there has been no maintenance action. Since the log history and the Deferred Item list are the only documents that we have to determine the airworthiness of the aircraft, all the maintenance actions should be recorded on these documents for review during preflight. A call to Maintenance Control should not be required"* (ASRS report no. 1014745)
Communication Difficulty **/** **COMM DIFF**	Events where communication between flight crew and maintenance personnel was difficult due to the medium involved (e.g. radio) or communication was made but one or both parties misinterpreted information due to terminology differences or assumptions	*"Just after takeoff we encountered fluctuating radar altimeter readings and associated nuisance GPWS alerts. I contacted Maintenance Control.... Maintenance Control advised us to pull and reset circuit breakers associated with the GPWS and radar altimeter system, which we did. At this time Maintenance Control realized that we were in the air already. We were then instructed to reset all circuit breakers, consult our QRH and talk to Flight Control for further instructions....My communication with Maintenance Control was lacking, however, at no time did Maintenance Control verify if we were on the ground or in the air....I also assumed that Maintenance Control knew we were in flight and were giving us instructions accordingly"* (ASRS report no. 1098512)
Not Informed of System Defect **/** **NOT INFM**	Complaints made by either flight crew or maintenance personnel that they were not informed of the maintenance status of an aircraft system in a timely manner	*"Upon arrival at the gate a mechanic came on the flight deck and stated that he had to perform maintenance on the aft flight attendant oxygen system....at some point, I assume after our departure, Maintenance had become aware that the oxygen generator had been removed but not replaced even though it was signed off as being accomplished... we should have been informed of the issue with the flight attendant's oxygen system while in flight so that we could brief the affected flight attendant of the situation and her options in the event of an emergency*" (ASRS report no. 1046796)
Defect Rectification Found Incorrect **/** **RECTF INCORR**	Post-flight discovery by flight crew that previous rectification of a system defect was incorrect	*"During planning I noted multiple write-ups in the maintenance history of oil leak on #1 engine - in one case traced to the IDG. FO noticed huge puddle of oil under #1 engine at gate. I advised line maintenance and sent an ACARS. Mechanics confirmed and thought it was over-serviced. I was sceptical of this quick fix....Upon arrival in XXXX, there were drips of oil running out of the #1 engine again. Maintenance found loose IDG line"* (ASRS report no. 754203)
Inflight Troubleshooting **/** **INFT TSHOOT**	Reports of inflight events where dissatisfaction is expressed by flight crew regarding the maintenance advice which was received	*"Maintenance asked us to pull the 'thrust reverser 1 DC' and 'thrust reverser 2 DC' circuit breakers to help troubleshoot the system. I feel this is a dangerous solicitation and it should not be complied with inflight" (ASRS report no. 693972)*

The second category of codes (B) was labelled *Outcome*. These codes were assigned where there were occurrences of a negative impact on aircraft operations or a negative impact on aircraft safety which could reasonably be connected with the Category A code. Table 6.2 depicts the Category B coding scheme. The codes were classified according to whether the effect was deemed to be of consequence to the airline operation or to the safety of the flight. Realistically these categories experience a degree of overlap and some outcomes could be viewed as having both operational and safety significance, but for the purpose of this study, operational-related outcomes are limited to those events which directly impact on an airline's schedule. Thus *Return to Gate*, *Flight Cancelled or Delayed* and *Flight Crew Refused to Fly Aircraft* are classified as 'Operational Outcomes'. The remaining codes, *Airworthiness Issue*, *Inflight Event*, *Argument*, *Discouragement to Report, Flew with Doubt, Pressured to Fly, Incorrect Maintenance, Trust Jeopardised*, *Refused Advice,* and *No Advice Forthcoming* are classified as 'Safety Outcomes' meaning that, potentially, they could be associated with an adverse safety event.

Category B codes were not mutually exclusive and each report was allocated as many codes as was applicable to the event. This coding was undertaken in a deductive fashion as the results from the previous studies predicted the range of outcomes which the reports were likely to present and 13 *a priori* codes were assigned accordingly. Table 6.2 depicts the category B coding scheme.

Table 6.2 *Category B Codes: Outcomes*

Name / Plot Code	Description	Example
Return to Gate / **Return to Gate** ***(operational outcome)***	Prior to becoming airborne, aircraft returns to departure gate due to either a maintenance defect and/or flight documentation issues	*"As the First Officer and I were reviewing the MEL I noticed the MEL said that you could not use this to defer emergency lighting. The Maintenance Control Desk said that if an engineer had approved it we were OK. We pushed back and started to taxi. During this time, I continued to think about this and the First Officer and I discussed this some more…..we then realized that a circuit breaker on the overhead panel had been pulled to comply with the engineering order. At this point I got a phone patch with dispatch and maintenance. I explained what my thoughts on this were and a different maintenance man asked a few questions and then did a wire trace. He said that this MEL could not be used with the circuit breaker pulled since some emergency light would be disabled. <u>We returned to the gate, got another aircraft and continued the flight</u>"* (ASRS report no. 842249)
Flight Cancelled or Delayed / **Cancel/Delay** ***(operational outcome)***	The fight is delayed or cancelled due to an aircraft defect, flight documentation issue and/or inability for flight crew and maintenance personnel to come to a mutually agreeable resolution to operate	*"I went down to the wheel well area and observed the piece of seal completely missing. The mechanic had obviously torn it off and signed the book as being repaired. I returned to the aircraft and wrote it up again. The same mechanic returned, as frustrated as ever and I informed him that the seal was missing and I would not accept the aircraft until repair was effected. <u>We took another long delay and the aircraft was finally repaired and signed off correctly</u>."* (ASRS report no. 939997)
Airworthiness Issue / **Airwrth Issue** ***(safety outcome)***	Aircraft operates without required maintenance documentation and/or carrying a defect which legally deems the aircraft not airworthy	*"During pre-flight I noticed the button was missing from the leading edge devices annunciator panel, and that it was in the test mode. We called Maintenance. They decided that they could not fix it and they did not have another to replace it with. Several maintenance personnel thought that it could be put on MEL, and several including the captain and myself believed that it should not. The Manager of Maintenance assured us over the phone that it was ok for a MEL and that we were reading too much into it. So we decided to take the MEL. <u>At a later date we found out that it was an illegal MEL so we decided to write safety reports</u>."* (ASRS report no. 853249)
Inflight Event / **Inflight Event** ***(safety outcome)***	Maintenance issue presents during flight requiring flight crew to address the problem. Includes events where a diversion or emergency landing takes place	*"<u>After take-off we discovered the main landing gear failed to retract fully. After complying with normal ATC requirements we attempted to perform QRH procedures</u>. After notifying ATC and Company via ACARS I determined based on our distance from departure airport and to our landing airport, as well as the current and degrading weather conditions at our departure airport, it was more prudent to continue on to our destination….After the completion of the flight, the post-flight revealed that the pins were still installed on the aircraft…. I believe that if a thorough briefing between the mechanic and captain were performed, this situation may have been avoided. I had a discussion with the Mechanic that signed the aircraft off that morning. He did not indicate, nor did I ask whether gear pins had been installed.* (ASRS report no. 901522)
Refusal to Fly Aircraft / **Refused to Fly** ***(operational outcome)***	Flight crew deem aircraft unacceptable for flight either due to a system defect or deferral	*"When I pulled up papers for pre-flight planning, I saw the aircraft was dispatched with a small fuel leak on the left engine. Write-up said it was found yesterday and 'ok to continue with leak less than 3 drops per min...fuel pump must be changed within 24 hrs.' On pre-flight I saw extensive leak. I timed it and came up with 24 drops per min. <u>I reported this to maintenance, and refused the aircraft in that condition as the observed leak well exceeded the allowed leak.</u>* " (ASRS report no. 747335)

Argument **/** **Argument** ***(safety outcome)***	Disagreement between a pilot and engineer whereby one or both parties expresses obvious irritation toward the other, including acts of aggressive communication or behaviour	*"A couple of minutes later a mechanic called on the interphone and started giving me a hard time…<u>he had a very disrespectful attitude. I told him it was written up twice and got an argument and more attitude in return</u>. I asked if they were going to talk to us about the write-up and he said 'no.' He said they were going to defer it. I asked if they planned to talk to us about the deferral. Again he said 'no, it's a legal deferral, we're going to defer it, and you're going to take it...unless you want to come down here and check on it again.' The last part was heavy on sarcasm. I said that I was coming down and he said 'well I'm going to get some tools so I won't be here.*"' (ASRS report no. 734735)
Discouragement to Report **/** **Disc to Report** ***(safety outcome)***	Any interaction which serves to dissuade flight crew from reporting their concerns about aircraft defects to maintenance personnel	*"When I disagreed with [maintenance] deferring a working pack over an air vent they said 'You should not have written it up and for these kinds of write up, wait till the end of the day when you know plane is going to the hangar for the night'. …<u>this attitude that you shouldn't have written it up or you should wait till the end of the day to write up discourages pilots to report discrepancies to Maintenance which can be detrimental to safety</u>"*(ASRS report no. 904769)
Flew with Doubt **/** **Flew with Doubt** ***(safety outcome)***	Cases where a flight crew has accepted an aircraft for flight but one or both pilots questions the legal and/or safety status of an aircraft system	*"Upon pushing back from the gate, I noticed that hydraulic system number one was slightly lower than number two so I told the First Officer that I was going to transfer some hydraulic fluid from the number 2 system to the number 1 system. Once completed, both systems were at 50% (40% is required). Considering that the fluid was above the minimum level and for fear of being scolded or getting into trouble for returning to the gate, I decided to proceed with the flight… <u>there was something strange about it (just a feeling but nothing that I could prove or show)…I simply had an odd feeling about them</u>"* (ASRS report no. 1116916)
Pressured to Fly **/** **Pressure to Fly** ***(safety outcome)***	Interactions where there is explicit pressure put on the flight crew by maintenance personnel to accept the aircraft for flight	*"On walk-around I found what looked to be a repair on the left leading edge of wing…Maintenance Control could not find any history of a repair in that area, so they told me to put it in the book and they would take care of it from there….I was called by a maintenance duty supervisor (on my cell phone). <u>He began to put pressure on me as to why I would find this at an outstation and not a maintenance base</u>. He told me I was either making a personal or political statement. He told me that because of my actions some very important people had to come to work that day. I shot back and asked him if he expected me to take a plane that may have a problem. I asked him if he was willing to repeat those accusations in front of my chief pilot and the FAA? He started to back off…company has no right to try and pressure a pilot into taking an airplane when a discrepancy with that plane exists*" (ASRS report no. 752335)
Incorrect Maintenance Performed **/** **Incorrect Maint** ***(safety outcome)***	Events where an engineer performs incorrect maintenance on the aircraft	*"The pilot informed me that the oil temp had risen to 135 degrees at its highest. To the best of my memory, the oil pressure was never discussed and I did not read the actual logbook write-up as 2 other technicians were reading it about the cabin door seal squeal. I have found in the past it is best to perform a face-to-face with the flight crew as more info can be obtained that way… I completed the sign off of all my work, signed off the airworthiness release and gave the logbook back to the flight crew. [Later] a maintenance coordinator called me and informed me an FAA inspector had checked the logbook…according to the write-up, the oil pressure had dropped to 18 psi…any time while the engine is running and the oil pressure drops below 34 psi, the engine has to be removed and all oil system components inspected. Therefore the aircraft was grounded and an engine change is in progress. Even though it was ultimately my responsibility to read that part of the write-up…if the pilot had made a separate logbook discrepancy write-up about the low oil pressure, I would not have missed the problem, but as it was, the pilot had put 2 discrepancies in 1 logbook write-up"*(ASRS report no. 709005)

Trust Jeopardised ***(safety outcome)***	Instances where the trust between a pilot and engineer is questioned	*"The extra 4500lbs of fuel, that we were unaware of, put us above the max takeoff weight for the runway and power setting we used, our corresponding v-speeds were incorrect, and this caused an overweight landing. Had we experienced an engine failure at takeoff, I don't know if we would have been able to sustain flight. Either the fueler put fuel into the tank without being aware he did or he lied to keep out of trouble. The mechanic took someone else's word without doing the procedure as specified and signed his name to an incorrect form, possibly because he didn't want a further delay. <u>As captain, I accepted a signed fuel slip and believed someone's word who said they did their job. Maintenance Control is just as culpable as the mechanic. Who can I believe?</u>"* (ASRS report no. 689503)
Refused Advice **/** **Refused Advice** ***(safety outcome)***	Advice given by maintenance personnel during an inflight event in order to troubleshoot an aircraft system is rejected by the flight crew	*"Engine #1 vibration indicator was showing 2.5 units of vibration, all other engine parameters were normal… we were holding at 11000ft awaiting release to start the approach…Line maintenance wanted us to turn off the engine hydraulic pump for engine #1 and turn the associated pack off. <u>We did not elect to give ourselves an emergency for an indication problem, so we did not follow the maintenance request</u>….there is no procedure in the flight handbook or QRH for what they wanted us to do…we are not maintenance test pilots and this was a Part 121 flight. I think there is a disconnect between maintenance and the pilots about what we can and cannot do. My biggest concern is that a junior crew might actually follow maintenance's request"* (ASRS report no. 704207)
No Advice Forthcoming **/** **No Advice Fthcmg** ***(safety outcome)***	Instances where flight crew seek advice from maintenance personnel in order to troubleshoot a system in flight but report that maintenance were either unable or unwilling to help	*"When I asked if Maintenance Control could assure us that the electric pump was not continuing to run, the comment made that, 'I can't assure you of that, I'm in an office and you are at 30,000 feet' was uncalled for and very unprofessional. Why should a flight crew ever be in a position of having to argue with Maintenance Control about a system clearly described in our Manuals? Our entire operation should be based upon supporting the ones who are at '30,000 feet', not being agitated by their problems. We look to Maintenance for guidance occasionally. <u>In this case they provided very little information, but what they did provide was in conflict with our System Handbook</u>. The manner and tone of their communication with us did little but exasperate our problem"* (ASRS report no. 842937)

During the coding process, frequent cross-checks were made against the information appended to each report by the ASRS database analysts[56]. This provided satisfaction that the coding scheme which had been developed for this study was valid and that the particular codes being allocated to each report were appropriate.

6.2 Analysis and Interpretation

Once all the reports had been coded, the dataset was organised such that category coding counts could be made. Following a basic descriptive analysis of counts, the data was then formatted appropriately in order for the correspondence analysis to be performed using IBM SPSS version 22. Although the correspondence analysis (CA) model itself is computed automatically by the software, the numerous statistical outputs which are generated are required to be analysed by the researcher in order to explain the correct interpretation of the resultant display plot. This then leads to a back-and-forth process of manipulating and refining how the data are used such that the final display which is chosen is the most logical in terms of presentation. A description of the analytical interpretations which were made in order to arrive at the CA model presented in the results section is detailed in Appendix K.

As described in Appendix K, the model presented here relates to analysis which was performed on a dataset containing Category A variables 1-10 and Category B variables 1-11. Category A variable 6 (*Pilot Write-Up*) and Category B variable 10 (*Incorrect Maintenance Performed*) were treated as supplementary rows and columns for computation of the axis weightings. Table 6.3 displays the contingency table for the raw

[56] Prior to being entered into the database, all ASRS reports are reviewed by a minimum of two qualified aviation data analysts (NASA, 2014). The analysts attach a number of codes to the report (for analytical and retrieval purposes) and provide a brief description of the report itself. In many cases, additional information gathered via telephone follow-up with the reporter is also appended.

data used in the correspondence analysis, the summation of frequencies for the row variables and column variables being represented under ‘Active Margin’.

Table 6.4 shows the statistical results of the final CA model solution. The chi-square value indicates a significant result of $\chi 2(72) = 677.4$ ($p < .001$). Total inertia is .381 with two dimensions accounting for 81.6% of this total.

Examination of Table 6.5 which details the row and column point contributions to the model, reveals that the transformation of the variables *Pilot Write-up* and *Incorrect Maintenance* to supplementary rows and columns resulted in the majority of variables being well represented by a two dimensional display. The exception to this are the categories *Flew with Doubt* and *Flight Delayed or Cancelled* which means that some caution is needed when interpreting these two variables within the two-dimensional space.

Table 6.3 *Pilot-maintenance Report Issues and Outcomes in ASRS Incidents January 2005 to January 2015*

REPORTED ISSUES	OUTCOMES											
	Return to Gate	*Flight Cancelled or Delayed*	*Airwrth Issue*	*Inflight Event*	*Refusal to Fly*	*Argument*	*Discouragement to Report*	*Flew with Doubt*	*Pressured to Fly*	*Incorrect Maint. Performed*[b]	*Trust Jeopardised*	*Active Margin*
Defect Rectification Disagreement	16	65	11	26	74	68	16	59	57	7	123	515
Logbook Procedure Issues	2	26	17	9	14	21	4	11	12	2	45	161
MEL Disagreement	3	28	11	9	25	27	2	21	9	5	27	162
Deferral Disagreement	4	39	7	11	90	36	1	32	35	2	37	292
MEL Confusion	10	20	44	41	5	2	3	38	5	9	12	180
Pilot Write-up[a]	0	19	10	9	0	0	1	4	0		0	
Engineer Signoff	3	17	12	22	9	11	0	11	6	3	18	109
Communication Difficulty	5	13	23	34	4	9	0	1	3	10	6	98
Not Informed of System Defect	0	8	14	1	0	1	0	0	0	1	15	39
Defect Rectification found Incorrect	5	6	57	52	2	2	2	23	8	0	65	222
Active Margin	48	222	196	205	223	177	28	196	135		348	1778

a. Supplementary row
b. Supplementary column

Table 6.4 *Summary table for final CA model*

Dimension	Singular Value	Inertia	Chi Square	Sig.	Proportion of Inertia		Confidence Singular Value	
					Accounted for	Cumulative	Standard Deviation	Correlation
								2
1	.504	.254			.667	.667	.019	.042
2	.238	.057			.149	.816	.021	
3	.160	.026			.067	.883		
4	.148	.022			.058	.940		
5	.133	.018			.046	.987		
6	.061	.004			.010	.996		
7	.035	.001			.003	.999		
8	.015	.000			.001	1.000		
Total		.381	677.447	.000[a]	1.000	1.000		

a. 72 degrees of freedom

Table 6.5 *Contributions of row and column points to model dimensions*

Row Point	*Contribution of Dimension to Inertia of Point*		
	Axis 1	Axis 2	Total
Defect Rectification Disagreement	.741	.096	.837
Logbook Procedure Issues	.079	.740	.818
MEL Disagreements	.522	.007	.529
Deferral Disagreements	.726	.151	.877
MEL Confusion	.702	.135	.837
Pilot Write-up	.206	.041	.248
Engineer Sign-off	.362	.132	.494
Communication Difficulty	.617	.140	.757
Not Informed of System Defect	.253	.370	.622
Defect Rectification Incorrect	.842	.059	.901

Column Point	*Contribution of Dimension to Inertia of Point*		
	Axis 1	Axis 2	Total
Return to Gate	.238	.212	.451
Flight Cancelled or Delayed	.260	.004	.263
Airworthiness Issue	.922	.003	.925
Inflight Event	.812	.106	.917
Refused to Fly	.771	.126	.897
Argument	.746	.001	.747
Discouragement to Report	.109	.226	.335
Flew with Doubt	.000	.129	.130
Pressured to Fly	.836	.001	.837
Incorrect Maintenance Performed	.207	.260	.467
Trust Jeopardized	.001	.943	.944

6.3 Results

6.3.1 Issues Reported

The individual frequency counts of the category A variables are displayed in Table 6.6. Considering each of the report issues separately, it can be seen that *Defect Rectification Disagreement* was the most common concern regarding the flight crew-maintenance interface making up 21.9% of the events within the dataset. This was followed by *Deferral Disagreement* (14.8%) and *MEL confusion* (11.9%). The least reported concerns were *Not Informed of System Defect* (2.3%) and *Inflight Troubleshooting* (3.6%). Of the 44 reports which were submitted by maintenance personnel, the most frequent interface issues which were reported were *Pilot Write-up* (40.9%) and *Communication Difficulty* (29.5%). No reports from engineers were coded under the issues of *MEL Disagreements, Deferral Disagreements, Not Informed of System Defect, Defect Rectification found Incorrect* or *Inflight Troubleshooting.*

When considering the various types of reports which made up the dataset, analysis of the distribution confirms that issues manifesting in some form of disagreement contributed to almost half (44.3%) of all interface issues within the ten year period. Issues with documentation, specifically the logbook and MEL, also factored highly. The reported issues of *Logbook Procedures* (8.2%), *Pilot Write-Up* (4.0%) and *Engineer Sign-off* (6.7%) reflect that as a communication medium, the logbook is a factor in 18.9% of interface concerns. Reports featuring the MEL also appeared frequently with 19.4% of reports expressing concern over either the interpretation or application of its contents. Considering the engineering reports separately, logbook issues dominated their submissions with *Pilot Write-up, Engineer Sign-off* and *Logbook Procedures* making up 56.8% of their reports. However, in contrast to the overall dataset results, the subset of engineering submissions only contained one report concerning a disagreement-related issue.

Table 6.6 *Issues Reported Concerning the Pilot-Maintenance Interface Jan 2005-Jan 2015*

Reported Issue	***Report Count***		***% of Total Reports***	
	Submitted by Pilots	*Submitted by Engineers*	*Submitted by Pilots*	*Submitted by Engineers*
Defect Rectification Disagreements	240	1	21.8	0.1
Logbook Procedures	87	3	7.9	0.3
MEL Disagreements	83	0	7.5	0
Deferral Disagreements	163	0	14.8	0
MEL Confusion	126	5	11.5	0.4
Pilot Write-Up	26	18	2.4	1.6
Engineer Sign-Off	70	4	6.4	0.4
Communication Difficulty	68	13	6.2	1.2
Not Informed of System Defect	25	0	2.3	0
Defect Rectification Found Incorrect	128	0	11.6	0
Inflight Troubleshooting	40	0	3.6	0
Total	*1056*	*44*	*96.0*	*4.0*

6.3.2 Report Outcomes

Table 6.7 details the Category B coding data on safety and operational related outcomes. As the coding was not mutually exclusive within Category B, a total of 1931 outcome codes were allocated across the 1100 reports in the dataset providing an overall allocation of 175.5% of codes to cases. Notwithstanding, codes in the ‘Operational Outcomes’ group tended to be allocated only once to any one report i.e. the flight was either delayed/cancelled, *or* the flight crew refused to fly *or* there was a return to the gate.

Table 6.7 *Outcomes Relating to Pilot-Maintenance Interface Issues Jan 2005-Jan 2015*

Outcome	***Frequency of code allocation***		***% of cases***
	N	**%**	
Operational Outcomes			
Return to Gate	49	2.5	4.5
Flight Cancelled or Delayed	241	12.5	21.9
Flight Crew Refused to Fly Aircraft	223	11.5	20.3
Subtotal	*513*	*26.5*	*46.7*
Safety Outcomes			
Airworthiness Issue	207	10.7	18.8
Inflight Event	217	11.2	19.7
Argument	182	9.4	16.5
Discouragement to Report	30	1.6	2.7
Flew with Doubt	205	10.6	18.6
Pressured to Fly	135	7.0	12.3
Incorrect Maintenance Conducted	57	3.0	5.2
Trust Jeopardised	353	18.3	32.1
Refused Advice	10	0.5	0.9
No Advice Forthcoming	22	1.1	2.0
Subtotal	*1418*	*73.5*	*128.8*
Total	**1931**	**100**	**175.5**

Inspection of the individual codes show that the most common outcome in the reports of flight crew-maintenance interface issues was an indication that trust had been breached, with 32.1% of cases assigned the *Trust Jeopardised* code. The next most frequent outcome was *Flight Cancelled or Delayed* which featured in 21.9% of all reports, followed by *Aircrew Refused to Fly Aircraft* (20.3%) and *Inflight Event* (19.7%). Four codes were allocated to less than 5% of cases, those being *Refused Advice* (0.9%), *No*

Advice Forthcoming (2.0%), *Discouragement to Report* (2.7%), and *Return to Gate* (4.5%).

6.3.3 Correspondence Analysis

To provide for a degree of orientation when analysing the final correspondence plot, it is worthwhile to examine the row and column points separately. This allows for any higher-order patterns within the two category groups themselves to be revealed prior to analysing the final display where such patterns may become obscured in the data clutter. Figure 6.1 displays the Category A variables (Reported Issue) as row points on the two dimensional plot. Within the two dimensional space the relationships between points are represented by relative distance; closer distances between the points can be interpreted as closer relationships between variables. Analysis of the display reveals that the types of events which were coded appear to fall naturally into two groups. The left-hand side of the x-axis contains the events where the reporter complained specifically about a disagreement with the other party (*System Rectification Disagreement*, *MEL Disagreement*, and *Deferral Disagreement)* as well as *Logbook Procedures.* Given that *Logbook Procedures* issues also tended to be events where opposing views were held (see example in Table 6.1), it might be said that all four of the issues on the left-hand side of the x-axis are associated with differences of opinion. In contrast, events associated with a desire for more information (*Engineer Sign-off, Pilot Write-up, Not Informed of System Defect*, *MEL Confusion* and *Communication Difficulty)* fall on the right-hand side of the x-axis. *Rectification Incorrect* also falls on the right indicating that this particular issue also shares a similar profile.

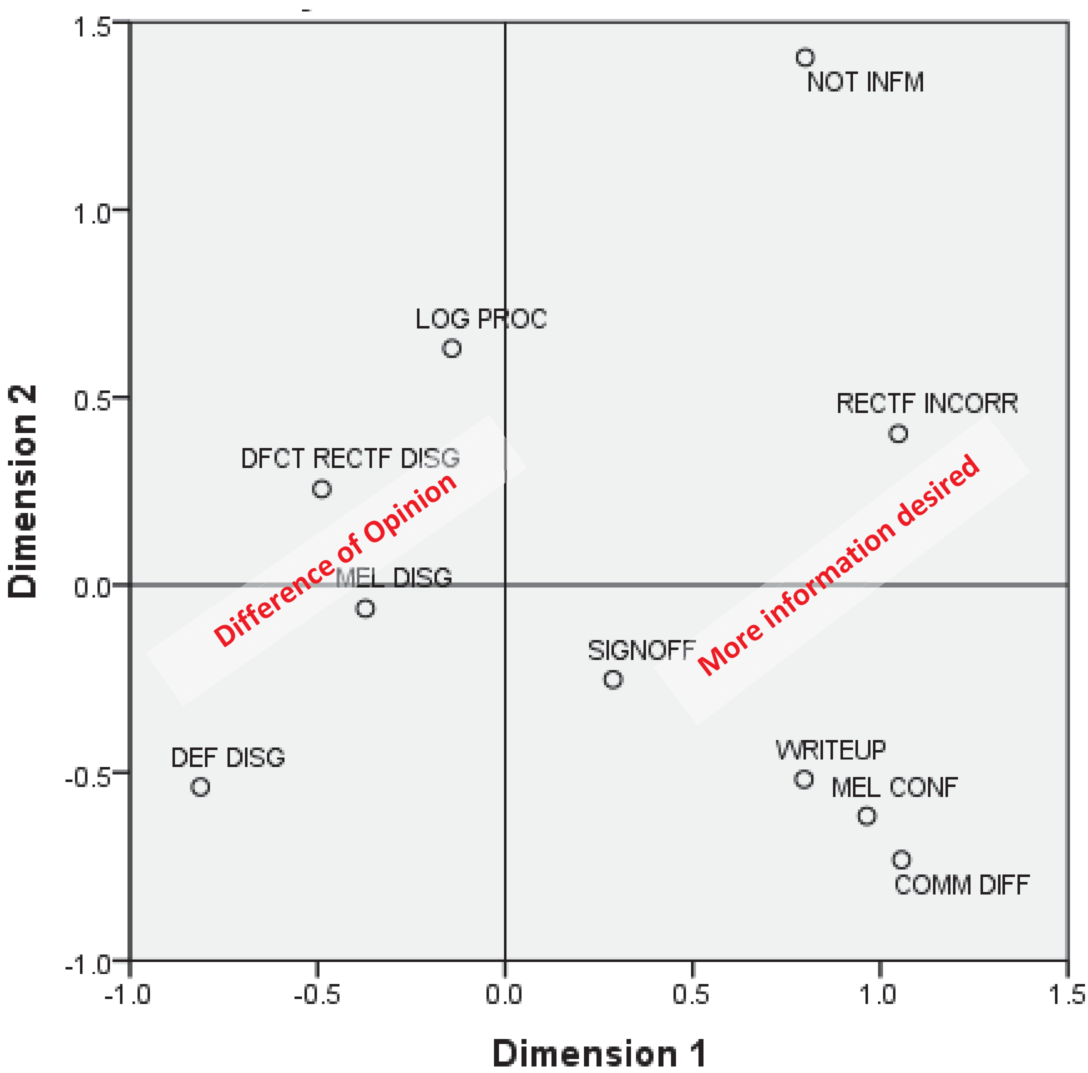


Figure 6.1 Row Point Display for *Reported Issue (see Table 6.1 for plot codes)*

The column point display is shown in Figure 6.2. As in the row point plot above, the distance between column points (*Report Outcomes)* can be interpreted by their proximity to each other with points which are closer together having similar profiles than points which are far away. The first obvious feature of interest is that *Argument* and *Pressure to Fly* have a very close relationship. While no statement about a causative relationship can be made, it does indicate that when one of these outcomes occurs, there is a high likelihood it will be in the presence of the other. The other pairing which appears to share a similar profile is *Trust Jeopardised* and *Discouragement to Report*. While not as closely connected as the previous pairing, it can be inferred that those events which are associated with a breach of trust might, on occasion, also act as a discouragement to report and vice versa.

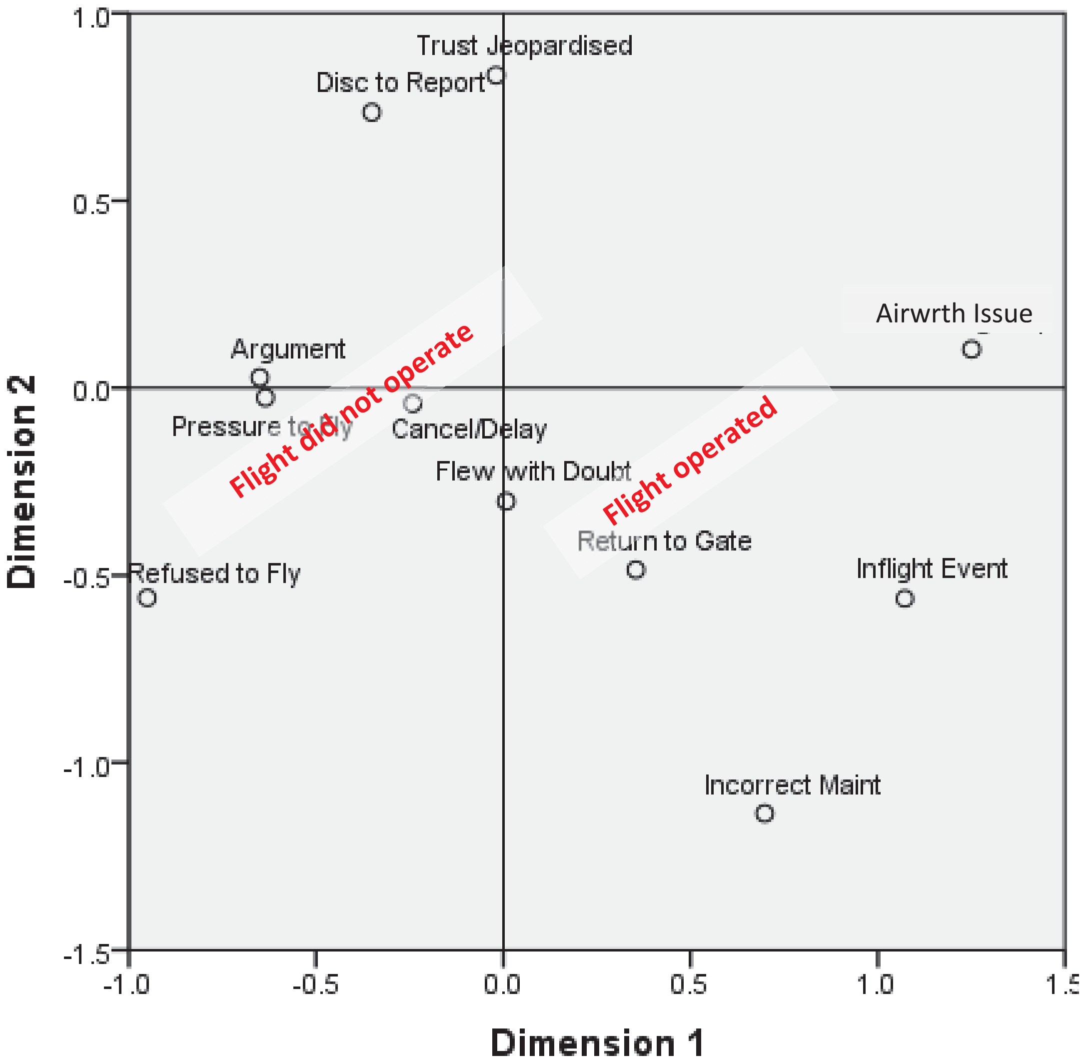


Figure 6.2 Column point display for *Outcome (see Table 6.2 for plot codes)*

Another pattern which can be observed is a relationship along the x-axis with regard to whether the flight departs or not. *Refused to Fly* and *Cancelled or Delayed* fall on the left-hand side of the x-axis while *Flew with Doubt*, *Returned to Gate*, *Inflight Event* and

Airworthiness Issues are all situated on the right-hand side of the display. By cross-referencing the pattern displayed in Figure 6.1, it is now possible to see a higher-order relationship between the issues which were reported and the outcomes. While differences of opinion between maintenance personnel and flight crew tend to be associated with disruption to the airline schedule, concerns regarding a lack of information tend to be associated with flights which depart and then subsequently have problems.

The final process in drawing results from the correspondence analysis is examination of the CA display map itself. Figure 6.3 illustrates the plot of reported issues and outcomes from maintenance-flight crew interface concerns. Unlike the row and column point displays, the distances between the row and column points cannot be interpreted precisely, however, the use of symmetrical normalization in computing the model does allows a *general comparison* to be made between the reported issues and the outcomes by standardizing the row and column data. Therefore, a small distance between points indicates a strong association comparative to a large distance between points which would indicate a lower association.

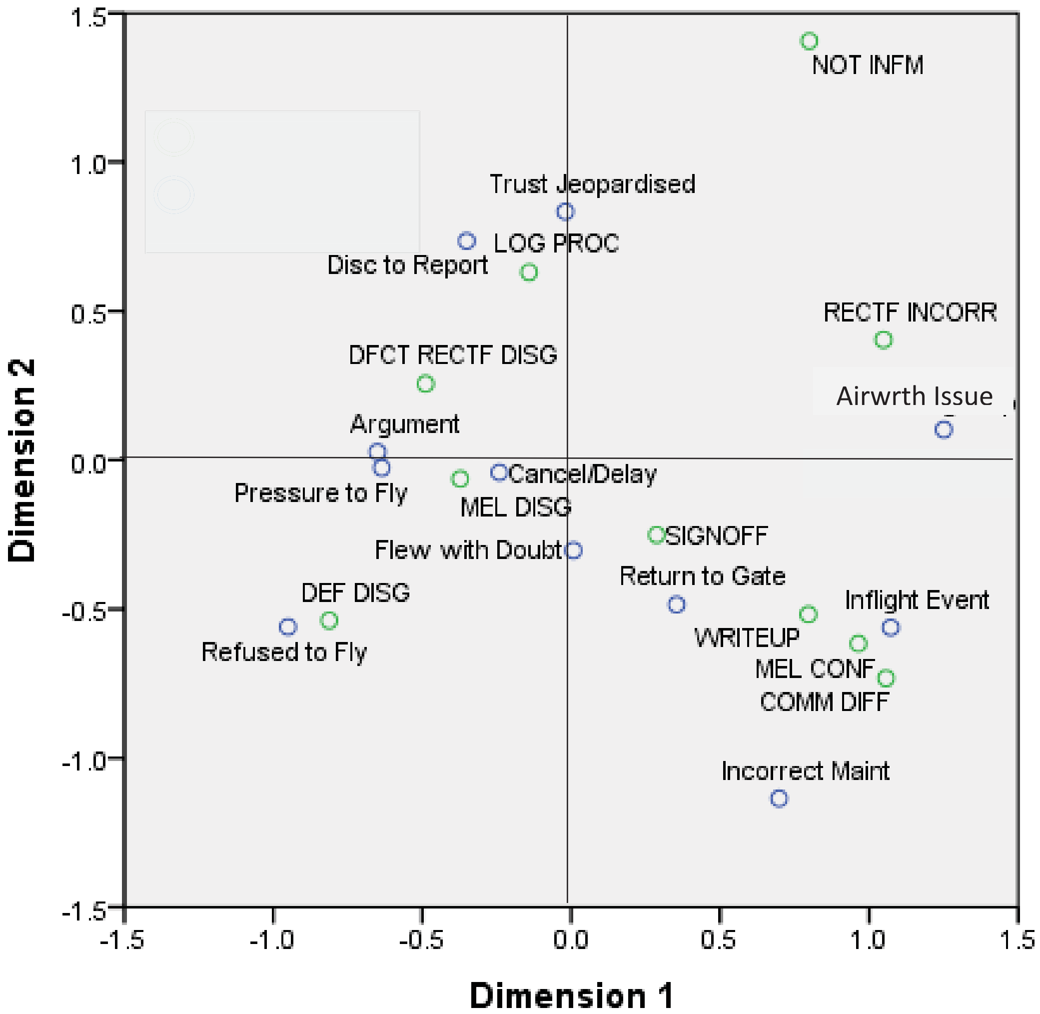


Figure 6.3 Correspondence plot of pilot-maintenance interface issues and outcomes

From the plot it can be seen that different types of disagreement have a tendency to be associated with different outcomes; *Deferral Disagreements* tend to be associated with a refusal to fly by the flight crew while *MEL Disagreements* are inclined to be associated with cancellations or delays. *Defect Rectification Disagreements* meanwhile tend to be associated with *Pressured to Fly* and *Arguments* and have a stronger association with *Trust Jeopardised* and *Discouragement to Report* than the other two subjects of disagreement. For those flights which do depart following a differing of opinions, all three tend to be associated with the outcome of *Flew with Doubt*.

Another relationship which is revealed in the bi-plot is the association between *Logbook Procedures* and *Trust Jeopardised. Trust Jeopardised* also tends to be associated with defect rectification issues whether they present prior to flight *(Defect Rectification Disagreement)* or are discovered subsequently *(Defect Rectification found Incorrect, Not Informed of System Defect).*

Moving across to the right-hand side of the display, it can be seen that cases where defect rectification was subsequently found to be incorrect, tended to be associated with flights which had airworthiness issues. These two points have a degree of separation from the other points on the display which tend to be clustered around the center suggesting a closer association with each other than they have with the other points.

The bottom right-hand quadrant of the graph contains the most points on the graph; four interface issues and three outcomes. These interface issues are all concerned with events where the reporter has expressed a desire for more information as seen from Figure 6.1, above. The clustered nature of these points indicates that they share similar profiles, thus it is becomes difficult to distinguish particular associations between pairs of issues and outcomes. However, examination of the points shows *Incorrect Maintenance* as an outcome appears most closely associated with *Pilot Write-up, MEL Confusion* and *Communication Difficulty.*

Care should be taken when interpreting the nature of outcome associations with the issue of *Communication Difficulty*. Despite appearing in close proximity to *Inflight Event*, this should not be construed as meaning that communication difficulties lead to inflight events, rather that inflight events which were reported often experienced communication difficulties during the event. This is different from, say, *MEL Confusion* as a reported issue, whereby its proximity to *Inflight Events* can be inferred as being a contributory relationship.

In summary, several associative relationships can be distinguished, including the higher-order patterns within the type of interface issue and the outcomes which were discerned from the separate row and column point displays. Whilst differences of opinion tend to be associated with schedule disruptions, issues concerning a lack of information tend to be associated with flights which depart, but either experience a maintenance issue during flight or are not technically airworthy. When flight crew do elect to operate following a disagreement with maintenance, these flights tend to be flown with an element of doubt on the part of the pilots. Arguments between flight crew and maintenance personnel are likely to occur in those instances where flight crew experience pressure to fly and tend to be closely associated with disagreement about defect rectification. Pilots' trust in maintenance personnel tends to be affected by logbook procedure issues, disagreement over defect rectification, and events where the aircraft has been flown carrying an unresolved defect. Incorrect maintenance tends to be associated with events concerning a lack of information including confusion over MEL procedures which itself is associated with inflight events.

6.4 Discussion

Investigation of 1100 reports submitted to the ASRS programme across a ten year period, confirms the presence of similar concerns relating to the interface between flight crew and maintenance personnel as were found in the previous two studies indicating that Airline ABC is far from unique in terms of the difficulties at time encountered by these two groups. Of the 11 different interface issues which were found to be present, problems regarding flight documentation, communication medium, information availability and the maintenance status of the aircraft itself all reflected the concerns shared by employees of Airline ABC. While the dataset was dominated by reports submitted from flight crew, the reports which were submitted by maintenance personnel contained narratives not dissimilar to those disclosed within the Study One focus group sessions. It is with a fair degree of confidence therefore that these results can be used with reference to the over-arching research question, '*how do the impediments which were identified by pilots and engineers affect airline operations and flight safety?'* with provision of the caveat that it is the perception of the flight crews which dominate.

6.5.1 Operational Impacts

The effect of problematic flight crew-maintenance interfaces on airline operations was assessed in terms of the impact to the carrier's schedule, thus a refusal by the captain to accept the aircraft for flight, a cancellation or delay, or a return to the gate were all deemed to represent a negative operational impact on the airline. Negative operational effects were common (46.7%), occurring in almost half of all the reports concerning a problematic interface between flight crew and maintenance personnel. This is a potentially troubling finding given the financial implications of schedule disruptions (Alamdari & Fagan, 2005) as well as other considerations such as customer satisfaction (Tiernan et al., 2008). Upon examining the cause of the disruption, it was found that a refusal by the flight crew to operate was almost as common (20.3%) as an operational decision to cancel or delay the flight for maintenance (21.9%) while there were far fewer instances of a return to gate (4.5%).

An interesting finding was the fact that the two main reasons for the schedule disruption appeared to stem from slightly different causes; refusal by a pilot to fly an aircraft tended to follow disagreements about system deferrals while cancellations or delays for maintenance were more likely to result from disagreements concerning the MEL. While the clustering of the points on the CA plot suggest there is probably a more complex relationship than that simply stated, it does, however, pose an interesting question as to whether the confusing nature of the MEL itself has an effect on the outcome.

Disagreements about deferrals tended to be more clear-cut for both parties which might suggest the crew felt left with no choice but to refuse to fly the aircraft if they do not wish to operate with a particular deferral even if both parties accept the deferral itself is legal. The complexities surrounding the MEL, however, might act to temper any disagreement by steering both parties toward remaining on the side of caution and taking a delay or cancellation in order to perform maintenance.

Irrespective of what drives these two outcomes however, the fact remains that any issues involving a differing of opinions tend to be associated with a negative impact on airline operations. This finding has particular relevance for airlines, given that disagreements between the flight crew and maintenance personnel – whether over defect rectification, deferrals or interpretation of the MEL - made up almost half of all the reports regarding interface issues within the ten year period.

6.5.2 Impacts on Safety

Negative effects on flight safety were examined using eight measures which can be broadly classified into two groups. The first group concerns those outcomes that manifested in a bona fide incident in their own right such as incorrect maintenance being performed, the aircraft operating in variance with regulatory and/or manufacturing specifications or an inflight maintenance event. These outcomes were *Incorrect Maintenance Performed, Airworthiness Issues* and *Inflight Event*. The second group contains the less tangible - yet nonetheless important – safety-related outcomes. These outcomes are those occurrences which could potentially have an adverse effect on safety, conceivably acting as latent conditions or precursors which could increase the risk of a safety-related event taking place. These outcomes were *Argument, Pressure to Fly, Flew with Doubt*, *Discouragement to Report* and *Trust Jeopardised*.

A notable finding was that the two types of outcome (actual events vs. potential precursors to an event) tended to be distinctly connected to different types of preceding issue, suggesting that there might be a characteristic pattern between the nature of the event and the manner in which this manifests in relation to flight safety. From the results it can be seen that the outcomes in the form of actual safety-related events tended to be associated with the reports which were concerned with a lack of information (i.e. *Engineer Sign-off, Pilot Write-up*, *MEL Confusion*, *Communication Difficulty*). However, the outcomes classified as being potentially detrimental to safety were more closely associated with the reports concerning a differing opinion (i.e. *MEL Disagreement, Deferral Disagreement, Defect Rectification Disagreement*, *Logbook Procedures*). As noted above, it should be acknowledged that a more complex relationship may be occurring. This finding reveals an interesting concept with regard to the different types of interface issue and the resultant outcome. Instances involving miscommunication between a pilot and an engineer and those where one or the other party does not feel well informed, appear to manifest both overtly and relatively closely in time to the event in question. Conversely, instances where there is disagreement between a pilot and engineer appear to have a more subtle, but potentially just as detrimental, effect on flight safety (Figure 6.5). These occurrences may adversely affect the overall wellbeing of the pilot-engineer relations as repeated experiences of these sorts of issues will, over time, entrench and reinforce negative views within the relationship itself.

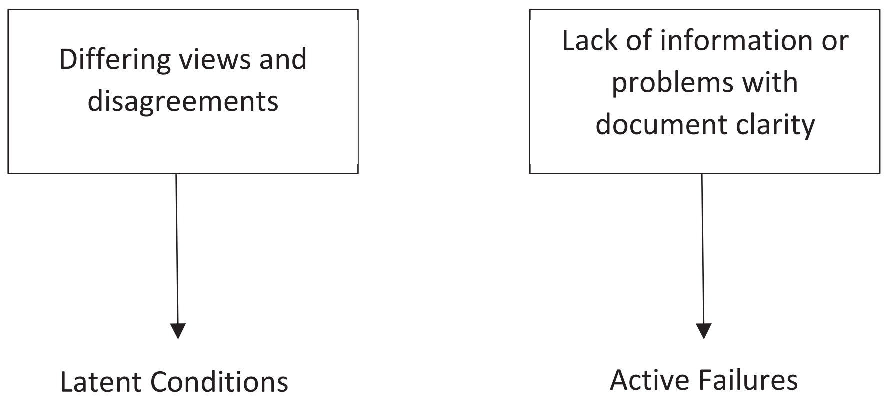


Figure 6.4 Different issues identified within the dataset appear to contribute to adverse events in distinct ways

In terms of measuring the impact on flight safety, it is not possible to say which factor is responsible for having the most detrimental effect as the outcomes themselves cannot be equivalently evaluated. However, of all individual safety-related outcomes, *Trust Jeopardised* was the most commonly occurring factor by a considerable margin, being found in over one-third of all reports. Interestingly, the CA model revealed that breaches of trust were commonly associated with events within both of the broad event classifications of 'Disagreements' and 'More Information Desired', making it somewhat unique in that regard. Had *Trust Jeopardised* been closely associated with one particular interface issue, a targeted approach to address that particular issue could then be made in the knowledge that by doing so it would have a significant influence in improving the intergroup relationship. However, breaches of trust are more inextricably woven throughout the range of interface issues; indeed the only type of event where there were no instances of a breach of trust was *Pilot Write-up*. This finding suggests that the most frequently occurring safety-related impact, and one which directly affects the pilot-engineer relationship, is perhaps also one of the most complex to address.

6.5.3 Effects of Conflict

Evidence of discord between pilots and engineers was plentiful within the dataset. Almost half the reports submitted across the ten year period concerning deficient communication between flight crew and maintenance were classified as being an occurrence of disagreement between a pilot and an engineer. However, while differing opinions between flight crew and maintenance personnel might, to a certain extent, be expected, one in every six reports contained evidence that disagreements between the two parties had escalated to the point where an argument occurred. Arguments were classified as overt expressions of irritation, including aggressive speech and behaviour, which indicated that communication between a pilot and engineer was no longer being conducted in an effective or professional manner.

Arguments were strongly associated with events which were classified as being disagreements, differences of opinion over the MEL, deferrals, defect rectification and logbook procedures being the source of 80 percent of all arguments. Yet despite conflict being most closely associated with sources of disagreement between pilots and engineers, not every disagreement resulted in an argument; indeed approximately two-thirds did not. This suggests that while the MEL, deferrals, defect rectification and the logbook may well provide the subject for a dispute, potentially there are other factors which determines whether an argument actually eventuates. One explanation might be that the flight crew perceive they are being pressured to accept the aircraft. Given that the report outcome of *Pressured to Fly* shared an almost identical profile to that of *Argument* as seen on the column profile plot (see fig. 6.2), the presence of this factor could possibly be interpreted as a trigger point for whether a higher level of conflict develops.

With regard to the effects conflict has on airline operations and flight safety, the findings are similar to those of the disagreement type events, given the close association arguments had with that group. Thus, the impact of conflict on airline operations tends to be either a refusal by the pilot to operate the aircraft, or a cancellation or delay for maintenance. In terms of flight safety, conflict appears to be less associated with actual safety-related incidents such as an inflight event or airworthiness issues. However, it should be noted almost 10% of the *Inflight Troubleshooting* reports involved an argument. While *Inflight Troubleshooting* was not included in the correspondence analysis, the raw code counts reveal that 2.7% of the argument codes were assigned to this event. Although this figure is low, any conflict which arises during a time when the flight crew are attempting to manage a maintenance problem during flight is clearly undesirable, distracting those involved from the task at hand.

6.6 Summary

The aim of Study Three was to examine the consequences of communication difficulties between pilots and maintenance personnel in relation to adverse effects on airline operations and flight safety. Utilising the analytical technique of Correspondence Analysis allowed associative relationships between particular interaction issues and their subsequent outcomes to be displayed graphically, thus enabling patterns of association to be more easily discerned. The ability to access an extensive repository of safety-related reports from outside the primary research environment lends support to the notion that communication issues between flight crew and maintenance engineers are not isolated to the participant airline where Study One and Study Two were conducted, nor its country of origin.

Findings from this study show an association between problematic flight crew-maintenance interactions and schedule disruptions. Negative operational impacts on an airline's schedule tend to follow incidents where there is disagreement between pilots and engineers over documentation and defect referral. Findings from this study also show an association between problematic interactions and negative impacts on flight safety. Issues relating to a lack of information or confusion over documentation tend to be associated with safety events relating to the airworthiness of the aircraft, while interactions involving disagreement between flight crew and maintenance personnel tend to be associated with undesirable psychological outcomes such as pilots feeling pressured to accept the aircraft or doubtful as to the safety or legality of the flight. Reports of being pressured to accept an aircraft were closely associated with occurrences where an argument also took place between a pilot and maintenance engineer indicating that attempts by maintenance personnel to persuade pilots to fly may be a particular source of conflict. The most common outcome associated with communication difficulties between pilots and engineers was a feeling on the part of the flight crew that trust between the two parties had been jeopardised, a finding which has implications for the well-being of the intergroup relationship.

CHAPTER SEVEN

General Discussion

This research examined the interactions between airline pilots and line maintenance engineers in order to identify impediments to effective communication between them and to determine what effect a poor interface between the two groups might have on airline operations. The first study utilised focus groups as a means to explore the relationship between pilots and maintenance personnel, both in terms of the practical difficulties each group faced when attempting to communicate, and the way in which the intergroup relationship itself affected communication. The second study made use of real-time interactions between pilots and maintenance personnel to investigate communication within an operational environment, specifically with regard to the impediments identified in Study One. The third study used correspondence analysis to explore the associations between problematic interactions, and adverse effects on airline operations and flight safety.

This chapter discusses the implications of the findings from the three studies in relation to the wider literature and considers the practical consequences for airlines. The discussion addresses the two parts of the central research question:

i. The impediments to effective communication between airline pilots and line maintenance personnel.

ii. The effects of a problematic interface between airline pilots and line maintenance personnel.

The discussion is made with reference to the three stages of research which were undertaken to explore:

- The nature of the intergroup relationship
- The way in which the two groups communicate
- The consequences to the airline

7.1 Impediments to Effective Communication between Airline Pilots and Line Maintenance Engineers

The literature review noted that pilots and engineers share similar communication and relationship difficulties observed between other professions. While their specific task-related difficulties may be unique, factors affecting their relationship are evidently shared.

7.1.1 The Role of the Communication Medium

Studies One and Two identified that the primary communication media used by the two groups has a significant impact on the ability for pilots and line maintenance engineers to communicate effectively in an operational environment. Congruent with those studies which have explored the written medium, (Lapacek et al., 1997; BASI, 1999; Mattson et al., 2001; Munro et al., 2004; 2008), the logbook is identified as being an impediment to effective communication between flight crew and line maintenance engineers. Results from the first two studies support the previously published findings that poor descriptions and a lack of information regarding defects negatively impacts on a line maintenance engineer's ability to troubleshoot (Lapacek et al., 1997; BASI, 1999; Munro et al., 2004). This research now provides further evidence that a lack of detail from engineers with regard to maintenance discrepancies can also negatively impact on flight crew who may elect to: a) fly without a full understanding of the aircraft's maintenance status, or b) face the consequences of having to delay a departure in order to seek further information. It can now be shown that both the constraints of the logbook and the different terminologies used by each group can have negative commercial implications for an airline.

The studies undertaken in this research have, however, also established that the logbook is only one of a number of sources of frustration for the two groups. Rather than being the primary *cause* of a problematic interface, the findings from this research suggest that the logbook serves to exacerbate communication difficulties that are likely to exist between the two groups due to differences in specialised terminology and a lack of understanding of the other profession's job requirements brought about by a poor intergroup relationship. In accordance with the Information Richness Theory (Mohan et al., 1997; McShane & Von Glinow, 2009) these findings suggest that the logbook is a less than ideal communication medium given that lean media are best suited when those communicating have common expectations and shared mental models. This has practical implications in terms of any steps potentially undertaken to address the problematic interface: despite the important role it plays, solely focusing on the issues associated with the logbook to improve communication between the two groups is most likely overly simplistic.

Results from Study Two indicate that clarifications between engineers and pilots are sought more often than not when communicating via radio and telephone. This illustrates the importance of medium-rich channels when communicating in non-routine and/or ambiguous situations (Mohan et al., 1997; McShane & Von Glinow, 2009). However, the communication media used by pilots and line maintenance engineers provides an additional set of challenges. Communication via the logbook can generate task-related conflict when information needs are not met. On the other hand, the richer medium of voice communication enables task-related conflict to become - or at least give the perception of becoming – interpersonal. This may go some way to providing an explanation for a somewhat contradictory finding identified previously (Eiff et al., 1997; Mattson et al., 1999; 2001) which indicated that despite both sharing a desire for more information in the logbook, pilots and engineers appeared to have an aversion to face-to-face interaction, the medium which by its very nature is the best suited to provide that information. Evidence of this paradox was identified in the focus group study; each profession expressed a clear desire for more information, yet also articulated feelings of belittlement and vulnerability when attempting to communicate via information-rich media i.e. radio, telephone and face-to-face. Evidence to support these claims was identified from the interactions which were examined in Study Two. Here it was found that while the majority of communication could be classified as being task-neutral, when disagreements arose both pilots and maintenance engineers tended to use negatively emotive language. The findings from this research indicate that this places the two groups in a rather disadvantageous position whereby the primary communication channel (logbook) does not satisfactorily meet their information requirements and supplemental methods (radio and telephone) can have potentially consequential deterrents which impact negatively on the intergroup relationship.

To summarise, the role of the medium with regard to impeding effective communication is twofold. Firstly, it can either moderate or aggravate the effects of preexisting communication difficulties between the pilots and line maintenance engineers caused by distinctive specialised terminology between the two professions and a lack of understanding of each group’s information needs. While information-rich media such as voice channels and face-to-face interactions will lessen the impacts of these effects, information-lean media such as the logbook will exacerbate them. Secondly, when pilots and engineers communicate via the radio, telephone or face-to-face, these media allow interpersonal conflict to become demonstrable which then creates a vicious cycle whereby the communication itself adversely affects the intergroup relationship.

7.1.2 Organisational Factors can create and sustain Psychosocial Barriers

The findings from the current studies reveal that psychosocial influences between airline pilots and line maintenance engineers are central to the development of an unhealthy intergroup relationship which negatively impacts on the ability of the two professions to communicate effectively. Airlines themselves, however, are implicated in this finding, specifically with regard to the way in which organisational structures and divisions can establish and maintain psychosocial barriers.

Short aircraft turn-around times and OTP pressures have created fewer opportunities for airline pilots and line maintenance engineers to spend time in each other's presence within their work environment. Previous research regarding pilots and cabin crew (Chute & Wiener, 1994; 1995; 1996; Chute et al., 1995; Ford, 2011) and pilots and maintenance engineers (Mattson et al., 1999) proposes that workforces who are physically separated not only lose the opportunity to collaborate and cooperate, but also suffer from a lack of understanding about the other profession's responsibilities and workload. This assertion also aligns both with findings within the medical profession (Baggs & Schmitt, 1988; Fagin, 1992; Lingard et. al., 2002a; 2000b; 2004) and with the more general literature regarding the role of Social Identity Theory in creating communication barriers within organisations (R. Fisher, 1993; Papa et al., 2008). The findings from the focus group study uphold the notion that organisational factors beyond the control of either group such as short aircraft turn-around times, OTP pressure, and no requirement to be physically present during the aircraft handover are largely responsible for the physical separation of the two professions.

An enhanced understanding of the connection between communication impediments now permits an advancement to the previous application of Chute and Wiener's (1994) cabin crew 'Five Factor Model of Communication Barriers' to the flight crew-maintenance interface. Earlier research (Lapacek et al., 1997; Mattson et al., 1999) has speculated that the communication barriers between pilots and engineers correspond to those experienced by pilots and flight attendants. However, as contended in the literature review, this notion called for more evidence. While the findings from the current studies do not support the presence of 'historical' and 'regulatory' barriers within this research context, the existence of 'organisational', 'physical' and 'psychosocial' barriers is confirmed. Additionally, this research undertaken for this thesis can now advance the concept of a distinct relationship between these three barriers. To date there has been no specific connection suggested between the barriers. Indeed they are presented as separate factors, and in no particular order. However, as the conceptual framework developed in this research has identified a directional connection between the communication impediments, by overlaying the barriers on to the model a relationship emerges. It suggests that organisational barriers generate physical barriers which, in turn, induce the presence of psychosocial barriers (Figure 7.1).

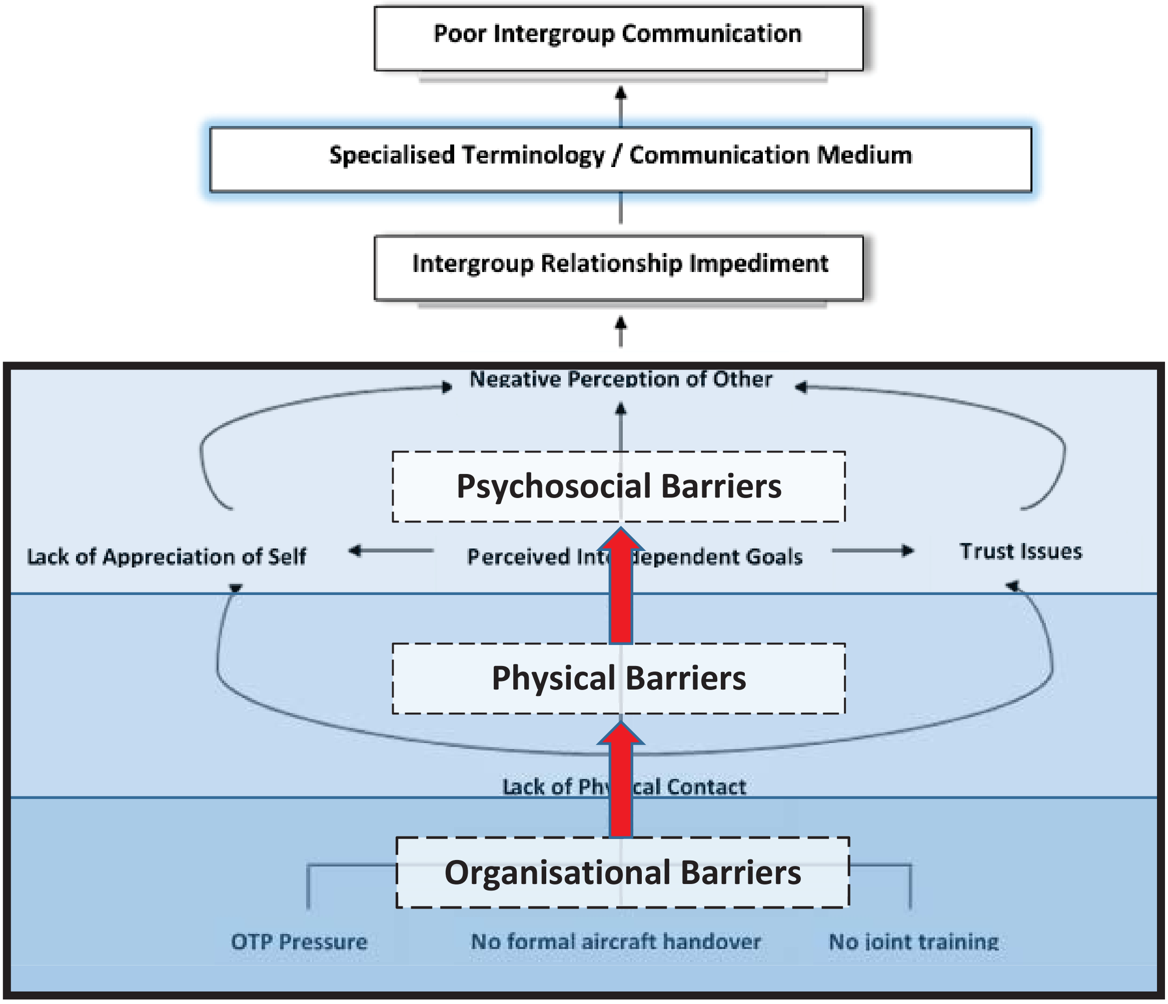


Figure 7.1. Relationship between Organisational, Physical and Psychosocial Barriers

The benefit of this model is that it can help identify the focus of airline interventions to improve communication between flight crew and line maintenance personnel. As noted above, when discussing the logbook, arbitrarily targeting one particular problem or simply choosing to address the more discernible issues such as the logbook or MEL, is potentially limiting. Instead, systematic consideration should be given to the way in which these barriers relate, and the instigating role of the organisation itself.

7.1.3 The Aircraft Turnaround: Superordinate or Interdependent Goal?

Within an airline environment, a successful aircraft turnaround is a desirable superordinate goal for pilots and line maintenance engineers and the airline should therefore be encouraging collaborative behaviour and reducing the practice of stereotyping (Schneider, 2004). The fact that aircraft turnarounds take place on a daily basis also means that the goal is ongoing, fulfilling the important stipulation that there must be a series of interdependent tasks in order to de-escalate intergroup conflict (Hartley, 1996). Organisational SIT research suggests that even in ideographic organisations where professionals identify strongly with their work group, it is possible that characteristic intergroup behaviours can be set aside in situations where a higher social responsibility is concerned i.e. safety (Hennessy & West, 1999). However, the three studies detailed here indicate that despite pilots and maintenance engineers sharing an overarching respect for flight safety and duty-of-care to those on board, the aircraft turnaround is not always fulfilling the requirements of a superordinate goal. It would seem therefore, that conditions which are central to the superordinate goal concept are not being met. Carr (2003) for example, states that the particular goal to be achieved must actually be obtained, a stipulation which, in the case of a successful on-time departure is not always accomplished according to the global delay statistics noted in Chapter Three. The findings from this research also support the caution from R. Fisher (1993) in that, while there may be theoretical agreement from groups about the importance of the overall mission to be achieved (i.e. working together for a successful turnaround), disagreements can arise regarding specific activities along the way (e.g. decisions about deferral processes, interpretation of the MEL). Finally, and perhaps one of the more concerning findings in relation to the aircraft turnaround, is that when an on-time departure is not achieved, the requirement to allocate delay codes effectively encourages the attribution of blame between the two groups, a situation which essentially provokes conflict between groups (Growler & Legg, 1981; Vaughan & Hogg, 2005; Gittell, 2006) and supports the notion that organisational factors are an important cause of communication difficulties.

7.2 Effects of a Problematic Interface between Airline Pilots and Line Maintenance Personnel

With the evidence from the first two studies supporting the notion of a problematic interface between flight crew and maintenance personnel, this section discusses the implications for airlines, firstly in terms of operational considerations and secondly in relation to flight safety. This section concludes by reflecting on how the findings from the current research relate to the previous arguments which have been made in support of joint CRM training for airline pilots and line maintenance engineers.

7.2.1 Implications for Airlines

This research sought evidence to support the supposition that a problematic interface between airline pilots and line maintenance personnel would adversely affect airline operations. Previous studies which have examined engineers' attitudes to the logbook found that maintenance personnel hold the opinion that poor pilot write-ups hinder defect rectification (Lapacek et al., 1997; BASI, 1999; Munro et al., 2004; 2008). Prior to the studies for this thesis, there had been no systematic research to analyse these suggestions. This research, however, goes some way toward verifying these opinions by identifying an association between inadequate pilot write-ups and subsequent difficulties with defect rectification. Evidence from the focus group sessions indicated that poorly written descriptions of defects can lead to extended troubleshooting or an inability to rectify a discrepancy until additional information from subsequent flights is gathered. While this can have safety-related implications, it is true that incorrect maintenance is also likely to impact primarily on an airline's schedule by manifesting as a reoccurring defect when the source of the maintenance discrepancy is not correctly identified in the first instance. As additional troubleshooting measures are then required, this then can incur the expense of having an aircraft removed from service unnecessarily.

In addition to the costs associated with incorrect maintenance, poor communication between pilots and engineers has another operational implication for airlines. Findings indicate that problematic interactions between pilots and engineers regarding, either the deferral process or MEL interpretation, are detrimental to an airline's on-time performance. This supports the argument from Gitell (1998; 2000; 2006) who highlighted the difficulties airlines have with coordinating highly interdependent work teams due to divisiveness across work functions, and recommended that investment in effective communication training could improve on-time departures. Given the importance airlines place on punctual departures due to the financial penalties incurred by delays (Tiernan et al., 2008; Sohoni et al., 2011) the findings from the studies in this thesis now offer evidence of the commercial implications of communication barriers between flight crew and maintenance personnel.

This research undertaken for this thesis also appears to be the first to link specific communication difficulties with subsequent operational impacts for an airline which may enable a greater understanding of the types of issues which can impact on an airline's schedule. As noted when discussing the purpose for this research, there has been little interest from airlines to provide CRM training specifically for flight crew and maintenance engineers. There is no regulatory obligation to do so and such an endeavour may be deemed superfluous to requirements and an unwarranted cost. This makes the findings regarding the commercial implications associated with inefficient communication between flight crew and line maintenance engineers particularly pertinent as they go some way to supporting a case for such an initiative.

7.2.2 Implications for Flight Safety

Despite unanimous agreement from the participants during the focus group sessions that safety is their number one priority, evidence suggests that poor communication can negatively impact on the ability of pilots and engineers to achieve this ambition. The findings from this research which showed associations between problematic interactions and adverse effects of flight safety are perhaps the most concerning given the grave consequences which potentially accompany aircraft incidents and accidents. While there are few documented accidents in which poor communication between pilots and maintenance engineers has been considered a contributing factor, the findings from this research support the arguments of Heinrich (1931) and Reason (1990; 1997) that a lack of accidents is not an indication that all is necessarily well.

As noted in the literature review, previous studies in this field have offered a logical conjecture on how a problematic interface between pilots and line maintenance engineers might impact on safety but restrict their suggestions to generalised statements such as the referral by Mattson et al., (2001) to the creation of ‘latent failures’ as a result of poor communication. The findings from this research lend a degree of evidence to support these claims and offers a more comprehensive understanding of the ways in which safety can be compromised.

The research studies of this thesis clearly provide evidence that the range of safety consequences relating to problematic flight crew-maintenance interactions is broad, encompassing associations with tangible events as well as more insidious activities. The results of the third study showed that problematic interactions which stem from confusion or miscommunication appear to be associated with events such as incorrect maintenance being performed, the aircraft operating in variance with regulatory and/or manufacturing specifications, or an inflight maintenance-related event. This suggests that these particular types of problematic interface are potentially examples of active failures given their relatively close temporal connection to a resulting event. Interestingly, the types of issues which can be classified in this manner are the same issues which were identified as exacerbating the discord in the intergroup relationship: the logbook and the MEL. As noted previously, these operational documents play an exacerbating role in contributing to poor communication and any targeted measures undertaken to improve these issues will not necessarily address the root cause of a problematic interface which has been identified as being driven primarily by organisational, physical and psychosocial barriers. This concept is supported by the knowledge that adverse safety events result from a complex interaction of both latent conditions and active failures (Reason, 1990; 1997; 2000; 2005; ATSB, 2008). Thus addressing specific issues which could be classified as 'workplace conditions' will only go so far in reducing the likelihood of an adverse event (Figure 7.2).

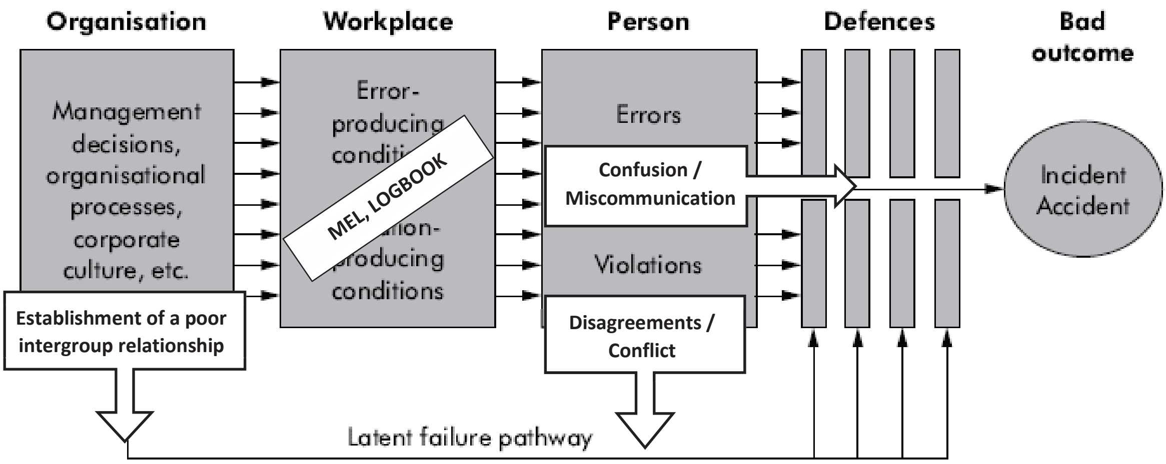


Figure 7.2. Problems associated with the logbook and MEL provide an opportunity for an adverse safety outcome. However, a poor intergroup relationship is a significant latent condition.

The findings from the Correspondence Analysis suggest that disagreements between flight crew and maintenance personnel tend to be associated with outcomes which can be classified as latent failures or conditions. These can be varied in nature and can take the form of adverse psychological states such as those which might be experienced following an argument, or feelings of doubt as to the airworthiness of the aircraft. These negative outcomes which are associated with disagreements lend support to the notion that for conflict to be productive, high levels of trust, openness and cooperation must be present (De Dreu & Weingart, 2003), factors which this research suggests are not always evident between pilots and line maintenance engineers. Given the significant influence latent conditions can have on subsequent events it is contended that disagreements between flight crew and maintenance personnel are likely to have a negative impact on flight safety. Due to the issues which are creating discord between the two professions – appropriateness of deferrals, applicability of MELs, the suitability of rectification techniques, and the way in which the logbook is utilised – any undertaking to improve safety in this context requires a comprehensive approach and one which seeks to address the root cause of these disagreements. As the findings from the focus group study have already indicated, conflict due to deficiencies in the understandings of each profession's role requirements stem from a poor intergroup relationship. This then remains the principle area of concern.

7.2.3 Joint CRM Training in Support of the Contact Hypothesis

The above discussion has noted that poor communication between flight crew and maintenance personnel can potentially have both commercial and safety-related ramifications. While it was not the purpose of this research to explore specific resolutions for the issues which were found, the process of examining the reasons behind the communication difficulties inherently exposes potential solutions. Previous research has advocated bringing pilots and engineers together for joint-CRM education (Mattson et al., 1999; 2001; Reithmaier, 2001; Munro et al., 2008; Ford, 2011). The results from the three studies in this thesis add weight to the view that there are numerous benefits associated with bringing airline pilots and maintenance engineers together for communication training. Firstly, and arguably foremost, creating an opportunity for pilots and line maintenance personnel to interact in a non-operational environment increases the amount of interpersonal contact the two groups have. This research has identified that the primary cause of the problematic interface between flight crew and maintenance engineers is an unhealthy intergroup relationship, both enabled and maintained by organisationally-imposed lack of physical contact. It follows then, that increasing the contact between the two groups may go some way to reducing intergroup conflict as theorised in the Contact Hypothesis (Allport, 1954; Pettigrew & Tropp, 2000). This research has demonstrated that a lack of personal interaction in the workplace is primarily connected to the development of adverse psychosocial influences (see Fig 7.1) and that trust within the relationship is often jeopardised as a result of communication difficulties. The primary aim of increased contact is to provide an opportunity to correct negative intergroup perceptions and counter the adverse effects that physical separation has on intergroup trust (R. Fisher, 1993). Providing a non-competitive atmosphere for flight crew and maintenance personnel to interact (as would be achieved by joint-CRM training) could serve to counteract the perceptual distortions which often accompany a lack of contact, and aid in the development and maintenance of intergroup trust.

In addition to the psychosocial benefits of increased contact, many of the practical difficulties associated with the flight crew-maintenance interface could potentially be addressed with a joint-CRM initiative. One of the primary concerns identified in this research was that both pilots and maintenance engineers felt their job responsibilities were not well understood by the other groups. CRM training could therefore provide a mediated environment for the discussion of those issues which tend to create task-related conflict such as the appropriateness of logbook entries or the way in which the MEL is used. In doing so, this could create a layer of defense within the organisation against those adverse events where poor pilot-maintenance communication contributes (Figure 7.3). Some of the approaches and techniques explored by Ford (2011) with pilot-cabin crew CRM may well prove to be useful in any proposed CRM training with pilots and line maintenance engineers.

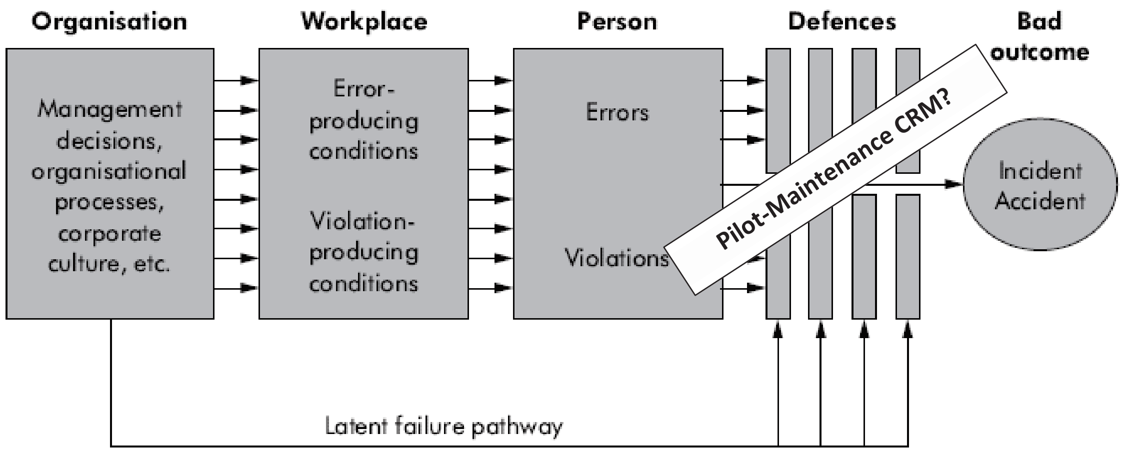


Figure 7.3. Joint CRM training for pilots and engineers may provide a defence against the issues that result from a poor pilot-maintenance communication.

CHAPTER EIGHT

Conclusion

8.1 Summary of the Research

This research was driven by a need to address what was deemed to be a knowledge gap in the literature regarding the way in which pilots and line maintenance engineers communicate. This research is believed to be the first of its kind to facilitate in-depth discussion with both airline pilots and maintenance engineers on the nature of their professional relationship in order to appreciate the range of difficulties they face when interacting with each other. Examination of operational radio and telephone interactions mean that this is also the first research to analyse actual communication between flight crew and maintenance personnel beyond that which is contained within the logbook. Through the use of focus groups and by applying Interaction Process Analysis to samples of operational communication this research has afforded an insightful understanding of impediments which hinder effective communication between these two groups. The use of Correspondence Analysis to examine the association between events where adverse operational and safety outcomes have been preceded by a flight crew experiencing a problematic maintenance-related interaction, also provides a unique perspective on many of the potential negative repercussions for airlines.

Previous research in this field has focused on, and subsequently cited, the logbook as the cause of a problematic interface (Lapacek et al., 1997; Mattson et al., 2001; Munro et al., 2004; 2008). Given that the logbook is the primary medium by which the two groups communicate, this is a logical path of research inquiry and one which has provided valuable insight into the way in which pilots and engineers interact. However, the level of disagreement between the two groups is suggestive of much deeper issues. It is difficult to believe, for example, that in its own right a poor logbook entry would warrant such reaction as a physical altercation on the flight deck such as occurred at Air India in 2015 (see Section 1.1). A number of studies have previously hinted at more complex issues between pilots and maintenance engineers (Lapacek et al., 1997; Eiff et al., 1997; Mattson et al., 2001), a concept which can now be confirmed by the findings of this research. This extends the previous knowledge regarding the pilot-maintenance interface by providing evidence that a poor intergroup relationship is contributing to communication difficulties between pilots and maintenance engineers. Findings from these current studies advance the notion that the primary cause of the problematic flight crew-maintenance interface is not entirely generated by the difficulties associated with operational artifacts such as the MEL and logbook, but rather it stems from organisationally imposed divisions between the two professions.

The primary barriers to effective communication which airline pilots and line maintenance engineers face are inherent to specialised work groups who must interact (Huseman et. al., 1976; Growler & Legg, 1981; R. Fisher, 1993; Papa et. al., 2008) and have been observed in other professions (Baggs & Schmitt, 1988; Fagin, 1992; Lingard et. al., 2002a; 2002b; Chute & Wiener, 1994; 1995; 1996; Chute, et al., 1995; Ford, 2010). Theoretically, the safe and efficient turnaround of the aircraft should see these two groups working together productively, yet with the immense commercial pressures to reduce aircraft turnaround times, organisational-imposed demands appear to render this intergroup goal counter-productive. Accordingly, the opportunity for these two groups to engage away from the operationally imposed demands imposed upon them becomes even more important. The potential benefits for pilots and maintenance personnel to participate in joint CRM-training have long been inferred (Mattson et. al., 1999; 2001; Reithmaier, 2001; Munro et. al., 2008). Given that the studies undertaken for this thesis now provide evidence of a relationship between problematic pilot-maintenance interactions and aircraft delays, cancellations and adverse safety outcomes, the research undertaken for this thesis lends weight to this argument.

8.2 Limitations, Implications and Recommendations

Two of the three studies undertaken for this research were conducted within a major New Zealand airline which presents limitations in the ability to generalise these findings to other cultural populations, and other aviation sectors. However, the reported issues and safety outcomes contained within the ASRS data used in Study Three mirrored those identified in the preceding studies. Consequently, while the nature of the intergroup relationship between pilots and line maintenance personnel could be unique to Airline ABC, the way in which problematic pilot-maintenance interactions manifest would appear to be common across other airline cultures. Whether the communication issues which were discovered within the airline environment would also be found in general aviation or the military is unknown and research within these sectors may potentially offer valuable insights for the airlines.

An interesting observation during this research was the disproportionate numbers of pilot reports within the dataset used in Study Three. While the lack of reports submitted by maintenance personnel must be acknowledged as a limitation to the study, it also raises questions as to whether there is a degree of underreporting from the maintenance sector on communication issues with flight crew. While many of the reports within the dataset detailed interactions which would not warrant a report from the maintenance engineer (such as a pilot becoming doubtful as to the interpretation of an MEL subsequent to the flight departing), the fact that only one report regarding a disagreement was submitted by a maintenance engineer is somewhat curious. This difference has been noted previously, Suzuki et. al., (2008) commenting *"Ten of these [ASRS reports] illustrated conflict between maintenance and flight crews…interestingly, these maintenance/flight crew cases were all reported by flight crew"* (p. 92). Whether a culture of underreporting exists within maintenance or whether pilots feel particularly aggrieved following these events and are motivated to file a report (perhaps due to feelings of distrust and concern as to the integrity of the aircraft) is unknown. This observation does, however, suggest an area of future research with regard to exploring how problematic interactions are perceived by engineers as well as their willingness to report such events.

The research undertaken for this thesis has three valuable implications for airlines. Firstly, airlines should be cognisant of the organisational factors which can be detrimental to teamwork between highly salient, professional groups with interdependent task functions. By their very nature, these groups are naturally susceptible to intergroup conflict within an organisation. Thus, while aircraft turnarounds theoretically provide a superordinate goal for pilots and line maintenance engineers, quick turnaround times and the requirement to allocate delay codes may only serve to aggravate this relationship, and potentially encourage discord.

Secondly, evidence from this research suggests there is a strong case for dedicated pilot-line maintenance CRM training to be incorporated into current human factors training syllabi for airline pilots and line maintenance personnel. It is recommended that airlines consider providing flight crew, and those maintenance personnel who interact with flight crew, dedicated CRM training on issues pertinent to communication within the line maintenance environment. Ideally this training should focus on the information needs of both the pilot and the maintainer, and include practical training such as how to provide appropriate descriptions of maintenance discrepancies and defect rectifications. Opportunities to explore perceptions associated with each of the professions by clarifying job functions and expectations is also considered beneficial. This is particularly important within those airlines where pilots and line maintenance engineers have very little contact. It is acknowledged that where there is no requirement by the regulator to provide training of this nature, there may be a reluctance by airlines to do so, due, both to the cost involved, and the lack of perceived benefits. While it was not the intent of this thesis to calculate the economic costs associated with a problematic flight crew-maintenance interface, the findings from this research offer a degree of evidence towards the merits of such an undertaking in the future. The findings from study three provide evidence of an associative relationship between poor communication and flight delays and/or cancellations and it is recommended that future research is conducted with a view to more fully explore the relationship between these variables. In order to examine the benefits of a dedicated CRM module for airline pilots and line maintenance engineers, it is further recommended that studies are undertaken to investigate the effects this type of training has on teamwork and communication between these two groups.

The third implication for airlines concerns the communication media available within the line maintenance environment. Although the aircraft technical log is a regulatory requirement, this research provides evidence that shared mental models concerning its use often do not exist between pilots and line maintenance engineers and for this reason the logbook is potentially an unsuitable medium in terms of a sole communication channel. The ability to utilise media-rich channels in order to communicate is essential to facilitate the accurate transmission of information between the two parties. While reduced turn-around times and OTP pressures appear unavoidable in the highly competitive commercial aviation sector, the benefits of real-time communication between those who fly aircraft and those who maintain them should not be underestimated. Insofar as the logbook is concerned, however, it is recommended that training is given to both pilots and engineers on how to make best use of the space which is available whilst considering the needs of the end users.

Finally, it is important also to acknowledge that aviation technology continues to advance at a considerable rate meaning that the ways in which pilots and maintenance personnel interact are also evolving. In order for research to keep abreast of the developments in this field, it is recommended that electronic media communication using tools such as ACARS and electronic logbooks is investigated so that the implications for the users are fully understood

8. 3 Final Overview

Exploration of the factors which cause communication difficulties between airline pilots and line maintenance engineers provides valuable insight into the nature of the relationship between these two groups. Examination of the impediments which were identified in these studies highlights a complexity associated with the pilot-maintenance interface due to the presence of both task and relational sources of conflict. Airlines should be attentive to the notion that many of the factors which affect the ability for pilots and maintenance engineers to communicate effectively are driven by organisationally-imposed pressures and constraints placed on these two groups. The concerns which were identified by this research would suggest that a concerted effort is required in order to address the practical difficulties associated with operational documentation as well as those behaviours inherent when specialised professions with interdependent work functions are required to interact. While this may seem challenging for organisations in terms of resource, airlines should be mindful of the fact that problematic interactions between pilots and line maintenance personnel can not only result in aircraft delays or cancellations, but can also pose a threat to flight safety.

> ***There are a few pilots who are also mechanics, and a few mechanics who are also pilots, but the majority of people in the aviation field focus on their area of specialty and leave the infinite details to the other side. It's a love/hate relationship, yet both realise they need each other. This need doesn't necessarily prevent them from questioning each other's intelligence, and battling wits is all in good fun, but ultimately pilots have to trust mechanics with their lives. Like any dysfunctional, co-dependent relationship that causes you grief, you just can't leave or ignore it. Pilots and mechanics have to work together, so both professions might as well make it easier to get the job done. A little respect coming from both sides of the logbook makes for a happy, safe and on time flight.***
>
> ***Pilot vs Mechanic: Disciplesofflight.com***

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Appendix A: Focus Group Interview Schedule

PRELIMINARY
Introductions
Conduct of Session
Ensure forms are all signed
Draw letters from bag for confidentiality/voice sample for transcription identification
`

OPENING
We're here to discuss the way in which pilots and engineers communicate with each other. To begin with, as a bit of a warm-up exercise, I'd like to know a little about what (engineers/pilots) think about (pilot/engineers). First of all I'd like you to write down 5 or 6 words which you think describes (pilots/engineers) as a group in general.

<u>Task:</u> Write down 5 or 6 words that you think best describes the traits/characteristics of (engineers/pilots) as a group in general.

<u>TASK:</u> Now I'd like you to do the same with your own profession…

Thank you, we will come back and discuss these a little further on.

QUESTIONS
Let's start the discussion now.

1. *Tell me in your own words what you guys think are some of the things that make your job harder when it comes to dealing with (pilots/engineers). Try and focus on the times when you have to interact with the other group rather than just general difficulties associated with your job.*

2. *What about some specific examples; has anyone got a story they could share about a time when they've had difficulty dealing with a (pilot/engineer)..?*
   <u>[Probes]</u> *What was the outcome?*
   How did that make you <u>feel</u>?
   What was the outcome on the <u>flight</u>?
   What do you believe should have happened in order to have a better outcome?

3. *Think about the way in which (pilots/engineers) tend to communicate with you – the words they use to describe things, the way in which logs are written up. What do you like/dislike about their style of communication?*
   <u>[Probes]</u> Do you see this communication being effective or not?
   What do you think of your own logbook write-ups?
   How about the other group's write-ups?

4. *Let's talk about goals and objectives when it comes to the operation of the aircraft. What are your goals? What do you think the primary objective of the (pilots/engineers) is?*

[Probes] Do you see yourselves working together towards a joint goal or competing against each other with goal interdependence?
Do you trust (pilots/engineers)? If not, why not?

5. *Let's have a look at some of the words you've used to describe the (pilot/engineer) groups?*

[Probes] Why do you think that of them?
What is this based on?
Do you respect them?

6. *What do you think (pilots/engineers) think of your group?*

[Probes] Why do you think they would think that?
What is this based on?
Do you think they respect/trust you?

7. *What about specific issues such as*:

[Probes] OTP? MEL? Aircraft authority? Aircraft despatchability? Quality of log write-ups, descriptions of defects?

8. *What impact does all of what we have discussed have on your job? Think in terms of enjoyment/satisfaction as well as tangible impacts with regard to despatch of the aircraft?*

(Last) *What would you like to see happen in order to improve communication with (pilots/engineers) i.e. what would you change/fix if you had the opportunity?*

[Probes] Do you think joint-CRM training would be beneficial?

CLOSING
Thank you
Contacts for further information/research results

Appendix B: Information Sheet

MASSEY UNIVERSITY
COLLEGE OF BUSINESS
KAUPAPA WHAI PAKIHI

Focus Groups to Explore Communication Barriers between Flight Crew and Line Maintenance Engineers

INFORMATION SHEET

Introduction
My name is Tahlia Fisher and I am currently studying toward my PhD at Massey University on a part-time basis. My degree is within the field of aviation; specifically my interest is the way in which airline pilots and line maintenance engineers communicate with each other during the course of their work. In addition being a doctoral student at Massey, I work at Air New Zealand as a full-time employee based in Auckland.

Project Description and Invitation
Anecdotal evidence suggests that pilots and engineers can have difficulty communicating with each other in an effective manner. Issues such as the despatchability of an aircraft or applicability of an MEL could be examples of situations where there is disagreement between the two parties. Potentially this can impact on the safety and/or efficiency of the operation. However, no research has yet been conducted to explore the issues that pilots and engineers themselves identify as being 'barriers' to good communication between their two groups. This study is the first in a series of three in my overall research plan, the aim of which is to explore communication between flight crew and line maintenance engineers. I am looking for Flight Crew and Line Maintenance Engineers who have an interest in this subject and would like to participate in this first study.

Overview of what is involved
To collect data for this study, I will be holding focus group sessions. In essence, the focus groups will be made up of small groups of participants who will have the opportunity to discuss some of the questions I pose to the group. I will moderate the sessions, but the purpose of the group is for free discussion to take place between the participants on the issues they feel are important. Pilots and engineers will take part in separate focus group sessions. In total there will be 3 or 4 focus groups for the pilots and 3 or 4 focus groups for the engineers. Each group will have approximately 4 or 5 participants, plus myself.

Recruitment and Procedures for Volunteers
To be eligible for this study, you must be employed as either a pilot (any fleet, rank) or a Licensed Aircraft Maintenance Engineer who is working in the line maintenance environment. MOC personnel are also invited to participate. Ideally you will be interested in the subject of communication between pilots and engineers or have been involved in an event which you believe demonstrated a problem with communication. The focus group sessions will run for approximately an hour, but no longer than an hour and a half. Light refreshments will be served. Please also be aware that as a participant in a focus group you have the right to review the transcript of the session for editing purposes (see Participant's Rights, below). Should you wish to do so, please take into account the time required for this when considering your decision to participate. Note: *Participation in this study is entirely voluntary. Participation or non-participation will not have any negative consequences on employment at Air New Zealand.*

Confidentiality
If you decide to take part in this research, you will be required to attend a focus group session along with other participants from your field of work. The discussion which takes place during the session will

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be audio-recorded for the purposes of transcription and analysis. To ensure confidentiality, no names or other identifying-information will be transcribed from the audio recording and the audio recording of the focus group discussion will be destroyed once the transcription has been completed. No references will be made in any published material that could identify or link you to this study, nor will any identifying-information be passed on to Air New Zealand. During the study, electronic data will be password protected and all audio records and consent forms will be stored securely in a locked office. Additionally, because information will be shared within a group setting, all participants are required to sign a confidentiality form stating that any discussion which takes place in the focus group session is not to be disclosed outside of the group.

Risks

There are no foreseeable risks or discomforts associated with your participation in this study. All participants should be aware that this study is for the purpose of academic research, and as such the following applies:

- No information regarding the participants identity will be shared with Air New Zealand or be made available in any research publications.
- No data will be stored on Company computers. This includes focus group transcripts, consent forms or any other material associated with data collection.
- All correspondence with participants will be via my Massey University email.
- Following completion of the research, participants will be entitled to the same information which will be available to Air New Zealand by way of the published research results.

Participant's Rights

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- ask for the recorder to be turned off at any time during the focus group session;
- withdraw from the study at any point up until the conclusion of the focus group session;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- read the transcript from your focus group session for editing purposes (note you may only edit your own individual contributions not those of other participants or the moderator).
- be given access to a summary of the project findings by either email/post when it is concluded. This summary will include the researcher's analysis of the results from the focus group sessions.

Project Contacts

If you have any questions with regard to this study, or would like to have more information about the research, please feel free to contact either myself or my supervisors:
Researcher: Tahlia.Anderson.1@uni.massey.ac.nz

Supervisors:
1. Dr Ross St George, Massey University School of Aviation, telephone: 06 350 5327, email: R.StGeorge@massey.ac.nz
2. Dr Ritchie de Montalk, Massey University School of Aviation, telephone: 06 3569099 email: R.J.deMontalk@massey.ac.nz
3. Dr Richard Batt, c/o Australian Transport Safety Board, 62 Northbourne Avenue Canberra ACT 2601. email: Richard.Batt@atsb.gov.au

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern B, Application 11/31. If you have any concerns about the conduct of this research, please contact Dr Nathan Matthews, Acting Chair, Massey University Human Ethics Committee: Southern B, telephone 06 350 5799 x 8729, email humanethicsouthb@massey.ac.nz

Appendix C: Pilot In-Group Descriptions

How pilots describe themselves. Brackets indicate frequency a particular description was used

Very Positive	Positive	Somewhat Positive
Professional (8)	Conservative (4)	A1 personality (2)
SOP-driven / procedural (5)	Structured / ordered (4)	More intelligent than engineers
Trustworthy / reliable (4)	Analytical (3)	Proud
Solution-orientated / conclusion driven (3)	Methodical (3)	Sociable
Intelligent / Knowledgeable (3)	Skilled (3)	Romantic
Leaders (2)	Focused (2)	Regimented
Big picture thinkers (2)	Prioritisation (2)	Hierarchical
Capable (2)	Cut to the chase / anti-bullshit (2)	
Safety conscious (2)	Flexible / often 'fluid' (2)	
High standards	Technical (2)	
Task focused (2)	Paperwork / exams and checks (2)	
Good problem solving skills	Career-driven	
Disciplined	Adventure	
In control	Paid well	
Diligent	Open	
Good communicators	Coordinated	
Thorough	Relaxed	
Responsible	Assertive	
Attention for detail	Inquiring	
Respected	Practical	
Goal-orientated	Good humoured, mostly	
Team members	Organised	
Coordinated hand/eye	Healthy / fit	
Safety and operational focus	Regulatory responsibility	
Confident	Determined	
Diplomatic	Above average technical knowledge	
Lateral thinkers		
Final filter		
Generally a great bunch of blokes		

Neutral
Unionised
Travel
Many types of thinkers and personalities
Individualistic

Somewhat Negative	Negative	Very Negative
Opinionated (2)	Don't know a lot about the technical world (2)	Argumentative
Some have little ability to relate to the engineer		
Reserved		
Competitive		
Tight-fisted		

Appendix D: Engineer In-Group Descriptions

How engineers describe themselves. Brackets indicate frequency a particular description was used

Very Positive	Positive	Somewhat Positive
Professional (9)	Humorous (5)	Pedantic / look for faults in everything (4)
Honest / Ethical (4)	Methodical / Systematic (4)	Down to Earth / Grounded (3)
Determined (3)	Exacting / demanding (2)	Hands-on
Responsible (3)	Constant education / educated in field (2)	Code of culture
Knowledgeable / Intelligent (3)	Good social interaction	Proud
Conscientious (3)	Caring	
Loyal / Dedicated(2)	Planner	
Safety conscious (2)	Happy amongst ourselves	
Perfectionists (2)	Keen to see a job through	
Thorough / Precise (2)	Diverse abilities	
Structured / Logical (2)	Approachable	
Analytical (2)	Realistic	
Reliable (2)	Mostly flexible	
Mechanical (2)	Accountable	
Team players	Serious when necessary	
Like to achieve	Forward thinking	
Thinkers	Customer focused	
Disciplined		
Confident		
Observant		
Practical / common sense		
Task orientated		
Focused		
Problem solvers		
Pride in getting it right		
Manual-driven / Procedural		
High standards		

Neutral
Black and white (2)
Individualistic
Common interest in engineering outside of work
Spontaneous
Literal
Tinkerers
Regulated
Drive older rugged cars

Somewhat Negative	Negative	Very Negative
Not good with spelling (2)	Poor computer skills	Grumpy (3)
Particular / fussy (2)	Disjointed (as a workforce)	Pessimistic
Variable in personalities	Salesmen	Not communicators
Critical view	Loners	

Appendix E: Pilot Out-Group Descriptions

How pilots describe engineers. Brackets indicate frequency a particular description was used

Very Positive	Positive	Somewhat Positive
Knowledgeable/Intelligent (7)	Measured/Steady (2)	Salt of the Earth
Technically minded (6)	Paperwork/lots of exams (2)	Quite chatty
Structured/logical (5)	Broad range of experience (2)	Can be good
Hardworking/dedicated (5)	Patient	
Manual-driven/procedural (5)	Mostly helpful	
Practical/Common sense (5)	Go-focused	
Professional (5)	Pleasant	
Solution-orientated (3)	Humorous	
Capable (3)	Conservative	
Thorough/precise (3)		
Under-valued/Under-appreciated (2)		
Good bunch/fun to have a beer with (2)		
Technically skilled (2)		
Good fellows/nice guys (2)		
Trustworthy/Responsible (2)		
Dependable		
Skilled		
Valued		
Strong ownership of issues/problems		
Task-orientated		
Good mechanics		
Mechanical		
Determined		
Neat personalities		

Neutral
Overalls/Kerosene (2)
Unionized (2)
Usually have a key technical interest focal point
Individualistic
Black and White
Under-manned
A1 personality

Somewhat Negative	Negative	Very Negative
Reserved / Serious (2)	'Closed shop' / stand-offish (3)	'Monkey wrench' / 'Grease-monkey' (3)
Bad handwriting (2)	Unhappy (2)	Defensive (2)
Look stressed /harangued (2)	different operational view to pilots (2)	Grumpy/Gruff (2)
Quick fixers	Non-commercial	Some will avoid work if they can
Don't like the question 'how long?'	Can be hard to deal with	Abrupt
Busy	Narrow range of personalities	Reluctance to offer information
Variable in their communication skills		Distain for pilots
Variable in personality		Don't make good pilots
Opinionated		Cheap to run: only have to pay them a banana a day
Tired		Unfit / not healthy
Not much humour		Not communicators

Appendix F: Engineer Out-Group Descriptions

How engineers describe pilots. Brackets indicate frequency a particular description was used

Very Positive	Positive	Somewhat Positive
Professional (9)	Methodical (4)	Alright (2)
Intelligent / knowledgeable (4)	Approachable / friendly (2)	Dedicated / long-serving (2)
Safety conscious (3)	Motivated	understanding
Meticulous / Exacting (2)	Routines	Wealthy
Good guys / nice characters (2)	Put you at ease during delay situations	Regimented
Good communicators	Skilled	Interested in my job
Process-driven	Time conscious	Hierarchical
High standards	Competent flyers	Polite
Big picture thinkers	Planners	
Capable	Really good	
leaders	Determined	

Neutral
unionised
Common interests with engineers outside of work

Somewhat Negative	Negative	Very Negative
Finicky / fussy / picky (3)	Do stuff by the book as opposed to understand it (4)	Arrogant (6)
Bus driver / system operator (2)	Militant / Regimented (3)	Egotistical (4)
Narrow field of vision (2)	Don't know a lot about the technical world (2)	Spoilt / Pampered (3)
Bit too professional / no banter (2)	Old fashioned / out of touch (2)	Elitist / I am the boss (3)
geeks	Bossy / demanding (2)	Rude / Pompous (3)
old	Unaccommodating (2)	Overpaid (3)
Big wallets and short arms	Stressed	Self-centred / selfish (2)
Pedantic / can be anal	Think they know how to fix the aircraft	Don't admit they're wrong or apologise when wrong (2)
	Us and them	Condescending (2)
		Confrontational (2)
		Can get nervous
		Blame the aircraft
		More concerned about allowances and benefits
		Superior attitude / body language
		A pain
		Grumpy old men
		Naive
		Narrow-minded
		Show-offs
		Social pygmy

Appendix G: Friendliness Scale

1	Tone of voice is unfriendly: clipped tone, cold, interruptions
2	Tone of voice is somewhat unfriendly: predominantly neutral interspersed with category 1 traits
3	Tone of voice is neutral: professional but neither friendly or unfriendly manner
4	Tone of voice is somewhat friendly: predominately neutral interspersed with category 5 traits
5	Tone of voice is friendly: warm tone, jokes, engages in pleasantries

Appendix H: IPA Sample Transcript

ENGINEER:	Maintenance Operations, [name] here [6]
PILOT:	Hi [name] [1], it's 289 again, reference that seat defect [6], um, we found the lever as you described [6], um, and they've exercised it [6], but unfortunately they're not able to over-ride it and lower it [5]
ENGINEER:	oh, okay…alright [3]…there must be something, um, something else, ah, that's in the way [5]. Do you know when they moved that lever, if they, if the seat actually did move at all or, what happened? [7]
PILOT:	No, I didn't get a report on that [6] but we can ascertain that and come back to you [4]….um, just from our position, not actually looking at the, ah, seat itself, I assume it's the screen message, not stowed message that's the electrical operation [5], would that be right? [8]
ENGINEER:	That's affirmative. [3] It's….I believe the message is 'stow monitor' [5] and they have tried to stow the monitor numerous times [6] so, for some reason, um, the sensor in there is not, ah, reacting properly and that's what's stopping the electrical operation [5]. Um, that shouldn't stop the manual operation though, um, it still should, um, come forward into the bed position if it's released. [5] Ah, the other thing that happens sometimes is the mechanism gets itself, ah, a little bit crossed up in there and tends to bind or jam [5]…ah, that may have happened in this case. [4]
PILOT:	Is there any way we can bypass that blocking electrical message from the screen? [8]
ENGINEER:	The only way to do it is, um, is as I described, manually release the seat. [5] And as I say, the message from the, ah, monitor stow sensor shouldn't stop the manual operation, [5] ah, there must be something else that's doing it, that's preventing that manual operation. [5]
PILOT:	okay, thank you. [1] Alright, we'll go back and report further if there's anything more we can add to that [4]. So we'll get back to you thank you [4]
ENGINEER:	okay, that's alright. Thanks for that [1

Appendix I: IPA results using the Mann-Witney U Test

	IPA Category	*U value*	*Sig.*
1	Shows Solidarity	5199	.180
2	Tension Release	5642	.857
3	Agrees	3847	.000*
4	Gives Suggestion	4031	.000*
5	Gives Opinion	5240	.285
6	Gives Orientation	3879	.000*
7	Asks for Orientation	5515	.646
8	Asks for Opinion	3995	.000*
9	Asks for Suggestion	3836	.000*
10	Disagrees	5188	.238
11	Shows Tension	4670	.020*
12	Shows Antagonism	5052	.139

* Indicates significance at $p < .05$ (two-tailed)

Appendix J: Example ASRS report with associated codes

Reviewing our release for our first flight of the day I noticed several MELs on the inbound aircraft, one of which indicated that the Passenger Address System was inoperative. Upon arrival at the gate, I noticed the 'A' Flight Attendant communicating with the passengers via the hand held megaphone. Maintenance was called and the mechanics repaired the PA system and removed the associated MEL. Shortly after the mechanics left, the PA system once again failed and I again requested maintenance. The mechanic stated they did not have the parts required to repair the aircraft and was going to apply the previously removed MEL back onto the aircraft. A review of the logbook displayed numerous entries for this system over the previous five days. While reviewing the provisions of the MEL, I noted that one requirement was for the chime system to operate 'normally.' I performed a test of the system and was informed by the three flight attendants that they did not hear any signals from the cockpit. I did hear the chime in the cockpit so I entered mid-cabin and had the first officer attempt the test a second time. The second test confirmed the system was not functioning in the cabin. While performing this test, several passengers informed me 'that hasn't worked since we left XXX'.I returned to the jetway and expressed my concerns to the mechanic that in my opinion we were not in compliance with the MEL as stated due to the chime system not functioning 'normally.' He stated he agreed but had been overridden by Headquarters. At this point I called Dispatch and requested a patch through to Maintenance. While discussing the MEL with Maintenance, it was apparent that they wanted the aircraft flown as is. When I told him of the failed test of the system his response was, 'Well, the mechanic said he heard a chime and that's good enough for me.' I told him that the two tests we performed demonstrated that the flight attendants could not hear the chimes and in my opinion the system was not operating 'normally' as per the MEL <u>[CODE A: MEL DISAGREEMENT]</u>*. At that point Maintenance started what I could best describe as pressure by guilt, saying such things as, 'So, you have no problem stranding all those passengers;' 'You don't feel bad that all those people are not going to get to see their families on time', etc* <u>[CODE B: PRESSURED TO FLY]</u>*. I told the Mechanic the only thing I wasn't going to do was fly an aircraft in direct violation of an FAR and risk my certificate* <u>[CODE B: FLIGHT CREW REFUSED TO FLY AIRCRAFT]</u>*. His response was, 'That's not going to happen.' His next and last response was, 'Throw the keys on the dash as you walk out. You're done.'* <u>[CODE B: ARGUMENT]</u> *I informed the Mechanic at the aircraft with me of the outcome to which he replied, 'I agree with you, the system is not operating normally'. The aircraft was removed from service and all of our passengers were moved to another aircraft. Maintenance needs to understand that it is NEVER my intention to inconvenience our passengers, but SAFETY overrides all other concerns. Flight attendants using the emergency megaphone for routine cabin announcements drain the battery of the device rendering it unusable in the time of a real emergency. In addition, the lack of a way to communicate with the cabin crew and passengers during flight [or during an evacuation] endangers everyone on board in the event of a real emergency*

Appendix K: Development of the CA Model

The first process undertaken was the creation of a two-way contingency table (Table 1) with category A codes represented as row variables and the category B codes representing the column variables. The summation of frequencies for the row variables and column variables are represented under 'Active Margin'. A correspondence analysis was then computed for the frequencies across all 24 variables using symmetrical normalisation in order for comparison to be made between the row and column variables. Table 2 presents the summary data for the correspondence analysis. A result of $\chi 2(120) = 2033.8$ ($p < 0.001$) indicated that the relationship of dependency between row and column variables was statistically significant making it appropriate to continue with the analysis. Following confirmation of statistical significance, interpretation was required to determine the appropriate number of dimensions to be used for the display. An exactly accurate display would have dimensions of m-1, where m is the row or column profile containing the fewest number of variables (Greenacre, 2007). In this case, the CA computation provided a solution for a model containing 10 dimensions which is not possible to visualize, thus a determination needed to be made as to how many dimensions would be appropriate.

As there were 11 row variables, should the data have had no significant dependencies at all with the column variables, each axis would account for 100/(11-1) = 10% of the total inertia of the model. Following this logic, any axis which accounts for more than 10% of total inertia can therefore be deemed relevant to be used in the display. As seen in Table 2, the CA summary calculated that the first dimension accounted for .546 (54.6%) of the total inertia and the second axis accounted for .247 (24.7%) of the total inertia. As the third dimension would only contribute a further .107 (10.7%) to the interpretation of the dependency between rows and columns on the display (and would also mean that a three-dimensional map would have to be used), a more logical choice was to use only the first two dimensions. Using a bi-plot allowed for a retention of .793 (79.3%) of the data subtlety whilst being considerably easier to interpret than a display with more dimensions.

The total inertia value for the model was 1.053. This reflects a relatively strong association between some column profiles (codes in Category A 'Reported Issues') and row profiles (codes in Category B 'Outcomes'). This was able to be confirmed simply by reference to the contingency table which showed that the outcomes (B-Category) of *Refused Advice* and *No Advice Forthcoming* were almost exclusively associated with the report issue (A-Category) of *Inflight Troubleshooting* resulting in profiles markedly different from the rest of the table (see Table 1). Verification that these variables were outliers was made by examining the results of the individual data points which would subsequently be plotted on the display. Outliers are deemed to fall more than one standard deviation away from the centric vertices in the display (Bendixen, 1996) and both *Refused Advice* and *No Advice Forthcoming* had standard deviations of 6.9 and 6.5 respectively. Outliers are problematic in that they have a distorting effect on the rest of the data due to the fact they dominate the interpretation of one or more axes leading to other data points being tightly clustered and difficult to interpret (Bendixen, 1996).

Confirmation that this had occurred was made when examination of the column point data revealed that the variable *Refused Advice* was providing a contribution of 32.5% in determining the axis to be used in the display and *No Advice Forthcoming* had the highest contribution of all at 65.1%. For this reason, it was decided to exclude these variables from the final CA so that better focus could be directed at the remaining association relationships which were not as apparent. The CA summary data for Category A variables 1-10 and Category B variables 1-11 is shown in Table 3

The resultant analysis with the three variables excluded still achieved a significant result of $\chi 2(72) = 837.9$ ($p < 0.001$). Removal of the outliers meant that the overall inertia was lower at .463 and therefore the data points were less dissipated on the display. With regard to the number of dimensions to be used for the display, examination of the summary data shows the data points would be able to be displayed using a bi-plot whilst retaining an overall retention of .824 (82.4%) display accuracy, which was slightly improved on the previous model.

The next step was to check the overall quality of representation of the row and column variables. As the process of dimension reduction will inevitably result in a loss of quality, it is possible to check the specific representation of individual rows and columns to the display in order to provide a greater understanding of how points should be interpreted. The degree of association between a column or row to a particular axis is measured by the squared correlation (Bendixen, 1996). Table 4 lists the contributions of the row and column points to each of the two axis. The data can be interpreted simply as the higher the value, the more association the particular point has with that axis on the display. The Category A variable *Defect Rectification Disagreement* as an example, would be strongly associated with dimension 1 on the resultant display and very weakly associated with dimension 2, having a squared correlation of .782 with the first and only .008 with the second (see Table 4). When assessing the correlation totals of all the points it was noted that for Category A variables, *Logbook Procedure Issues, Engineer Signoff* and *Not Informed of System Defect* were not well represented by the model. Similarly, the Category B variables *Return to Gate, Discouragement to Report* and *Flew with Doubt* were also not well represented by the model.

In an effort to achieve a better representation of quality across the variables without having to increase the dimensions of the display, a decision was made to transform the Category A variable *Pilot Write-up* into a supplementary row and Category B variable *Incorrect Maintenance Performed* into a supplementary column. Within a CA display, supplementary points are still plotted, however, their values make no contribution to the construction of the dimensions of the display (Greenacre, 2007). This pairing was selected due to the fact that both points had significantly high representations of quality (.939 and .962 respectively) and upon generation of the display itself both points were almost co-situated but somewhat distant from the rest of the group. By making these two points supplementary, the dimensional axis were subsequently more evenly distributed (as shown in Section 6.3) yet the similarity in profile between the two points was not lost. By accomplishing the steps described above, the final CA model was constructed in such a way so as to provide a clear picture of the data whilst achieving a good retention of the data accuracy.

OUTCOMES

REPORTED ISSUES	*Return to Gate*	*Flight Cancelled or Delayed*	*Airwrth Issues*	*Inflight Event*	*Refusal to Fly*	*Argument*	*Discouragement to Report*	*Flew with Doubt*	*Pressured to Fly*	*Incorrect Maint. Performed*	*Trust Jeopardised*	*Refused Advice*	*No Advice Forthcoming*	*Active Margin*
Defect Rectification Disagreement	16	65	11	26	74	68	16	59	57	7	123	0	0	522
Logbook Procedure Issues	2	26	17	9	14	21	4	11	12	2	45	0	0	163
MEL Disagreement	3	28	11	9	25	27	2	21	9	5	27	0	0	167
Deferral Disagreement	4	39	7	11	90	36	1	32	35	2	37	0	0	294
MEL Confusion	10	20	44	41	5	2	3	38	5	9	12	0	0	189
Pilot Write-up	0	19	10	9	0	0	1	4	0	18	0	0	0	61
Engineer Signoff	3	17	12	22	9	11	0	11	6	3	18	0	0	112
Communication Difficulty	5	13	23	34	4	9	0	1	3	10	6	0	1	109
Not Informed of System Defect	0	8	14	1	0	1	0	0	0	1	15	0	0	40
Defect Rectification found Incorrect	5	6	57	52	2	2	2	23	8	0	65	0	0	222
Inflight Troubleshooting	1	0	1	3	0	5	0	5	0	0	6	10	21	52
Active Margin	49	241	207	217	223	182	29	205	135	57	354	10	22	1931

Table 1. *Contingency Table of Reported Issues and their Outcomes*

Table 2. *Correspondence Analysis summary data using all variables*

Dimension	Singular Value	Inertia	Chi Square	Sig.	Proportion of Inertia: Accounted for	Proportion of Inertia: Cumulative	Confidence Singular Value: Standard Deviation	Confidence Singular Value: Correlation 2
1	.758	.575			.546	.546	.046	.021
2	.510	.261			.247	.793	.018	
3	.336	.113			.107	.900		
4	.219	.048			.046	.946		
5	.155	.024			.023	.969		
6	.137	.019			.018	.986		
7	.098	.010			.009	.995		
8	.056	.003			.003	.998		
9	.036	.001			.001	1.000		
10	.017	.000			.000	1.000		
Total		1.053	2033.831	.000[a]	1.000	1.000		

a. 120 degrees of freedom

Table 3. *Correspondence Analysis summary excluding variables 11(A), 12(B) and 13(B)*

Dimension	Singular Value	Inertia	Chi Square	Sig.	Proportion of Inertia		Confidence Singular Value	
								Correlation
					Accounted for	Cumulative	Standard Deviation	2
1	.516	.266			.574	.574	.019	.127
2	.340	.116			.250	.824	.034	
3	.198	.039			.084	.908		
4	.139	.019			.042	.950		
5	.115	.013			.029	.979		
6	.086	.007			.016	.994		
7	.039	.001			.003	.998		
8	.033	.001			.002	1.000		
Total		.463	837.921	.000[a]	1.000	1.000		

a. 72 degrees of freedom

Table 4. *Contributions of row and column points to model dimensions*

Row Point	*Contribution of Dimension to Inertia of Point*		
	Axis 1	Axis 2	Total
Defect Rectification Disagreement	.782	.008	.790
Logbook Procedure	.139	.094	.232
MEL Disagreements	.463	.149	.612
Deferral Disagreements	.728	.034	.762
MEL Confusion	.704	.000	.705
Pilot Write-up	.280	.660	.939
Engineer Sign-off	.329	.000	.329
Communication Difficulty	.674	.065	.739
Not Informed of System Defect	.217	.081	.298
Defect Rectification Incorrect	.539	.425	.964

Column Point	*Contribution of Dimension to Inertia of Point*		
	Axis 1	Axis 2	Total
Return to Gate	.117	.034	.150
Flight Cancelled or Delayed	.020	.709	.730
Airworthiness Issues	.851	.069	.920
Inflight Event	.779	.017	.796
Refused to Fly	.772	.030	.802
Argument	.751	.015	.766
Discouragement to Report	.106	.002	.108
Flew with Doubt	.005	.016	.022
Pressured to Fly	.874	.003	.878
Incorrect Maintenance Performed	.259	.703	.962
Trust Jeopardised	.050	.518	.568